A HANDBOOK FOR FIFTH GRADE SCIENCE: INTEGRATING SCIENCE PROCESS SKILLS AND THE CURRICULUM

MASTER'S PROJECT

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To Joe, whose small part made the biggest difference.

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CHAPTER I

INTRODUCTION

Background

Science programs in elementary schools need to reflect the societal and technological demands facing students. The children of today will face problems of AIDS and other health issues, sufficient energy resources and dwindling natural reserves, environmental harmony, population demands, and the exponential rates of computerized and technological discoveries. Today's children will become tomorrow's leaders, and educators must instill in them a love for exploration, investigation, and experimentation. These interests and desires can be addressed by the proper type of science curriculum and teacher attitude and values. Educators are bombarded by government and private studies opposing or approving a variety of alternative methods for teaching science to students. Some of these programs are Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS and SCIIS), Science - A Process Approach (SAPA), and Project 2061: Science For All Americans. This researcher will further explore these programs in Chapter II of this document. Unfortunately, educators are rarely counseled in their decisions, except by Madison Avenue Marketing, as to the best method for structuring their curriculum, classrooms or school environment. Therefore, teachers are left to muddle through on their own and choose a method for science education that will adequately prepare students for the future, stimulate their interest in science, and communicate the course of study approved by the school district.

Teachers are in need of a method of science instruction that fosters science interest, communicates to students the necessary process skills of science, addresses the prescribed course of study, and prepares students for literacy in a technological world. The handbook to be developed as part of this study will aid teachers in using inductive methods of teaching science. The majority of the activities will utilize the discovery-like methods of instruction. Carin's (1993) research clearly suggests that hands-on science is an effective way to communicate science process skills to children in the elementary grades. Students learn best when they are actively involved in learning. According to Piaget's theory of cognitive development, students in the concrete operational stage of development need concrete activities to firmly establish a basis for later formation of abstract concepts, theories, and principles (Slavin 1991). Piaget theorizes that the concrete operational stage of intellectual development typically exists between the ages of seven to eleven years. This researcher is primarily interested in a handbook for students in the fifth grade (ages ten to twelve years old). Activities will be formulated in such a manner that an instructor who teaches a different grade level will be able to easily adapt material from the handbook with a minimum of reorganization.

Teachers are often hesitant to try discovery learning in their classrooms because of the increased need for materials and planning time. Linn (1980) found discovery lessons worth the rewards in student autonomy and self-motivation. Many educators, psychologists, and researchers have advocated the use of discovery learning. One of the earliest and most famous teachers, Socrates, used a questioning rather than telling method of instructing his pupils. More recently, John Dewey advocated students learning through experience. And in the 1950's and 1960's, Jerome Bruner theorized and tested discovery methods of learning as opposed to methods of rote learning and lecture.

Other methods of inductive learning will also be addressed by this researcher. Children perform many of the discovery tasks in groups. Foster and Penick (1985) have shown that important social skills are incorporated and developed along with greater opportunities for learning and retention of information when students are challenged to participate in a group activity. Finally, Gega (1990) has stated the need for educators to present science in a manner that involves students with a wide variety of objects they can manipulate. Science presented in this manner will enable students to think about what they are learning and to learn by doing science.

Problem Statement

The purpose of this handbook is to provide for teachers a handbook of science activities and investigations that address the current recommended content curriculum guide for science and foster science process skills as recommended by the National Science Teachers Association (NSTA). These activities will be in accordance with this researcher's science course of study, which was adopted by the school district. The activities contained in this handbook are to be used in place of the current adopted textbook. This researcher advises that the textbook be used as a supplemental reference guide to further enhance the students' understandings and as a source of additional information to address a particular unit of study. Also included in this handbook will be additional inductive teaching strategies so teachers may vary the methods of presenting science information to students. Carin (1993) has shown that no two students learn in exactly the same manner and educators must be well-versed in a variety of teaching methods and strategies. Finally, Chapter 3 focuses on evaluation methods adapted to discovery and other inductive teaching methods.

Methodology

The activities contained in this handbook will address the skill objectives outlined in this researcher's school district's course of study. There are two separate listings for science objectives in the course of study. The primary objectives have been adopted to assist teachers in selecting those subjects "essential to the grade level." This method was adopted to address a need for fewer concepts presented in greater depth. There are eighty-two primary objectives in the fifth grade course of study. The extension objectives are presented for those instructors who have time to present these topics "with the depth needed to build understanding of the topic." There are ninety extension objectives in the fifth grade course of study. All objectives will develop the understanding of basic generalizations, relationships and principles applied to life, physical, and earth sciences. Included in the program goals and objectives are the science process skills of observation, classification, measurement, space-time relationships, collection, organization, notation and interpretation of data, graphs, research, model construction, equipment, and science vocabulary. The verbs used in the objectives are: identify, name, list, describe, draw, compare, define, explain, classify, give examples, conclude, discuss, evaluate, infer, distinguish, state, contrast, interpret, relate, trace, and locate. Activities will be designed in such a way that the objectives will be achieved. Activities will also be arranged in thematic units to facilitate students in concept association to real-world situations. Emphasis will also be placed on the development of science processing skills: observing, classifying, ordering, data collecting, measuring, communicating, and inferring.

Many of the activities presented in the handbook will make use of various materials. The research will include directions for constructing and maintaining a science kit. This will reduce the added stress of trying to gather materials needed for any planned science lesson or unit. Teachers will gather materials for the science kits prior to implementing the lesson. Included in the kit construction will be information regarding availability of materials. This will help reduce planning time for discovery-like lessons.

Assumptions and Limitations

The researcher assumes that an activity-based curriculum will enhance the quality of science experiences so students are better able to achieve acceptable levels of preparation for their future educational endeavors. The researcher also assumes that discovery-type science activities will increase comprehension, standardized test scores, and reduce gender and racial biases.

The ideas presented in the handbook are given for a rural school district. Activities are structured to address the objectives outlined in the Valley View Board of Education Science Course of Study. As a consequence, they may not be appropriate for school districts with dissimilar populations or objectives.

Statement of Terms

Inductive Teaching Methods - Those methods of teaching that incorporate inductive logic defined by Orlich et al. (1985) as "a thought process wherein the individual observes or senses a *selected number* of events, processes, or objects, and then constructs a particular pattern of concepts or relationships based on these limited experiences. Inductive inquiry, then, is a method that is used by teachers when they present sets of data or situations and then ask the students to infer a conclusion, generalization, or a pattern of relationships" (p. 256). Inductive inquiry lessons may be conducted as guided or unguided. This researcher will deal exclusively with the guided inductive methods. Methods of inductive teaching include: questioning, inquiry, problem-solving, discovery learning, and the Suchman Inquiry Model.

Course of Study - The prescribed outline of objectives, relating to science instruction, as defined by the Valley View Board of Education, State of Ohio, 1989 (Revised every fourth year). Activities and science kits prescribed in this handbook may not pertain to all fifth grade science curricula.

Science Kits - Teacher constructed kits consisting of inexpensive and readily available items for use in hands-on science.

Rationale

Students need to be "doing" science rather than reading about science. If educators expect American students to keep pace with other industrialized nations, teachers must assist students in developing and implementing the critical thinking skills and science process skills. This proposed handbook will assist teachers with incorporating necessary skills into the science course of study. For our students of today to successfully contribute to the technological world of tomorrow, educators must re-evaluate their teaching strategies and adapt to the demands of society, technology, and the global market. The United States cannot afford to be in "the bottom of the stack."

CHAPTER II

REVIEW OF RELATED LITERATURE

Students in today's elementary and middle schools need experiences in problem-solving, cooperation, decision-making, and performing experiments. Educators can help students gain these kinds of experiences by incorporating inductive inquiry methods of instruction into their daily teaching methodologies. Particularly suited for this type of instruction are those lessons conducted in the area of science. Educators are further advised to explain the workings of the world to children in ways that parallel the methods used by scientists and technologists. If students become familiar with solving problems and observing the world critically, they will be more likely to pursue careers in the fields of science, industry, and technology.

Before methods of instructing science can be addressed, it must be established exactly what is meant by "science." Science is an aspect of daily life that is encountered in many ways. Children usually view science as nothing more than a reading class of facts and rules that must be memorized and "cookbook" recipes for demonstrations and experiments with "right or wrong" outcomes. Science can be broken into four main components:

1) organizing observations of the world around us,

2) establishing sense of our observations by looking for and discovering patterns,

3) using these new patterns to make predictions about what may happen in the future and,

4) testing our new-found knowledge in different situations to see if we are correct in our predictions.

These components of science are accepted by scientists and educators alike (Carin, 1993 and Gega, 1990). In many ways, the above components make more sense when viewed as a reason for wanting to study science.

Science Skills and Processes

Science is extremely important when preparing students for the future. The science they receive in elementary and middle school readies them for the task of understanding the world around them. They must have a basis to process new information. Science helps them process this information by helping them associate new experiences with previous experiences. Once students have seen the relevance of science in their daily lives, they are interested in learning more. Human beings are very willing to investigate those instances that have pertinence to their interests, likes, and dislikes. Children especially are more willing to participate in an activity that is viewed as fun and practical rather than an activity that does not apply to "the here and now." These activities help children exercise and develop the skills of problem-solving and decision-making in a friendly, helpful environment. Skills of problem-solving and decision-making must be practiced in the elementary years in order that they are available for use in the future.

Children must also be prepared to be an active participant in a technological world. Science educators can help students toward this goal by providing proper science instruction. Technology as defined by Carin (1993) proposes solutions for problems of human adaptation to the environment. These problems of the environment and adaptation are the basis for Project 2061, a study by the American Association for the Advancement of Science (AAAS). This long range plan suggests considerations for science education in the United States. It addresses many concerns regarding American education and the preparation and readiness of American students for careers in technology, science, and society in general. All three of these areas are issues educators must address in daily lessons. STS (Science/Technology/Society) issues are good ways to incorporate "real-life" problems in daily lessons (Yager, 1988). Students are more motivated to solve problems that are relevant to their life and society in general (Carin, 1993). Science lessons are also effective ways to practice the problem-solving/decision-making skills so necessary to childrens' educations.

Finally, state and national organizations are realizing the importance of science and its many implications on the future of our country. Goals and objectives are outlined for each school district. Many of these same goals have been prescribed in state and national documents advising educators of ways to encourage students to be more technologically and scientifically prepared for the future. Such a document currently being prepared for Ohio, Goals and Outcomes for Science Education in Ohio (1993), states those objectives that Ohio science educators need to convey to students. The document lists five goals for science education. They are:

Goal 1: The Nature of Science and Technology . To enable students to understand and engage in scientific inquiry; to develop positive attitudes toward the scientific enterprise; and to make decisions that are evidence-based and reflect a thorough understanding of the interrelationships among science, technology, and society.

Goal 2: The Physical Setting. To enable students to describe how knowledge of the physical universe has been and is acquired; and to reflect upon and be able to apply the principles on which it seems to run.

Goal 3: The Living Environment. To enable students to determine and verify how living things are structured and function; to assess how they interact with one another and the environment; and to make choices that ensure a sustainable environment.

Goal 4: Societal Perspectives. To enable students to appraise the interactions of science and technology in society, in the past, present and future.

Goal 5: Thematic Ideas. To enable students to use pervasive scientific ideas to explore phenomena, inform their judgments, resolve issues, and solve problems; and to explain how things work.

The goals illustrate society's concern with science education and establish reasons for educators to review their methods of instruction and re-evaluate the information they are conveying to students.

For students to adequately investigate phenomena they encounter in their everyday lives, they must be familiar with and practiced in using the three basic elements of science; science products, science processes, and science attitudes. The first element, science products, is also called scientific knowledge. In recent history, and unfortunately still today, science products have comprised the whole of science education (Elliott and Nagel, 1987). The scientific knowledge includes facts, concepts, generalizations, principles, theories, and laws. Modern science program authors are not advising educators to discontinue using facts, concepts, generalizations, principles, theories, or laws. Rather they are advising that students learn to experiment and create their own generalizations that are compared and contrasted to existing scientific knowledge. This establishes a sense of "ownership" rather than merely reading about knowledge and failing to internalize the principles for further use in explaining daily observations.

Educators, then, must assume the responsibility for making information available to students so they may check their findings with current scientific knowledge. This is not as scary as it may seem. The instructor does not need to be a walking encyclopedia! Rather, students are given the opportunity to learn how to conduct research under the watchful eye of an instructor who can seize the moment for a mini-lesson on "how to do research." Secondly, science is an organized search for patterns and generalizations. Scientists and researchers are continually proving or disproving scientific knowledge. Educators may acquaint students with these processes of finding the consistencies and inconsistencies in their discoveries. Activities centered on proofs will only further the students' understandings of STS and the processes of science.

The processes of science are the actual methods that scientists use to carry out their relentless search for information, patterns, and generalizations. Children can greatly benefit from using these same processes, not only in science but throughout any subject and any exploration they choose to investigate. Gega (1990) suggests that educators regard the process skills of science as tools that enable children to gather data for themselves that they can construct into a form that will help them reason about the environment. There are six science process skills.

Classifying

Observing

Measuring

Inferring

Communicating

Experimenting

Most educators will see these six process skills and immediately think of "the scientific method" learned in high school or college. Although these are the same skills emphasized, researchers caution not to always use the skills in the same order or at the same time (Styer, 1984). Although, students need to be aware of the skills and educators must model the proper use of each skill, educators must be careful not to communicate to students a rigid plan for always using each skill in the same manner. Students may even be interested to know that scientists do not use all the skills in the same order all the time. Students will benefit from knowing that scientists are people too. Educators can also help children see the integration of subject areas by pointing out science process skills used during other subject area instruction. This is particularly easy to do if the educator has a self-contained classroom.

The final element of science that educators must communicate, model, and develop in students relates to the students' scientific attitudes. Programs such as Science Curriculum Improvement Study (SCIS) were intended to foster positive student attitudes toward science. The developers of the SCIS program perceived student attitudes as essential to the development of scientific literacy. The four attitudes most emphasized were curiosity, inventiveness, critical thinking, and persistence. How can educators not only introduce these attitudes, but foster, nurture, and develop them? Consider curiosity first. Children are naturally curious. Unfortunately, educators try to insist that students sit quietly in their seats and read about science. This will not only curb the students' desire to internalize science but it will also squelch their natural curiosity. Children must be given opportunities and guided experiences to maintain and spark their curiosity. Educators can help channel student curiosity down the "right path" by appropriately directed questions and communicated expectations.

Inventiveness, a second attitude, addresses the need for creativity. This not only involves originality, but also fluency and flexibility (Gega, 1990). Fluency describes the number of ideas a child will generate when faced with a problem that must be solved. Flexibility is the willingness to change one's thinking to accommodate other's ideas and to establish a new idea. An example of developing flexibility is to ask questions: What can we use in place of . . . ?, What else can we find to do this . . . ?, How could you use . . . ? This will aid students in expanding their thinking so they initiate new and different ideas.

Critical thinking skills are best defined as those skills which enable students to look at information in a manner that questions the accuracy of the premise. Critical thinking skills are modeled by the instructor and students are helped to see alternative ways of looking at information. Most students are unsure of their own ideas and findings. They are accustomed to accepting the fact that the textbook or instructor is always right. This creates an often uncomfortable situation for both the instructor and the student. Children must be shown how to question and test theories and generalizations so they can develop thinking skills, as well as, confidence in their thinking abilities.

Persistence is an attitude that many children and adults fail to develop or use. Too often if a problem seems too difficult, lengthy, or frustrating, both will give up and move on to less taxing activities. Usually the results, if the participant would have persisted, are such that a new discovery was waiting "around the bend." Elliott and Nagel (1987) found that teaching by the textbook does not help develop persistence in science: "Compressing science activities into short lesson segments gives students little opportunity to experience either the spark of curiosity and suspense of a possible discovery or the often dreary monitoring of long experiments that add only small bits of insight" (p. 10). Science attitudes are integrated and one attitude will help develop another. A simple activity has many possibilities. For example, an activity where students try to determine the size and shape of an object in a sealed box will develop, not only the attitude of persistence, but also the student's curiosity, inventiveness, and critical thinking.

Cognitive Theories

Piaget introduced his theory of cognitive development in the 1960's. Since its introduction, his theory has influenced psychologists and educators in the ways they view children and the way children acquire knowledge. Others have proposed theories of personal, social and moral development with the same emphasis on steps of development. The developmental premise is that children do not develop gradually but continue through a series of steps called "stage theory." Piaget's theory is comprised of four basic concepts of intellectual development; schema, assimilation, accommodation, and equilibration, and four stages of cognitive development.

The first of Piaget's ideas is the development of a scheme. Schema is defined by Slavin (1991) as a pattern of thinking or interpreting objects that are encountered in daily life. Piaget states that all information interpreted by a child or adult must first be matched with the proper scheme for appropriate understanding. Children are not born with these schema but must develop them through experiences. Piaget's next process is assimilation. This is the process of taking the new information and trying to understand it by making it fit with the existing schema established by the individual. Accommodation must be employed when the new information or stimuli do not fit the existing schema. Here the child changes the existing scheme to include the new information. Finally, the child reaches a process of equilibration when the existing schema is challenged by a new situation that upsets the established schema of the individual. Science teachers can capitalize on these startling moments by presenting information in demonstrations that upset the child's existing schema. These situations tend to spark curiosity in the child. They wish to find out more about the situation and make sense of the observation in terms they can understand.

Piaget's four stages of cognitive development cover the life of a human being. This researcher will define all four stages. However, the main concentration will be the stage of development pertaining to fifth grade students.

Piaget's first stage of development is the sensorimotor stage. This stage occurs from birth to two years of age. Children in this stage are establishing schema by their senses and the basic motor skills. The child will investigate all new information by using a sense (sight, hearing, touch, or taste) or by physical actions (grasping, reaching, sucking). During this stage, the child slowly develops an idea of time, space, and causality (Hamachek, 1990).

The second step is the preoperational stage, which occurs from the ages of two to seven years. Children's thinking during these years is governed more by intuition than by logic. Language plays a major role in cognitive development and is characterized by egocentrism, repetitiveness, imitation, and experimentation. Preoperational children, in particular those in the early stages of this development, are not very good at handling concepts or categories. Toward the end of the stage, children develop the ability to handle the terms of class, simple concepts, and draw simple relationships.

The third stage is called the concrete operational stage and involves children typically between the ages of seven and eleven years. During this stage children develop skills of logical reasoning and conservation but have difficulty applying these skills to abstract or unfamiliar situations. Conservation is a skill necessary to science as well as the cognitive development of the whole child. Conservation is defined by Slavin (1991) as "the concept that certain properties of an object (such as weight) remain the same regardless of changes in other properties (such as length)" (p. 29). Because of the concrete nature of this stage, children learn best when permitted to experiment and manipulate objects and test situations to develop schema for understanding and processing data. This is particularly true when regarding new or unfamiliar concepts. Other developments in this stage are the ability to infer reality. In this capacity, a concrete operational child is able to see things in the context of other meanings such as conceptualizing situations without being distracted by irrelevant information. Another skill acquired in the concrete operational stage is the ability to organize and arrange things according to one or more attributes. They are also able to make comparisons between classes because of "additional tools of thinking" (Slavin, 1991). These tools are reversibility, the ability to perform an operation and then mentally reverse the operation so it is returned to its original starting point; decentration, the ability to focus on more than one attribute at a time; and reasoning from part-to-whole relationships. The important factor to remember about the concrete operational stage of development is these children are firmly established in the manipulation and experimentation of real objects. They are only able to relate more abstract thoughts through careful supervision, concrete examples, and relationships that deal with familiar objects and situations.

The final stage is the formal operations which is defined by Slavin (1991) as the "stage at which the ability to deal with hypothetical situations and to reason abstractly is acquired" (p. 35). This generally happens from eleven years to adulthood, although some research has found that many adults "are neither capable of, nor interested in, that sort of logical, 'scientific' reasoning" (Hamachek, 1990, p. 159). Therefore, the majority of students in the elementary schools capable of reasoning from abstract examples and concepts to understanding is very slim. Science educators that teach students from textbook readings and worksheets are operating on a level of cognitive development above the students. Students are not ready to reason in their heads about problems incompatible with existing schema. Children in the formal operational stage are able to imagine several different relationships and compare them mentally with a concrete example. This is not true of the concrete operational child. They would be able to perform the reasoning skills if there were actual objects to compare and manipulate, but they become easily confused when asked to perform the skill without the physical example.

This researcher has stated that the proposed handbook is targeted for the fifth grade curriculum. These children are between the ages of ten and twelve years. Therefore, according to Piaget, these students are in the concrete operational stage. Scruggs (1988), in her evaluation of elementary science textbooks , supports this statement. She found 40 percent of 10-year-olds and 90 percent of 15-year-olds function at or above the late concrete operational level of development. Therefore, she contends, instruction must be geared toward the early to mid-concrete operational level for science instruction. Most textbooks and curriculum guides assume that students in the fifth grade are ready mentally, physically, and educationally for the more formal skills of abstract reasoning and hypothesis formation. A major source of the problem lies in the evidence that 80 percent of the students will be totally confused. This is not to say that educators should not stretch children in their thinking. Piaget implies that instruction needs to be adapted to the child's level of cognitive development, but the instructor needs to help students extend their thinking a little beyond their functioning level (Slavin, 1991).

Another key aspect to the concrete operational years addresses the area of hands-on experimentation and manipulation of new objects and situations. Educators can give their students needed advantages by teaching lessons through active involvement. Because children are learning through concrete examples and experiences, educators will promote better understanding, spark student curiosity, and foster science process skills through discovery-like methods of instruction. Slavin (1991) further contends "Applying Piaget's insights to instruction means constant use of demonstrations and physical representations of ideas" (p. 39). The discovery method of learning introduced by Jerome Bruner utilizes these means. Joyce and Weil (1980) also describe a basic three phase strategy for using Piagetian theory in instruction. Phase 1 involves presenting a puzzling situation to students that matches their current developmental level. Phase 2 directs the instructor to elicit student responses explaining the witnessed phenomena and justifying their responses. Phase 3 presents other related tasks and checks student responses to determine understanding of the new concept. This last phase ensures that students are transferring newly acquired skills, concepts, and generalizations to other schema.

A final idea for incorporating Piagetian theory into instruction is outlined by Vygotsky (1978). His application suggests that instructors should focus on developing those skills students are on the verge of learning. Teachers can best help students acquire and test those skills they are developmentally ready for but have yet to investigate. Lessons must be structured such that unfamiliar skills are presented in a physical manner. He also suggests that students may acquire these skills easier if they are paired with other students at the same developmental stage. This way students are able to work and reason together thus explaining in familiar terms reasoning processes or skills.

Teaching Methods

Researchers agree the best way to help children in the concrete operational level internalize abstract concepts is through active participation in demonstrations and investigations (Carin, 1993; Gega, 1990; Greene, 1991). This researcher has shown evidence that inductive methods of instruction are needed for teachers to aid students in attaining necessary S/T/S skills (Shymansky et. al. , 1982). Resnick (1983) supports this evidence by cautioning teachers "Too quick an advance to formulas and procedures will not help children acquire the kinds of analytical and representational skills they need" (p. 478). This would imply that instructors need to adapt science curriculum to the students' interests, cognitive development level, and actively involve them in the learning process. Inductive teaching models are designed to accomplish just such objectives. This collection of teaching methods, as shown by Eggen and Kauchak (1988), is designed to be a straightforward and yet powerful strategy that develops the critical thinking skills, science process skills, communication skills, questioning skills, concepts, and generalizations. But exactly what are inductive teaching methods? The term must be defined. As stated in Chapter I, Orlich et. al. defines inductive teaching as a way of interpreting data or objects presented by the instructor as following a particular pattern or relationship. These patterns or relationships are then grouped and discussed so as to form a generalization about something in the student's world. Students are helped by the instructor to infer this generalization rather than simply hearing or reading the information and accepting it as true. There are several different strategies within the inductive teaching model. They include:

1 - Inquiry Learning (guided or unguided)

2 - Questioning

3 - Problem-solving

4 - Discovery Learning (guided or unguided)

5 - Suchman Inquiry

6 - Concept Attainment

All of the above strategies incorporate the critical thinking skills of assessing conclusions and identifying irrelevant information (Eggen and Kauchak, 1988). Therefore, they are alternative strategies for communicating thinking skills as recommended by the NSTA and the State of Ohio. This researcher proposes to comprise a handbook using the guided discovery learning strategy. Appendixes are planned for the handbook which will discuss ways to implement the science lessons using other inductive strategies. At that time, the researcher will present definitions and guidelines for planning, presenting, and implementing lessons using these alternative strategies.

Guided discovery learning was originated in the 1960's by Jerome Bruner. His main contention was that a teacher should create situations in which students were able to learn on their own rather than accept information in a neat, organized style from either the textbook or teacher-talk lectures (Slavin, 1991). This method of implementing a discovery lesson was termed free or unguided discovery learning because of the nature of letting students spend time with materials actively searching and discovering concepts and principles on their own. In the "pure" sense of the term, practical application and implementation of unguided discovery learning was time consuming, difficult to prepare, and unmanageable in a classroom of twenty to thirty students. The strategy did gain popularity when implemented with a more guided approach, careful teacher preparation and stated goal objectives, student introduction by carefully controlled experiments and practice sessions, and help from instructors as to methods of experimentation and inferring meaning from learned concepts and generalizations. This adaptation was termed the constructivist approach to guided discovery learning. Constructivists feel that students should build their own meanings for concepts and relationships by taking opportunities to experiment with ideas and infer their own meanings. Constructivists argue that the teacher's role is to help guide the discovery of critical concepts and structure lessons and experiments so students receive the appropriate materials necessary in building foundations for learning. This strategy integrates an expository technique of instruction along with the guided discovery learning strategy. Research has found that educators feel more comfortable implementing the guided discovery learning in their own classrooms if they can prepare students before the activity with facts, explanations, and specific ideas (Hamachek, 1990).

It would seem that the inductive teaching model is the perfect "cure-all" for the ills of education. But, there are a few drawbacks with the guided discovery learning method. Many educators still do not implement this strategy in their lesson plans. Research has found that the single biggest complaint with the guided discovery learning strategy is time. Resnick (1983) cites "it is becoming clear that it takes a long time, and many different examples, for understanding to develop" (p.478). This is especially true when students are assessed for their understanding of a concept by noting how well they can apply new concepts to a different situation. This researcher has found few critics of the guided discovery learning strategy. One published critique by Hamachek (1990), lists several reasons for opposing the guided discovery learning strategy: 1) Wrong answers are sometimes mistaken for "right" ones. Actually this is not a problem as long as the instructor is carefully supervising activities. Further instruction and class discussions of data, along with group hypothesis sessions, should help alleviate any misconceptions before they have a chance to become firmly rooted in the student's schema. Instructors, however, must be well-versed in the content so they can demonstrate to the student why a misconception is inappropriate. Further research states that "concentration of 'right thinking' rather than 'right answers'," is a more appropriate approach to elementary science programs (Scruggs, 1988). 2) Discovery learning negates the impact of the teacher. Without the teacher, there would be no *guided* discovery learning. Someone, presumably the teacher, must introduce the concept, facts, explanations, and specific ideas to the students. Someone must also bring the lesson to closure and provide for class discussion regarding findings, questions, possible future experiments and studies, and possible hypotheses or inferences from the activity. It may be possible for the teacher to be negated by an unguided discovery learning strategy, but definitely not so with a guided discovery learning lesson. Birnie and Ryan (1984) have constructed a chart showing the continuum of discovery learning patterns. On Birnie and Ryan's chart, each action is classified with either a "T" (teacher is in control) or an "S" (student is in control). A final analysis of the score shows that during guided discovery learning the teacher of the lesson twice as often as the students. Clearly, this does not confirm Hamachek's (1990) concerns. 3) Discovery methods are not appropriate for all schools. This researcher had no trouble disputing this claim. Children have never been very good at sitting quietly in a chair and listening to someone discuss the reasoning behind why a natural phenomena occurs. Just think about children on an elementary playground. Students need to have a supportive environment where they are free of fear, anger, and anxiety (Greene, 1991). These are all qualities that any instructor strives to create in their classroom and have no bearing on the use or disuse of discovery learning methods! With guided discovery learning strategies, students perform many of their investigations and experimentations in small groups. This only further enhances a feeling of responsibility and belonging to the student. Hamachek (1990) further contends in his argument against discovery learning that students in the primary grades may find discovery learning inappropriate. Jacobsen, Eggen, and Kauchak (1989) cite several examples of guided discovery learning scenarios in their book, Methods for Teaching: A Skills Approach. Hamachek's (1990) final argument involves children that come from disadvantaged environments. According to Piaget, these children especially need to have guided discovery learning experiences to help them establish schema that otherwise have been neglected. The guided discovery learning strategy employs materials, situations, and experiences that are familiar to most students. If disadvantaged students are excluded from these important experiences, they will only remain further disadvantaged. 4) Not all subjects fit the discovery mode. Hamachek (1990) cites as a shortcoming of discovery learning studies that have shown test results from elementary students illustrating concepts learned faster and easier by the lecture method rather than discovery learning. Research from Berliner and Casanova (1987) and Resnick (1983) show that students retain concepts and relationships longer and are able to apply them to new situations better with discovery learning than with lecture or expository learning alone. Eggen and Kauchak (1988) further show that a number of subjects may be easily adapted to guided discovery learning. Their text, Strategies for Teachers: Teaching Content and Thinking Skills, illustrates nicely several scenarios using guided discovery learning for other subject areas.

CHAPTER III

IMPLEMENTATION

For all the reasons articulated in Chapter 2, hands-on guided discovery learning should be the basis for all science instruction in the elementary school. This researcher is convinced that the way to interest students, motivate them to learn, and apply science skills to their daily lives is through guided discovery learning. Educators who are searching this handbook for ideas of their own will be able to adapt suggested activities to their curriculum. But what about those objectives that are not covered in this proposed handbook? This researcher will present a list of ideas and guidelines for planning and implementing guided discovery lessons.

Planning Units of Study

Researchers are discovering that the best way to entice students to concentrate on science is to make it apply to their daily lives. This is not difficult since science and technology are all around. Each adult and most children use some form of a science process skill each day. The challenge for educators is to mold these everyday occurrences into a cohesive unit of scientific study. Hurd (1991) suggests that the reform movement of the 1990's calls for such an integration of all subject matter. He calls for "an integration of school subjects: a conceptual convergence of the natural sciences, mathematics, and technology with the social and behavioral sciences and the humanities into a coherent whole" (p.35). Similarly, Loving (1991) initiates a "call for a more thematic, integrated approach to teaching science, allowing in-depth focus on important issues" (p.824). Finally, Yager (1988) concludes that "science is understandable and useful for most people . . . when it is put in a meaningful and useful context" and "real learning occurs only when there is actual/direct involvement between learners and specific objects, events, situations in that person's life" (p.185). Keeping in mind these findings, this researcher proposes to integrate the current adopted course of study with societal and technological issues. One further adaptation following these recommended guidelines will be to group science skills into cohesive units of study. The researcher proposes the following units, which are derived from the Valley View Science Curriculum Guide primary objectives.

1) The Forest

2) Animal Life Cycles

3) Weather

4) Energy and Our Environment

These units will offer students experiences in familiar situations and continue to develop cognitive skills, science process skills, and schema while addressing the recommended objectives in the science course of study.

Planning the format for the units of study is another consideration. Carin (1993) offers ten major questions to help educators address the format of a planned guided discovery lesson.

1. What age-level range might benefit from this activity?
2. What scientific/technological topics might students be exposed to in this activity?

3. What questions or problems might be investigated?
4. What science processes are involved?
5. What scientific concepts might students discover or construct?
6. What will I need for guiding this activity?
7. What will we communicate or discuss?
8. What actions will students take, individually or in groups?
9. How will students use or apply what they construct or discover?
10. What must I know? Where do I find it?

Jacobsen, Eggen, and Kauchak (1989) have a list of suggestions for helping educators plan guided discovery learning lessons. Their first criterion is to have a definite objective in mind when planning. The objective should be recorded so it is easier to stay "on track" when planning. Secondly, the selection of concrete examples or experiences is crucial because students will be learning an abstraction based solely on the examples presented. Examples must be clear, concise, and familiar to the students. The next step is to order the examples as they will be presented. It is important to put the examples in a logical order so that students will reap the full benefits of the lesson. If the instructor is using a guided discovery learning experience for the first time, the examples should be presented in order from most obvious to least obvious. The ordering will aid the students in hypothesizing the concept to be learned. If the instructor wishes to challenge the students, examples can be ordered in reverse - - most difficult to easiest. The researchers present a list of steps in guided discovery teaching that may be helpful.

Teacher	1:	Present example
Students	2:	Describe example
Teacher	3:	Present second example
Students	4:	Describe second example and compare to first
Teacher	5:	Present additional examples and non-examples
Students	6:	Compare and contrast

Teacher	7:	Prompt students to identify characteristics or relationship
Students	8:	State definition or relationship
Teacher	9:	Ask for additional examples

These guidelines should provide assistance and support for educators who must construct their own guided discovery lessons.

Presenting The Lessons

Implementation of lessons can follow many different directives. The scope of these methods is only limited to the judgment, flexibility, creativity, and preference of the teacher. Several pre-service teacher textbooks provide needed ideas of how to improve the science curriculum. Two especially good references are Science in Elementary Education by Gega (1990) and Teaching Science Through Discovery by Carin (1993). These references will be used extensively in preparing the proposed handbook of guided discovery learning activities.

A very important skill required by teachers using the guided discovery learning strategy is the ability to ask good questions and "think on their feet" (Jacobsen, Eggen, and Kauchak, 1989). Carin (1993), too, incorporates a great deal of discussion to effective, student-centered, problem-solving questioning techniques. He provides an extensive list of suggestions for developing better questioning/listening skills. These skills are critical for an instructor that wishes to develop in their students the ability to critically think, evaluate, question, and test the findings of the science community. The most important characteristic that Carin (1993) emphasizes is to increase the amount of wait-time before calling on students. This will help those students who seem to need a lot of time to carefully think through their answers and check to be sure they have their premise correctly stated. Another suggestion is to ask more divergent questions. Divergent questions are the types of questions with no one right answer (e.g., Identify all the different ways to protect a forest). Such questions will increase student participation and encourage those students that are shy about participating in the class discussion without fear of ridicule. Further questioning techniques suggest using questions developed for higher order thinking skills. Rather than comprehension and fact-laden questions, use questions incorporating application, analysis, synthesis, and evaluation. A final suggestion from Carin (1993) is to keep the class discussion more student-centered rather than teacher-centered. This involves letting the students ask questions and enable students to discuss among themselves instead of always asking the teacher for confirmation. The technique takes some practice to allow students to learn how to ask questions without intimidation or ridicule, but the rewards of permitting students to develop their own critical thinking skills is worth any effort involved.

Preparing Materials

Gathering materials can be a frustrating part of trying a guided discovery learning strategy or it can be as rewarding as an outlet shopping expedition. The key to finding and acquiring inexpensive or free materials for science instruction is to always keep tabs of any suggestions overheard in casual conversation. The trick is making sure that parents know what materials are needed and the students remembering to bring the materials with them. A suggestion for informing parents would be to include at the beginning of the year a listing of all materials that could be saved. Do not hand out the list and forget it. Keep sending "friendly reminders" home with students so parents are aware of the need for such articles. Secondly, many area commercial suppliers have materials easily adapted for science instruction. Materials for activities and experiments are available from hardware stores, craft shops, grocery stores, discount houses, outlet shops, and variety stores. The instructor must become a careful shopper who is always on the look-out for unexpected sales and bargains. Garage sales and flea markets are other suppliers of inexpensive materials for guided discovery learning. A final suggestion would be to ask for supplies from various sources in the school's community. The cafeteria (if there is a self-contained hot lunch program) usually has materials they are more than willing to give to teachers. Cheese boxes, metal cans from institutional size fruits and vegetables, bread wrappers from sandwich buns, plastic jugs, and other kitchen-type supplies are hard for the cafeteria to dispose of properly. Recycling by supplying a teacher is a welcome remedy to this dilemma. Other community businesses may have supplies of boxes, corrugated cardboard, containers, and other materials they will be more than willing to donate to the local school. There is no harm in asking and most principals and administrators are more than pleased to save some funds by resourceful, creative thinking. Students will also benefit by seeing the variety of ways everyday, common articles can be used for science learning.

Assessment and Evaluation

Finally, the teacher must incorporate ways of assessing and evaluating concepts and generalizations learned by students. Gega (1990) has many suggestions for easy ways to adapt assessment to the guided discovery learning strategy. He points out that many children are not capable to neatly stating a generalization. This is due in large part to the lack of formal operations cognitive development. A suggestion to accommodate this development stage is to ask students to demonstrate their knowledge by using concrete materials - - they can be materials already investigated presented in a new way or new materials used in a way already investigated. Either way, the student demonstrates understanding by applying the learned concept or generalization in a new situation. If the instructor were to ask the student to perform an experiment already investigated, the instructor is only testing the child's recall of procedures. A further application of a generalization is to ask the student to explain, predict or control objects or events. Presumably those objects that are new to them will increase the likelihood of displaying transfer and application of the generalization. Process skills can also be evaluated by asking the student to demonstrate a use of one of the science process skills. However, according to Gega (1990), "The best way to evaluate skill objectives is to observe the child in action during the regular activity time" (p.166). He also cautions teachers to remember that process skills are slowly developed over time and with continued use. These factors should be taken into consideration in science process skill evaluations. Another aspect of science instruction that needs evaluation are the students' scientific attitudes. These, like the students' science process skills, are slowly developed over time and with continued use. The same type of observational evaluation should be used to determine whether or not a student is acquiring the necessary scientific attitudes. Teachers can use some specific activities to develop and show students progress with these particular attitudes. Finally, written tests must be discussed. Most written tests only measure the amount of recall a student possesses. Because recall and knowledge are on the lower levels of Bloom's Taxonomy, they do not entail use of science process skills. Therefore, educators must create new ways of evaluating higher order thinking skills and scientific attitudes. Another limiting factor of these paper-and-pencil tests is the students reading and writing ability. Because writing and reading develop at a slower rate than attainment of science concepts, these tests are often a poor indication of the child's knowledge of science (Gega, 1990). The teacher should use three different methods to evaluate student progress in the subject of science. First, a diagnostic test may be given before the unit of study is started. This enables teachers to determine any misconceptions students may have and structure activities appropriately to student levels of understanding. A good diagnostic test is the concept map or word web (Novak, 1991). The teacher is advised to practice word webbing several times with students before using it as a diagnostic tool. But Novak has shown that the use of a concept map is helpful in diagnosing misconceptions, as well as, helping students conceptualize connections between established schema and new concepts or generalizations. A second assessment tool is the formative evaluation. The teacher makes these notes and observations during hands-on activities and discussions. Students should be given immediate feedback from the instructor as to concepts that are incorrect or faulty and helped to further understanding of a developing scheme. This feedback will in turn foster development of correct thinking and solid generalizations. Finally, a summative evaluation assesses the students' achievements after completion of a unit of study. This may take the form of a review session or class discussion and questioning session. Or the instructor may have students complete an experiment project, construction, drawing, experiment report or other work-related project. Tests can help a teacher discover the information the child has retained but the main basis for student evaluation and assessment in a discovery learning classroom should be a compilation of teacher-child contacts and happenings from class activities and discussions. "But the procedures and formulas must be treated as matters that make sense, and children must be involved in the task of making sense of them" (Resnick, 1983, p.478).

Educators must take charge of preparing students to function in an advancing, technological world. More and more educators, state and national agencies, professors, and scientists are coming to the realization that something must be done to help this country back to its 'first place' position. Many programs have been developed and tried in schools but, so far, none remains a major innovator for change in the science education of Americans. This researcher feels that the real change will come through educators themselves. Individuals must decide for themselves to make a difference in their students' lives and leave them better prepared for a new tomorrow. This proposed handbook will assist educators in selecting potential discovery strategies and techniques that can be used in science. This researcher has shown the advantages of using discovery learning strategies. Researches suggest that discovery approaches can be a major factor in developing cognitive skills, science process skills, scientific attitudes, and creating in students an interest and desire to study science (Carin, 1993, Gega, 1990, and Resnick, 1983). When students are challenged and interested in participating in the scientific and technological world, the educators of today can rest assured of a "job well done."

CHAPTER IV

GOALS AND OBJECTIVES

State educational offices and school districts are beginning to hear the cries of students yearning for better preparation, more actively involved instruction, and higher standards of achievement for American students. Discovery learning, inquiry learning, hands-on activities and other inductive methods of instruction are becoming increasingly popular with educators, scholars, researchers, and the general public. The proposed educational goals for science instruction in the State of Ohio reflect the necessity for these changes in current elementary science curriculum guides.

In order to incorporate these goals, this handbook will focus on the primary objectives outlined in the Valley View Board of Education Science Course of Study. These objectives will be addressed in light of the proposed educational goals and outcomes for the State of Ohio. This handbook will concentrate on the following five proposed state goals.

Goal 1: The Nature of Science and Technology.

Goal 2: The Physical Setting.

Goal 3: The Living Environment.

Goal 4: Societal Perspectives.

Goal 5: Thematic Ideas.

This handbook will present activities to further develop and refine students' critical thinking skills. It will also contain ideas for extending activities beyond the proposed lesson. Because of the nature of inductive teaching methods, some activities do not directly address objectives outlined in the course of study. Some lessons have been designed to acquaint students with critical thinking skills, decision-making, STS (Science/Technology/Society) issues, environmental concerns, and other objectives not directly reflected in the researcher's fifth grade course of study. However, in order to provide the most comprehensive experience possible and to preserve the continuity of the thematic unit, these activities have been included. Teachers adapting this handbook for their own use should evaluate each activity according to their own educational goals, objectives, and course of study.

HANDBOOK OF
DISCOVERY LEARNING SCIENCE

ACTIVITY LISTING

HOW TO USE THE HANDBOOK

This handbook has been designed as a replacement for the existing textbook. The textbook should be retained as a supplementary component of the science curriculum. The handbook should facilitate teachers in their efforts to teach the primary objectives as defined by the Valley View Board of Education, State of Ohio, 1989, course of study for the fifth grade science.

The activities presented come from a wide variety of sources. The activities are a springboard for lessons that more actively involve students in science. Teachers are encouraged to adapt and modify the lessons to meet their own needs. In this way, teachers and students will provide their own creativity and ownership while actively participating in science discoveries.

RECOMMENDED SEQUENCE

The recommended sequence of activities for this handbook utilizes the changing seasons. Since the units are based on outdoor activities and functions of our changing world, interactions between students and the environment occur in many of the activities. Wherever possible, the natural cycle of the seasons provide for excellent opportunities. Following this sequence will enable the teacher to provide for hands-on experiences.

A. Beginning of school year through mid-November : "The Forest"

B. Mid-November through January: "Animal Life Cycles"

C. January through Mid-March: "Weather"

D. Mid-March through end of school year: "Energy and Our Environment"

Teachers should allow for some activities to exceed their specified time limits. If students seem to enjoy the unit of study, encourage them to extend their discoveries and involvements. However, do not let an activity or unit of study overstay its welcome. It's better for students to feel they could have learned more than to feel bored with the assigned topic. Activities and units are structured such that one unit will provide a natural bridge to the next unit of study.

THE FOREST

ACTIVITY #1

WOODLAND TERRARIUM

OBJECTIVES: Identify the environment as everything that surrounds and affects a living thing.

Define the terms ecology and ecosystem.

Describe how living and nonliving things interact in an ecosystem.

Describe a community as all plants and animals that live and interact with each other in a place.

SCIENCE PROCESS SKILLS: classifying, observing, communicating

AVERAGE CLASS TIME: 1 - 2 class periods; learning center activity

MATERIALS: teacher-made woodland terrarium
student observation sheet

QUESTIONS: What does the terrarium look like?
What does it feel like?
What does it smell like?
What kinds of conditions are present in the terrarium?
Are there any organisms that look familiar to you?

PROCEDURE:
1: Introduce the students to this mini-ecosystem by brainstorming definitions for an ecosystem.

2: Gather and record verbal observations to help students formulate definitions for "observable traits".

3: Have students see how many objects they can name that are living and nonliving organisms.

4: Distribute the student observation sheet and model acceptable ways to make and record observations.

5: From the class list of living and nonliving organisms, have students pick one object to observe.

6: Have available trade books, science textbook, or other reference materials for informal research.

7: Continue terrarium observations throughout The Forest unit. Encourage students to help maintain terrarium and research any questions or interests they may develop.

EXTENDING ACTIVITIES: Teacher-made terrariums of other climates for comparisons and contrasts of different ecosystems.

Students may classify lists of living and nonliving organisms. Encourage students to work in cooperative groups. Reward creative, divergent thinking.

Terrariums may be introduced as a learning center activity. Introduction and instructions should be communicated to the students first. Be sure to include written instructions for students' review.

Students could help build the terrarium as an introduction to the unit. Directions for the construction of a woodland or other type of terrarium can be found in most libraries.

ACTIVITY #2

BEAUTIFUL BASICS

OBJECTIVES: Identify the life process that all living things carry out to stay alive.

Name three things needed by all living things to stay alive.

SCIENCE PROCESS SKILLS: classifying, comparing, analysis

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: chalkboard

QUESTIONS: What do people (pets, wildlife, all organisms) need to live?
How are pets and wildlife different? same?
Can we group any terms together?

PROCEDURE:
1: With the headings (people, pets, wildlife, and all organisms) on the chalkboard, generate ideas about essential items each group needs to live.

2: Determine if any terms describe the same thing and eliminate any repetitions. Use the term "arrangement" to mean food, water, shelter, and space available in a way that is suitable to the particular organism.

3: All headings should contain the same items. Students should notice a pattern between the needs of people and all organisms, pets, and wildlife. Each list should contain the following: food, water, shelter, space, arrangement, sunlight, soil, and air.

EXTENDING ACTIVITIES: Have students list at least four essential things both plants and animals need to survive.

Have students examine the lists they created during the exercise. Ask students to identify which items are needed by animals but not by plants.

Ask students to observe the terrarium again. Have each student give an example of each essential need represented in the terrarium.

Adapted from Project Wild, 1985, p. 29

ACTIVITY #3

PARTS OF A SEED

OBJECTIVES: Identify the parts of a seed.

Describe the function of each of a seed's parts.

Identify the two main types of seeds.

Draw the events in the formation of a seed and its germination.

SCIENCE PROCESS SKILLS: observing, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: bean seeds (one per student) - soaked in water overnight
corn seeds (one per student) - soaked in water overnight
newspaper to cover student desks
paper towels
hand lens
white paper for drawing seed parts

QUESTIONS: What do you notice about your seed?
How many different parts do you find?
How does the seed feel without its cover?
What will you see when you open your seeds?
Which part of the seed do you think will grow into a plant?
How are the two seeds alike? different?

PROCEDURE:

1: Distribute all materials to students.

2: Students respond to class discussion questions using their seeds for their observations.

3: Draw and label both seeds. Have students check drawings with other group members.

4: Conclude the lesson with a discussion or reading assignment about the parts of a seed.

ACTIVITY #4

PARTS OF A PLANT

OBJECTIVES: Describe the function of roots, stems, and leaves in the transport of materials needed by green plants to make food.

Identify the flower as the reproductive part of a flowering plant.

Describe the parts of a flower and the role of each in reproduction.

Draw the events in the formation of a seed and its germination.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating,

AVERAGE CLASS TIME: three forty-five minute class periods

MATERIALS: collection of plants with roots attached (dandelions, grass, radish, nasturtium, petunias)
newspaper
hand lens
white paper to record observations and drawings
celery (one stalk per student)
beakers or sturdy plastic cups
food coloring
water
ruler
knife

PROCEDURE:
1: Carefully remove plants from soil keeping roots intact.

2: Group students in fours or fives. Give each group several different plants to examine.

3: Identify the stem, leaves, roots, root hairs, and flowers of the plant specimen. Record the information.

4: Compare and classify the plants as to their root structure, flowers, stems, or leaves. Use many different categories.

5: Give each student a stalk of celery. Make a fresh cut on the bottom of the stalk.

6: Place the celery in colored water and observe the movement of water every couple of hours. Let the celery sit overnight in the colored water.

7: Break the celery in half and observe the colored water in the capillaries. Students should make inferences about how water moves through a plant.

8: Examine the parts of a flower. Be sure to use a simple flower such as a nasturtium or petunia.

9: Count the petals and make a cross-section drawing of the parts discovered. Compare drawings with others.

10: Provide reference materials so students may check their findings and label drawings. Conclude with discussion or reading assignment about pollination and fertilization.

EXTENDING ACTIVITIES: Teacher may grow two different common plants. Students are given reference materials and asked to identify the two plants. Students must prove their hypotheses.

Students may use a carnation instead of celery to help them identify function of stems and capillary action.

ACTIVITY #5

FOOD MAKING FACTORIES

OBJECTIVES: Identify the cell as the basic unit of living things.

List things needed by green plants to make food.

Describe the process of photosynthesis.

Draw the movement of materials in and out of a leaf during photosynthesis.

Describe the process of respiration.

Compare the processes of photosynthesis and respiration.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: 3 - 4 class periods

MATERIALS: large collection of various tree leaves
hand lens
student observation sheets
geranium or philodendron plant
petroleum jelly
aluminum foil
elodea or other water plant
water
test tube
wide-mouthed jar
wide-necked funnel
long wooden matches
graduated cylinders
plastic bags
pebbles
rubber bands
centimeter grid paper

QUESTIONS: How are leaves alike? different?
What does a plant need to make food?

How much water is given off by plants?
How much oxygen is given off by plants?
Do plants need carbon dioxide? oxygen?
Does the size of leaf or size of the plant effect the amount of water given off?

PROCEDURE:

1: Set up as a learning center activity the classification of tree leaves. Discover vein types, shapes, sizes, color variations, etc. Record classifications and infer the function of different leaf types.

2: Discuss with students the function of cells. Assign reading material to give background for photosynthesis and respiration.

3: Discover the location and function of stomata in a leaf. Using a geranium or philodendron plant and petroleum jelly, coat one leaf on the top, one leaf on the bottom, and mark one leaf as a control. Leave the plant in a sunny location for a few days. Examine the leaves and hypothesize what happened.

4: Discover that leaves need sunlight for photosynthesis. Using the plant from procedure 3, cover one leaf completely with aluminum foil. Have students infer what will happen. Leave the plant in a sunny location for a few days. Examine the leaf and hypothesize what happened.

5: Discover that leaves give off oxygen. Obtain an elodea or other water plant. Submerge a wide-mouthed jar under water. Add the plant. Cover the plant with the funnel.

6: Submerge the test tube under water. Cover the funnel with the test tube. Make sure there are no large air pockets in the test tube.

7: Remove the assembled equipment from the water and pour a little water from the jar. Set the experiment in a sunny location for a few days.

8: When the test tube is half full of air, remove from the sunny location. Light a long wooden match. Blow it out and quickly remove the test tube. Insert the glowing match into the test tube. In the presence of pure oxygen it will reignite.

9: Infer why the match relit.

10: Discover that leaves give off water. In a heavily foliaged area, have students select branches with several leaves.

11: Cover a leaf branch with a plastic bag. Place the pebble in the bag so any water will be collected in the bottom. Secure with a rubber band. Record the time.

12: Check the bags in several hours. If results are visible, pour the water into a graduated cylinder. Measure and record the amount. Record the time.

13: Average class results. Hypothesize why different results were obtained.

EXTENDING ACTIVITIES: Check a plant for the presence of starch.

Remove the chlorophyll from a leaf.

Obtain slides of a plant cell, leaf, stem, and root showing root hairs. Examine the slides under a microscope.

Adapted from How Nature Works, 1991, p. 41 and Our Wonderful World, 1987, p. 12.

ACTIVITY #6

TREE COOKIES

OBJECTIVES: Identify the parts of a tree.

Describe the function of the parts of a tree.

Draw and label the parts of a tree.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: tree cookies (cross section of a tree or branch), one per student
ruler and metric tape
hand lens
white paper for drawing

QUESTIONS: How can we identify the heartwood from the sapwood? the inner bark from the outer bark?
When does a tree have its most growth?
What factors might affect the growth rate of a tree?

PROCEDURE:
1: Group students in fours or fives. Students should share information and ideas with other group members.

2: Distribute all supplies to students. Use the cookies to answer questions generated during discussion.

3: Record results, questions, ideas, and inferences on paper.

4: Discuss or assign reading materials to assist students in correctly identifying parts of their cookies.

Adapted from Our Wonderful World, 1987, p. 16.

ACTIVITY #7

WEB OF LIFE

OBJECTIVES: Describe how living and nonliving things interact in an ecosystem.

Describe a community as all plants and animals that live and interact with each other in a place.

Identify populations of living things.

Identify the factors that affect the size of a population.

Define the terms predator and prey.

SCIENCE PROCESS SKILLS: classifying, observing, inferring, communicating

AVERAGE CLASS TIME: 1 - 2 forty-five minute class periods

MATERIALS: large paper to draw a class mural
lightweight cardboard
reference materials with pictures of forest animals
old magazines

QUESTIONS: Where does the animal live? Why?
What arrangement does it require?
What does it prey upon?
What plants and animals does it live with?
How does the animal influence its environment?
What did you discover about your animal that surprised you the most?
Is it an endangered species? Why is it endangered?

PROCEDURE:

1: Draw the background setting of a forest. Display the mural on a classroom wall or bulletin board.

2: Choose a forest animal to research. Generate questions to guide research. If duplicates occur, specify young, old, male, or female.

3: Draw and cut out a picture of the animal on the lightweight cardboard.

4: Report orally on the animal. After discussion, animal is placed on the mural in an appropriate habitat. Explain reasons for the placement.

5: Using different colored yarn, create a food chain by connecting all predators to their prey. Connect animals to their needs for habitat.

Adapted from Project Learning Tree, 1990, p. 106.

ACTIVITY #8

CREEPY CRAWLIES

OBJECTIVES: Describe how scientists classify animals.

Identify vertebrates and invertebrates as the two main groups of animals.

Describe characteristics of arthropods.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: live lobster
rhinoceros beetle
crayfish
clam or land snail

PROCEDURE:
1: Introduce the lesson by discussing the location of our skeleton and the temperature of our bodies.

2: Show the live lobster. Observe that the lobster has a skeleton on the outside of its body and it is cold to the touch.

3: Show the rhinoceros beetle or other large beetle. Compare and contrast the lobster and beetle. Write any similarities on the chalkboard.

4: Repeat the process with the crayfish. Formulate a statement of similarities of the three animals. Introduce students to the term "arthropod."

5: Show the clam or land snail and apply the statement to the animal. Conclude that the animal is not an arthropod.

6: Discuss other examples and non-examples of arthropods with students.

Adapted from Strategies For Teachers, 1988, p. 109.

ACTIVITY #9

CREEPY CRAWLIES IN YOUR CLASSROOM

OBJECTIVES: Describe the main characteristics of a reptile.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating

AVERAGE CLASS TIME: one class period; learning center activity

MATERIALS: student observation sheet
appropriate habitats for animals
natural sponge
planarian
earthworms
starfish
land snail
crayfish, spider, cricket, ants, or other forest insects
salamander or toad
box turtle or garter snake
mouse or rabbit

QUESTIONS: How are vertebrates and invertebrates alike? different?
What do all animals have alike? different?
How do animals contribute to the ecosystem of a forest?

GENERAL PROCEDURE:

1: Introduce students to learning center activities as a whole class.

2: Discuss questions and investigations for each animal.

3: Introduce one animal at a time. If animals are obtained from the wild, be sure to return them as close to their natural habitat as possible. Only keep wild animals for observation about one week.

PROCEDURE:

1: Gather in a circle on the floor. Present box turtle to students.

2: Observe actions of turtle and infer characteristics of turtle and reptiles. Record information on student observation sheet.

3: Develop questions and research information on box turtles from class reference library. Be sure to include several copies of trade books about the animal(s) you present to the students.

EXTENDING ACTIVITIES: Experiments and investigations of individual animals may be carried out. Students are given the opportunity to study each animal in depth as a group or whole class activity. Use an many different animals as possible to give students sufficient experiences.

Elementary Science Study (ESS) has teacher's guides and activity cards available for a small fee. The guides include units of study on earthworms, mealworms, brine shrimp, butterflies, tadpoles, and ants.

ACTIVITY #10

HABITAT COMPARISONS

OBJECTIVES: Describe the differences in habitats and the types of organisms they can support.

Appreciate the uniqueness of each habitat.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating

AVERAGE CLASS TIME: approximately one and a half hours

MATERIALS: thermometers
metric rulers
dull kitchen knives or spoons
string
popsicle sticks (four per student)
graph paper
pie tins
pH paper or soil test kit
area that includes a forest and a meadow habitat

PROCEDURE:

1: Distribute all supplies to students. Discuss the investigations to be performed. Assign areas to groups of two or four students.

2: Measure the surface temperature of habitat #1. Let the thermometer sit for three minutes before recording the temperature.

3: Dig a hole deep enough to hide the thermometer. Let it sit for three minutes and record the temperature.

4: Using the pH paper or soil test kit, measure and record the pH level of the surface soil and the soil from the bottom of the hole.

5: Measure a 20cm square and put the string around the perimeter. Separate grass, sticks, insects, roots, or other organic and inorganic material into pie tins.

6: Count and record the amount of material.

7: Discard items and dig down 5 cm, saving and separating all items collected.

8: Repeat this procedure for each 5 cm. Continue to a depth of 20 cm.

9: Repeat the above steps for habitat #2.

10: Return all earth to the area when investigation is complete.

11: Construct a graph comparing temperatures of the two habitats and a graph showing the amount of materials found at each level.

EXTENDING ACTIVITIES: Compare the graphs and habitats.

Repeat the procedures including one water habitat. Compare the results.

Adapted from Our Wonderful World, 1987, p. 15.

ACTIVITY #11

PREDATOR AND PREY

OBJECTIVES: Conclude that color is a camouflage technique used by some prey to escape their predators.

SCIENCE PROCESS SKILLS: observing, inferring

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: various colored pipe cleaners
stopwatch or watch with second hand

QUESTIONS: What color was brought back most frequently?
What color would you choose to be if you were the prey?
Why do you think there are few brightly colored animals in the forest?

PROCEDURE:

1: Mark off an area appropriate to the size of the group. Scatter pipe cleaners throughout area.

2: Explain to students they will have ten seconds to collect as many pipe cleaners as they can. When time is called, they must return to their group. Each member of the group will get the same amount of time to collect pipe cleaners.

3: Group students four or five to a team.

4: When all members have had a turn, chart pipe cleaners collected.

5: Discuss the survival rate of certain colored "worms."

Adapted from Our Wonderful World, 1987, p. 30.

ACTIVITY #12

BIRDS AND THEIR ADAPTATIONS

OBJECTIVES: Describe the main characteristics of birds.

Describe the functions of feathers.

Give examples of different types of nests.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: 2 - 3 forty-five minute class periods

MATERIALS: bird flight feathers
downy feathers
hand lens
pictures of birds including close-ups of their beaks and feet
construction paper
plastic drinking straws
various materials for constructing a feather
household tools and utensils including scissors, linoleum cutter, sieve, knives (serrated and plain), wooden spoons, nutcracker, salad tongs, tweezers, tea ball, medicine dropper, needle-nosed and standard pliers, hammer, ice pick or punch, chopsticks, and grater

QUESTIONS: Why are feathers special?
What purposes can feathers serve?
Can you make a feather?
How have birds adapted to eating?
How does a bird use its feet?
Where do birds live?
How are their homes adapted to their habitat?

PROCEDURE:

1: Give groups of four or five students a flight feather and a downy feather.

2: Starting with the flight feather, separate the filaments and locate the barbs. Hypothesize about the function of these parts.

3: Carefully smooth the filaments together. Observe and record what happened. Does this remind you of any man-made devices?

4: Compare the flight and downy feathers using the hand lens. Hypothesize why the downy feather is closer to the body and its function.

5: Outline the flight feather on construction paper. Measure the shaft of your flight feather.

6: Using any materials available, construct your own feather. Consider the characteristics of a real feather when evaluating materials.

7: Display the pictures of birds so students can observe the beak and feet types.

8: Show students an assortment of household items. Infer which items are most like which beak and feet types. Infer why birds have these adaptations.

9: Display several different types of nests or pictures of several different nest types.

10: Infer why a particular type of bird would build a particular nest type.

EXTENDING ACTIVITIES: Students examine and dismantle several different types of nests. Compare materials and infer why certain materials are present.

Students collect organic and inorganic material from around the schoolyard or home. Construct a bird nest using the material collected. Test your nest strength with clay eggs or marbles. Experiment with different types of materials and nest designs.

Adapted from Life Science Activities for Grades 2 - 8, 1986, p.126 - 130.

ACTIVITY #13

FOREST IN A JAR/ POND SUCCESSION

OBJECTIVES: Define the term succession.

Describe succession in a forest after a fire and natural succession in a pond community.

Identify the pioneer and climax stages of succession.

SCIENCE PROCESS SKILLS: observing, inferring, communicating

AVERAGE CLASS TIME: ongoing activity for several weeks, final activity 30 minutes

MATERIALS: large glass jar
- water
- soil
- elodea or other water plant
- bird seed
- student observation sheet
- grow light (if classroom does not have windows)
- large flower (sunflower, geranium, nasturtium)

QUESTIONS: How does a pond become a forest?
- How long does it take for succession to begin?
- What changes take place first?
- Do any animals live in two different habitats at the same time?
- What happens after a forest fire?
- Are all forest fires bad?

PROCEDURE:

1: Put two inches of soil and three inches of water in jar. Put the jar in a sunny location overnight. Do <u>not</u> put a lid on the jar.

2: Plant the elodea or water plant in the jar. Place the jar by a classroom window. If you do not have windows, use a grow light.

3: Let the water evaporate from the jar. Infer what will happen to the elodea.

4: Once or twice a week, place a few bird seeds in the jar. Infer what will happen to the bird seeds.

5: When the water has evaporated, plant a large flower to symbolize a tree growing. Keep soil moist by watering.

6: Discuss the succession of the "pond". Draw a representation of what happened in the jar. Compare the jar to the class woodland terrarium.

7: Label the stages of pond succession.

8: Assign reading material about pond succession and the stages of forest growth. Discuss the implications of forest fires.

EXTENDING ACTIVITIES: Share trade books and reference materials about pond succession with students.

Create a flipchart from an artist's sketch pad showing the stages of pond succession.

Adapted from Project Wild, 1986, p.91.

CULMINATING ACTIVITIES
FOR THE FOREST

SUGGESTIONS:

1: Create a wall chart of endangered animals. Prepare a report and poster about animal. Include habitat, why the animal is endangered, and any actions that have been taken to help the animal.

2: Conduct a field trip to a local park. Prepare activities for students or have students design their own experiments and investigations to conduct.

3: Conduct a field trip to a wildlife rehabilitation center. Arrange to have a wildlife veterinarian present a talk to students about efforts to return the animals to their natural habitat.

4: Locate an area close to the school needing beautification. Design a park and natural habitat for the area. Contact local businesses and citizens to help return the area to a natural state that can be enjoyed as a park.

ANIMAL LIFE CYCLES

ACTIVITY #14

IS IT WORMY?

OBJECTIVES: Identify and draw the stages in the life cycle of a mealworm.

Name the main groups of arthropods.

Compare the stages to the stages of development in humans.

SCIENCE PROCESS SKILLS: observing, inferring, communicating, experimenting

AVERAGE CLASS TIME: one class period; learning center activity

MATERIALS: mealworms
large shoebox
oatmeal, bran, or finely shredded paper
scraps of potatoes
student observation sheet

PROCEDURE:
1: Set up a location for mealworms. Use them to feed the salamander, turtle, or other reptiles/amphibians you may have in your classroom.

2: Observe and record the appearance of a mealworm. Include the larva, pupa, and adult beetle stages.

3: Infer how long it takes a mealworm to develop into a beetle.

4: Design experiments to find out if the mealworm has any preferences for light, temperature, sound, texture, or other sensory activity you would like to test.

EXTENDING ACTIVITY: Students may conduct comparisons between mealworms and earthworms. Are mealworms really worms? How do you know? What is alike (different) about them?

ACTIVITY #15

EATING TO STAY ALIVE

OBJECTIVES: Describe how animals with stinging cells use the stinging cells to capture food.

Describe the movement and food capturing behavior of a starfish.

Explain the function of various body parts of mollusks.

SCIENCE PROCESS SKILLS: classifying, observing, inferring, communicating, experimenting

AVERAGE CLASS TIME: 2 - 3 forty-five minute class periods

MATERIALS: pictures of a hydra, jellyfish, coral, and sea anemones
starfish
land snail or slug
wide mouth jar with damp soil
aluminum pie plate
sheet of black paper
small index card
hand lens
spoon
ruler
piece of lettuce
small container of water
student observation sheet

QUESTIONS: How does an animal use its stinging cells to capture food?
Does it use any tricks?
What does a starfish eat?
How does it open the shell?
How does a snail move?
Does it have any body parts?
What happens when you gently touch its body?
Will a snail go to a light area or a dark area first?
Will a snail go to a wet area or a dry area first?
How does a snail eat?

PROCEDURE:

1: Observe pictures of animals with stinging cells. Discuss the actions used by these animals to attract and capture their food. Infer the function of colors and habitats used by these animals.

2: Observe the body structure of a starfish. Observe pictures of a starfish in its natural habitat. Using a hand lens, observe the tubular feet and mouth on the underside of the starfish.

3: Infer how a starfish opens a clamshell to get the clam. Discuss the actions of a starfish's stomach. Assign reading material about the life cycle of a starfish.

4: Group students in fours or fives. Distribute the supplies to each group and one snail or slug per group.

5: Emphasize the careful handling required of these animals. Review their purpose and function on the food chain.

6: Investigate and observe to answer questions about the function of a snail. Have reference books, textbooks, and trade books available to help students label and identify the parts of a snail.

7: Record observations and discoveries from experiments. Draw and label a picture of the snail and its body parts. Discuss findings with the whole class.

Adapted from Science In Elementary Education, 1990, p. 483.

ACTIVITY #16

HOW DOES YOUR BLOOD RUN?

OBJECTIVES: Describe the characteristics of a cold-blooded animal.

Compare a warm-blooded animal to a cold-blooded animal.

SCIENCE PROCESS SKILLS: classifying, observing, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: box turtle
chalkboard
reference books on turtles
student observation sheet

PROCEDURE:
1: Students prepare for discussion by researching the characteristics, eating habits, habitat, and reproduction of box turtles.

2: Present box turtle to the class. Observe turtle and record data.

3: Discuss characteristics of a box turtle. List on chalkboard under heading of cold-blooded.

4: Compare humans with cold-blooded characteristics. List on chalkboard under heading of warm-blooded.

5: Conclude lesson by generating a list of similarities and differences.

ACTIVITY #17

SOMETHING FISHY

OBJECTIVES: List the main characteristics of fish.

Describe how fish get oxygen under water.

SCIENCE PROCESS SKILLS: observing, inferring, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: whole dead fish from market
knife
hand lens
reference books on fish
student observation sheet

PROCEDURE:
1: Students prepare for discussion by researching the characteristics, eating habits, habitat, and reproduction of fish.

2: Present the fish to the students. Lift the gill cover to observe the gill slit.

3: Dissect the fish and examine carefully the organs.

4: Record observations and discuss any questions.

5: Remove some scales from the fish's side for examination with a hand lens. Draw the fish scale. Show how to tell the age of the fish from the scale lines.

EXTENDING ACTIVITIES: If an aquarium is available, observe fish and how they breathe. Observe the functioning of gills and mouth together.

Wrap a live fish in soaked cotton. Place the fish's tail under a microscope and observe the flow of blood through the arteries, veins, and capillaries. Do not continue this experiment for more than fifteen minutes.

Adapted from Science for the Elementary School, 1993, p. 581.

ACTIVITY #18

HERPS IN OUR WORLD

OBJECTIVES: Describe the main characteristics of an amphibian.

Draw the main stages in the life cycle of a frog.

Describe the main characteristics of reptiles.

List the four main groups of reptiles.

Identify the largest group of reptiles.

SCIENCE PROCESS SKILLS: classifying, observing, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: pictures of amphibians and reptiles
live frog or salamander
live box turtle
index cards
reference books and trade books on amphibians and reptiles

QUESTIONS: What is a herp?
Why are reptiles and amphibians scary?
How does a reptile compare to an amphibian?
How do herps compare to a human?
Are herps really descended from the dinosaurs?

PROCEDURE:
1: Discuss feelings and reactions to amphibians and reptiles (herps). Observe live animals or pictures of common and unusual amphibians and reptiles.

2: Write one characteristic of an amphibian and one characteristic of a reptile on the index cards.

3: Place cards under the appropriate headings on the chalkboard, wall, or bulletin board.

4: Review list and eliminate duplicates. Add any missing information.

5: Review the life cycle of a mealworm. Discuss the life cycle of a tadpole.
Note any patterns, similarities, and differences.

6: Show a cross-section of man's internal organs and a cross-section of a lizard's internal organs. Compare organ types and locations.

7: Conclude lesson by discussing theories, speculations, myths, and folktales about herps.

EXTENDING ACTIVITIES: Obtain a sample of tadpole eggs and develop them into frogs. Observe the stages of the life cycle. Return the frogs to the wild after observation. Elementary Science Study (ESS) has a unit of study on tadpoles.

Compare and observe a box turtle and a salamander. If animals are wild, be sure to return them to their natural habitat.

Adapted from Art to Zoo, December 1992.

ACTIVITY #19

EGGS-ACTLY

OBJECTIVES: Draw and label the parts of an egg.

Describe the function of an egg.

SCIENCE PROCESS SKILLS: observing, inferring

AVERAGE CLASS TIME: two forty-five minute class period

MATERIALS: hard-boiled eggs (one for each pair of students)
raw eggs (one for each pair of students)
plastic containers
vinegar
paper towels
plastic knives
reference books or drawing of egg cross-section

PROCEDURE:
1: Discuss parts of an unfertilized egg. Show drawing of egg cross-section. Record questions.

2: Group students in pairs.

3: Distribute raw egg, plastic container, and vinegar to student pairs. Place raw egg carefully in container. Fill with vinegar so egg is submerged.

4: Set aside for next class period.

5: Distribute hard-boiled eggs, paper towels, and plastic knives to student pairs. Carefully peel the egg. Identify parts of egg.

6: Draw and label all parts identified. Cut egg in half. Identify, draw, and label all parts.

7: Discuss findings and compare drawings to reference materials.

8: Infer what will happen to raw egg.

9: After setting for 24 hours, remove egg from vinegar. Carefully remove any remaining shell.

10: Use cool water and a paper towel to wash and rinse the egg. Draw and label parts of the egg.

11: Discuss similarities and differences between the raw egg and the hard-boiled egg. Share discoveries and questions.

EXTENDING ACTIVITIES: Discuss the process of osmosis and transfer of materials from the raw egg to the vinegar. Place the egg in a container of water overnight. Check and discuss the results.

Obtain fertilized eggs and an incubator. Observe the life cycle of chickens by hatching eggs in the classroom. Contact someone who raises chickens. Arrange for a presentation on raising chickens. Donate hatched chicks to a farmer.

Adapted from Life Science Activities for Grades 2 - 8, 1986, p. 106.

ACTIVITY #20

WOLVES

OBJECTIVES: Describe the main characteristics of mammals.

Identify mammals as the most complex vertebrates.

Describe how mammals can be both helpful and harmful to people.

SCIENCE PROCESS SKILLS: classifying, observing, inferring, communicating

AVERAGE CLASS TIME: 1 - 2 thirty minute class periods

MATERIALS: pictures of wolves
reference books, trade books, magazines about wolves
information on endangered animals

QUESTIONS: How are wolves like humans?
What are some myths and superstitions about wolves?
Why are wolves scary?
How do wolves fit in the ecosystem?
Are they endangered? Is anything being done to help them?
How can I help?

PROCEDURE:
1: Prepare for class discussion by reading material about wolves. Record questions about wolves before discussion.

2: Present Native American legends and stories about the wolf. Discuss feelings and beliefs shared by these people about the importance of the wolf.

3: Research the pack life of wolves. Compare to the human society. List similarities and differences in eating habits, habitat, education of the young, protection, and pecking order.

4: Write to the National Wildlife Federation to receive information about re-introducing wolves to National Parks. Discuss the pros and cons of such an action.

5: Debate the issue in a class discussion. Prepare for the debate by researching information supporting your views.

National Wildlife Federation
1412 16th St., NW
Washington, DC 20036

CULMINATING ACTIVITIES
FOR ANIMAL LIFE CYCLES

SUGGESTIONS:

1: Pick an animal and research its role in myths and folktales. How is it portrayed? Does this help or hurt the animal? Why? Show pictures of the animal.

2: Watch cartoons or read comic books portraying animals. Record observations about animal. Is it wild or tame? What are the characteristics shown in the cartoon? Are these characteristics real? Has the cartoon image helped or hurt the animal? Design a comic animal character that helps an endangered animal.

3: Find at least one advertisement that makes use of the natural environment or a wild animal to sell its product. Examine and evaluate the advertisement. Does the image portray stereotypes about nature or wildlife? What is the advertiser's purpose? Does it help or hurt wildlife? Does the advertisement portray the image in a realistic way? Identify and describe any ways the advertisement might contribute to unwise or inappropriate actions. Adapted from Project Wild, 1986, p. 169.

4: Research national symbols that use wildlife. Collect pictures or drawings of symbols you have found. Why does the country use this particular animal? What feelings and images are portrayed by the animal? Has the animal become endangered because of its association with the national symbol?

WEATHER

ACTIVITY #21

WEATHER STATION

OBJECTIVES: Describe weather conditions that often accompany the movement of a warm front or a cold front into a region.

Identify cumulus, cirrus, and stratus clouds.

Describe weather conditions that are associated with cumulus, cirrus, and stratus clouds.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period; learning center activity

MATERIALS: poster or bulletin board for recording information
2-liter pop bottle
knife
ruler
1 square foot corrugated cardboard
empty thread spool
plastic drinking straw
construction paper
pencil with eraser
glue
plastic bead
straight pin
two thermometers
small container of water
thread
cotton tube
empty waxed drink carton
Ping-Pong ball
12" monofilament nylon line
protractor
bubble level
red marker
long sewing needle

tongue depressor
glass milk bottle
large balloon
rubber band
wooden matchstick
rubber cement
index card mounted to block of wood
student instruction sheets

QUESTIONS: How much rain do we get in one week?
How might rainfall amounts affect our community?
What does it mean when the wind is blowing in a particular direction?
What is a hygrometer?
Why does it feel hotter or colder than the temperature sometimes?
What is an anemometer?
Does the speed of the wind indicate any weather changes?
What is a barometer?
What does air pressure have to do with weather?

PROCEDURE:

1: Group students in fours or fives. Assign each group to a different weather instrument.

2: Distribute student instruction sheets. Place all materials in a convenient location.

3: Upon completion of weather instruments, assemble outdoors and demonstrate the proper use of all instruments.

4: Practice making readings until comfortable with use of equipment.

5: Take weather readings three times a day for one week. Record observations on poster or bulletin board.

6: Infer which weather conditions precede others. Observe cloud types each day. Infer weather conditions that are associated with certain cloud types.

ACTIVITY #22

UNEVEN HEATING EFFECTS

OBJECTIVES: Conclude that the earth's atmosphere is heated unevenly because the earth's surface is heated unevenly.

Identify three causes of the uneven heating of the earth's surface.

SCIENCE PROCESS SKILLS: observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: one fifteen minute set-up session; thirty minute class period

MATERIALS: two shoeboxes
soil
thermometers
four clear plastic cups
water
dark sand
white sand

QUESTIONS: Why is it hotter at the equator than in the Midwestern United States?
Does color make a difference in temperature?
Does water or soil heat faster? Which cools faster?

PROCEDURE:
1: Set up three different experiments. Group students in three groups. Each group is responsible for a different experiment.

2: Experiment #1. Fill shoeboxes with soil. Insert a thermometer in each box. Make sure they are submerged the same distance. Record the starting temperature on each.

3: Set the shoeboxes in a sunny window. Lie one box flat. Place books or a piece of wood under one side of the other box so it is tilted into the sun.

4: Leave the boxes for one hour.

5: Record and compare the temperatures of the shoeboxes. Discuss why the tilted box is warmer than the box that laid flat.

6: Experiment #2. Fill one plastic cup with dark sand and one plastic cup with white sand. Place both cups in a sunny window for one hour.

7: Record and compare the temperature of the dark sand and the white sand. Discuss how color affects heat attraction.

8: Experiment #3. Fill one plastic cup with room temperature water and one plastic cup with soil. Record the starting temperature of each cup's contents.

9: Place both cups in a sunny window for one hour.

10: Record and compare the temperature of the water and soil cups. Discuss which heated faster and why.

11: Let cups cool for fifteen minutes and record temperatures again. Discuss which cup lost heat faster. Observe and record the amount of time elapsed before the temperature returns to the starting temperature. Compare results.

ACTIVITY #23

WINDS

OBJECTIVES: Identify the cause of winds.

Compare the movement of air in sea breezes and land breezes.

Identify the factors that cause global winds.

Define an air mass as a large body of air that has about the same temperature and moisture throughout.

SCIENCE PROCESS SKILLS: observing, inferring, communicating, experimenting

AVERAGE CLASS TIME: 1 - 2 forty-five minute class periods

MATERIALS: large glass aquarium
large sheet of cardboard (must cover aquarium)
two glass chimneys from oil lamps
candle
matches
thick, tight roll of paper towels
small piece of dry ice
thick gloves for handling dry ice
globe

PROCEDURE:
1: Cut holes in opposite sides of the cardboard for glass chimneys. Place the candle in the aquarium.

2: Position the candle under one glass chimney.

3: Light the candle. Light the paper towel wad so that it produces smoke.

4: Put the smoking material in the chimney without the candle underneath. Observe what happens to the smoke.

5: Discuss the flow of air in the aquarium. Infer that temperature of air causes winds.

6: Review the results of heating soil and water. Infer how land breezes and sea breezes occur.

7: Present dry ice to class. Observe the movement of mist. Feel the temperature of the mist. Discuss reasons for air movement. Infer how temperature of air affects direction of flow. (Exercise *extreme caution* when handling dry ice. It will cause severe frostbite if handled without protection.)

8: Discuss the movement of air around the globe. Infer how air masses develop and move around the world.

Adapted from Science for the Elementary School, 1993, p. 407.

ACTIVITY #24

THE METEOROLOGIST AND OUR WEATHER

OBJECTIVES: Define the term front.

Compare the movement of air masses at a cold front with the movement of air masses at a warm front.

SCIENCE PROCESS SKILLS: observing, inferring, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: meteorologist from local news station
newspaper weather maps
outline of United States

PROCEDURE:
1: Assign reading material or textbook selection to prepare students for visit.

2: Prepare questions about weather, forecasting, careers, or other related topics.

3: Follow up visit by collecting several days worth of newspaper weather maps. Create your own weather symbol dictionary.

4: Use an outline of the United States to transfer written weather forecast into symbols.

ACTIVITY #25

NORTH AMERICAN AIR MASSES

OBJECTIVES: Define an air mass as a large body of air that has about the same temperature and moisture throughout.

Identify the four basic kinds of air masses and the type of region over which they form.

SCIENCE PROCESS SKILLS: classifying, observing

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: map of United States
reference books and science textbook

PROCEDURE:
1: Discuss the air masses present over the United States.

2: On the map, draw in the location, temperature, and movement of air masses that affect the weather over the United States. Note whether the air mass is present year-round or seasonal.

ACTIVITY #26

CLOUD IN A BOTTLE

OBJECTIVES: Describe how a cloud forms.

Identify cumulus, cirrus, and stratus clouds.

SCIENCE PROCESS SKILLS: classifying, observing, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: two clear glass baby bottles
hot and cold water
ice
matches
cotton balls
blue construction paper

QUESTIONS: What do you see happening in each bottle?
Why do you think clouds or fog formed in the bottle with hot water and not in the bottle with cold water?
How do clouds and fog form in nature?

PROCEDURE:
1: Fill one bottle with approximately 2 cm of cold water. Fill the other bottle with an equal amount of hot water.

2: Light a match and drop it in the cold water bottle. Immediately cover the bottle with ice.

3: Repeat the procedure with the hot water bottle. Observe the results.

4: Discuss the difference in the bottles and why one bottle forms a cloud and the other does not.

5: Distribute construction paper and cotton balls.

6: Create cloud pictures using the cotton balls. Try to show the difference in shape and appearance of the different types of clouds.

ACTIVITY #27

THE WATER CYCLE

OBJECTIVES: Draw the movement of water in the water cycle.

SCIENCE PROCESS SKILLS: observing

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: large glass jar
ice cubes
hot water
aluminum pie pan
flashlight

PROCEDURE:
1: Fill the jar halfway with very hot water. Place the ice cubes in the aluminum pie plate.

2: Place the pie plate over the mouth of the jar.

3: Dim the lights and direct the flashlight beam on the jar.

4: Observe what happens in the jar. Share your ideas.

5: Record the results of the experiment.

Adapted from Thematic Units, 1993, p. 157.

CULMINATING ACTIVITIES
FOR WEATHER

SUGGESTIONS:

1: Research ways scientists are experimenting with artificial weather. Report on the success or difficulties with creating your own weather.

2: Compare the climates in the United States. Research the effects of global warming on the United States. Design a pamphlet informing the public about global warming and how we can prepare, prevent, or protect ourselves.

3: Design an experiment to test for air or water pollution. Is the pollution helped or hurt by the weather? How do you know?

4: Report on unusual or destructive weather in the area. How common is it? How can we prepare or prevent it?

ENERGY AND OUR ENVIRONMENT

ACTIVITY #28

WHAT IS ENERGY?

OBJECTIVES: Identify common forms of energy.

Give examples of ways energy can change form from one form to another.

SCIENCE PROCESS SKILLS: classifying, observing, inferring, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: chalkboard

PROCEDURE:
1: Write on the chalkboard the following statements.
Energy is food. Energy is clothing.
Energy is shelter. Energy is heat.
Energy is transportation.

2: Discuss the muscle energy needed to grow your own food. Assume that all tasks are carried out by hand. Infer the amount of produce obtained if a garden were completely cared for by hand. Conclude the amount of energy required by food.

3: Repeat the discussion in the same manner using clothing and shelter.

4: Relate the winter experiences of pioneers and early settlers. Conclude that energy is heat.

5: Discuss transportation by muscle power. Conclude that energy is transportation. Summarize the discussion by naming the five major energy sources (coal, oil, gas, hydroelectric, nuclear).

Adapted from Teaching Science to Children: An Integrated Approach, 1991, p.281 - 283.

ACTIVITY #29

TOTAL ENERGY USE

OBJECTIVES: Identify three fossil fuels and some ways in which they are used.

Identify problems with the use of fossil fuels.

Compare nuclear fuel with fossil fuels in terms of the amount of energy each produces.

Identify some problems in obtaining energy from moving water.

SCIENCE PROCESS SKILLS: classifying, inferring, communicating, experimenting

AVERAGE CLASS TIME: one one-hour class period

MATERIALS: chalkboard
graphs or charts showing U.S. energy consumption

QUESTIONS: How much energy do we get from each energy source?
How much energy do we need to generate electricity?
Where is energy used?

PROCEDURE:
1: List the five major energy sources. Rank them in order of their use.

2: Rank the sources again in order of their use to produce electricity.

3: List the four groups of energy use (industry, commercial, home including the family car, and transportation). Rank the four groups as to how much energy each uses.

4: Discuss rankings and actual information. Infer that the greatest amount of energy comes from petroleum. Hypothesize what happens when we run out of petroleum.

5: Infer that coal is used most to produce electricity. Hypothesize what happens when we run out of coal.

6: Infer that the home and the family car uses the most energy. Design a plan to calculate how much energy your family uses. Experiment with ways you and your family can conserve energy consumption. Test out your ideas at home and record the results. Share your findings.

EXTENDING ACTIVITY: Read your gas and electrical meter. Report to the class the readings. Count the electrical appliances in your home. Research to find out how much electricity each uses. Can you help your family cut down on their energy consumption? Devise a plan for conserving energy. Include a way to measure the energy you conserved. Test your plan for a specific time period.

Adapted from Teaching Science to Children: An Integrated Approach, 1991, p. 286.

ACTIVITY #30

BUILD A GENERATOR AND TURBINE

OBJECTIVES: Describe the steps in the production of electricity from burning fossil fuel.

Describe the steps in the production of electricity in a nuclear power plant.

Describe two ways in which solar energy is used to produce electrical energy.

Describe two ways in which the energy of moving water can be used to generate electricity.

Define the term geothermal energy as energy from natural heat trapped beneath the earth's surface.

Describe how geothermal energy can be used to generate electricity.

Identify some problems in the use of geothermal energy.

Describe how energy from the wind can be used to generate electricity.

SCIENCE PROCESS SKILLS: observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: 1 - 2 forty-five class periods

MATERIALS: round top from a metal can
- hammer and nail
- tin snips
- pliers
- large knitting needle with flat head
- rubber tubing
- water from faucet
- glass flask
- hot plate
- one-hole rubber stopper
- plastic tubing bent at right angle

insulated copper wire
voltmeter
bar magnet
cross-section drawing of a generator

NOTE: The students will be able to understand the workings of a generator and turbine after this simple demonstration. The principles of operation for a turbine-driven generator remain the same regardless of the energy source used to create heat. Therefore, teachers are able to explain many different energy sources used to produce electricity with this one demonstration.

PROCEDURE:

1: Assemble equipment prior to demonstration. Assign reading material to prepare students for demonstration and class discussion.

2: Use a pencil to divide can top into eight equal sections. Use tin snips to cut each section. Leave about 1/2 inch from the center uncut.

3: Punch a hole in the center with the hammer and nail. Make hole big enough to fit the circumference of the knitting needle.

4: Twist each section with pliers to form a right angle. Insert knitting needle into hole. Hold by pointed end of knitting needle.

5: Attach the rubber hose to a faucet. Turn on the water and direct the spray on the paddles. Observe turbine action.

6: Record any questions and discuss turbine action in a generator.

7: Fill the flask with water. Place stopper and rubber tubing securely in flask. Place on hot plate until water begins to boil rapidly.

8: Direct the steam toward the turbine. Observe turbine action.

9: Record any questions and discuss similarities and differences between water turbine and steam turbine. Infer how hydroelectric, geothermal, and wind generators operate.

10: Infer the amount of energy required to operate both turbines.

11: Coil the wire about fifty times. Tape into a circle. Strip insulation from ends of wire.

12: Attach ends to a voltmeter and set on lowest setting. Pass a bar magnet quickly through the wire coil. Observe the reaction on the voltmeter.

13: Move the wire coil quickly over the wire coil. Observe the reaction on the voltmeter. Record and discuss any differences.

14: Discuss the parts of a generator. Observe cross-section drawing. Infer the operation of the generator from demonstrations of a turbine and generator. Define mechanical energy and electrical energy.

15: Discuss fuel needed to start generator.

Adapted from Science for the Elementary School, 1993, p. 403.

ACTIVITY #31

HOW DO YOU VIEW NUKES?

OBJECTIVES: Describe two ways in which energy is released from the nuclei of atoms.

Describe the steps in the production of electricity in a nuclear power plant.

Compare nuclear fuel with fossil fuels in terms of the amount of energy each produces.

SCIENCE PROCESS SKILLS: observing, inferring, communicating

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: student surveys

PROCEDURE:
1: Distribute survey. Answer questions to the best of your ability.

2: Discuss results of survey. Research scientists feelings about nuclear energy. Survey other adults to learn their views about nuclear energy.

3: Infer the advantages and disadvantages of nuclear energy. Research how nuclear energy may harm the environment.

EXTENDING ACTIVITIES: Debate the issues of nuclear energy. Research your point of view and support your feelings with available evidence.

Arrange for a scientist to visit the class and discuss the advantages, disadvantages, and newest discoveries in nuclear energy. Prepare questions for class discussion.

Prepare a pamphlet supporting your views on nuclear energy. Be sure to include facts, sources, and colorful illustrations. Present your pamphlet to the class.

Adapted from Teaching Science to Children: An Integrated Approach, 1991, p.288 - 289.

ACTIVITY #32

SOLAR APPLES

OBJECTIVES: Describe the greenhouse effect.

Describe two ways in which solar energy is used to produce electrical energy.

Identify problems in the use of solar energy.

SCIENCE PROCESS SKILLS: observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period; several hours in the sun

MATERIALS: 2 Styrofoam or unwaxed paper cups per student
white paper
aluminum foil
black paper
plastic bags
newspaper
sturdy box
apples
knife

PROCEDURE:
1: Divide the class into two groups. Distribute all materials except aluminum foil and knife to all students.

2: Give one group the aluminum foil.

3: Line the inside of one paper cup with black paper. Be sure to line the bottom too.

4: Place a slice of apple in the cup. Cover the entire cup tightly with a plastic bag.

5: Make a large cone with the white paper. Place the apple cup in the narrow base of the cone. Securely tape the cone.

6: The group with aluminum foil will line their cone with aluminum foil. The other group will leave their cone with white paper.

7: Cover the bottom of the cone and cup with another cup to secure it.

8: Place cones in a sturdy box. Crumple newspaper around cones to secure them.

9: Take assembled equipment outside to a sunny location that will not be disturbed for several hours. Position the cones for maximum sun exposure.

10: Return equipment to classroom after several hours. Eat your baked apple. Observe which baker worked best. Infer why one apple baked better than another. Discuss the problems with relying on solar energy.

EXTENDING ACTIVITIES: Design a solar hot dog baker. Test your design and share the results with the class. Can you think of other foods we cook in the sun?

Experiment with other methods of cooking apples or other foods. Test your design. Share the results with the class.

ACTIVITY #33

COLORED PAPER MELT

OBJECTIVES: Conclude that sunlight is changed to heat when it is absorbed by some kind of matter.

Conclude that light-colored surfaces do not absorb as much sunlight as dark-colored surfaces do.

Identify heat as a form of energy.

SCIENCE PROCESS SKILLS: observing, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: white, black, green, red, and blue construction paper (one sheet per student)
ice cubes
ziplock plastic bags
graduated cylinders

PROCEDURE:
1: Distribute all materials. Choose uniform size ice cubes. Place one ice cube in each bag.

2: Place paper with ice cube bag in a sunny location. Each color paper should receive the same amount of sunlight.

3: After 20 minutes, return to location and collect bags. Pour water into graduated cylinders.

4: Measure and record the amount of water collected from each color.

5: Record your results. Graph results and infer which color best absorbs the heat energy.

ACTIVITY #34

PINWHEELS

OBJECTIVES: Describe how energy from the wind can be used to generate electricity.

SCIENCE PROCESS SKILLS: observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: one forty-five minute class period

MATERIALS: six-inch construction paper squares
straight pin
plastic drinking straw

PROCEDURE:
1: Distribute all materials to students. Make a 3-inch cut at each corner of the square.

2: Bend each corner into the center. Overlap the corners.

3: Secure by pushing the pin through the center of the square. Secure the square to the straw.

4: Test the pinwheel by gently blowing at a right angle to the edge.

5: Assemble in pairs outdoors. Investigate different locations, directions, and heights. Record all observations.

6: Discuss findings on wind energy. Infer the best location for a windmill. Hypothesize about problems with a windmill.

ACTIVITY #35

BIOMASS/BIOCONVERSION

OBJECTIVES: Define the terms biomass and bioconversion.

Describe three ways in which living things or once-living things can be used to produce energy.

SCIENCE PROCESS SKILLS: observing, inferring, communicating

AVERAGE CLASS TIME: one thirty minute class period

MATERIALS: reference books and trade books on alternate energy

PROCEDURE:
1: Assign reading materials to prepare students for class discussion.

2: Discuss biomass and bioconversion as a possible solution to landfills.

3: Infer advantages and disadvantages.

4: Arrange for a visit from a sanitary engineer. Prepare questions about the feasibility of biomass and/or bioconversion for your community.

ACTIVITY #36

SAVING OUR ENVIRONMENT

OBJECTIVES: Appreciate the natural environment.

Identify problems of environment.

SCIENCE PROCESS SKILLS: classifying, observing, measuring, inferring, communicating, experimenting

AVERAGE CLASS TIME: 3 - 4 forty-five minute class periods

MATERIALS: Paper Making
5 feet of clean toilet paper per each student
2 pieces of wire window screen, 4-inch square
bowl
warm water
bucket
newspaper
large spoon
Oil Spills
dish of colored water (one per group)
spoon
vegetable oil
string
popped popcorn or packing peanuts
liquid dish detergent
cotton balls

PROCEDURE:
1: Group students in pairs. Distribute materials for paper-making to students.

2: Shred the toilet paper into the bowl. Pour two cups of warm water over the shredded paper.

3: Stir vigorously until paper resembles a thick "soup".

4: Pour "soup" onto one screen. Catch the water in the bucket. Place the screen on newspaper.

5: Place other screen over screen with "soup". Cover with newspaper. Squeeze out as much water as possible.

6: Leave on a windowsill until dry.

7: Group students in fours or fives. Distribute oil spill materials to groups.

8: Add one spoonful of oil to colored water. Your task is to use the other materials to clean up the oil.

9: Observe the difficulties in removing all the oil. Evaluate your success. Infer which methods would not be possible to use on an ocean oil spill.

10: Discuss findings with class.

11: Collect all packaging material from your family's garbage for one week.

12: Discuss the amount collected by your class. Infer how companies and citizens might eliminate some excessive packaging.

EXTENDING ACTIVITIES: Write to a local packaging company about your concerns for the environment. Ask for information about any environmental policies in effect. Share your findings.

Construct your own compost column. How long does it take for materials to decay? How might you use your compost? Research other ways to recycle or reuse household waste products. Share your results. Information on compost columns available from Bottle Biology Resources Network; 1630 Linden Dr., Madison WI 53706.

CULMINATING ACTIVITIES
FOR ENERGY AND OUR ENVIRONMENT

SUGGESTIONS:

1: Design your own energy machine. Demonstrate how it works, what kind of energy it uses, and how it will help the environment.

2: Make a sculpture from garbage. Focus on the aesthetic qualities of recycling and reusing materials. Find a prominent place to display your sculpture.

3: Conduct a debate about landfills. Invite community speakers to listen and evaluate the issues. Design a brochure for distribution in the community announcing your debate. Include research, facts, and interesting information to support your views.

4: Design a board game about building a new power plant. Include the different available energy resources available to the construction site. Include rewards and consequences for environmental or wasteful decisions. Play your game with the class.

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CHAPTER V

RECOMMENDATIONS

The purpose of this handbook has been to provide for teachers a compilation of discovery learning lessons that address the adopted science course of study. These discovery methods are necessary for creating student interest, fostering creativity, addressing current technology and societal issues, and providing experience in problem-solving skills. The National Science Teacher's Association has issued recommendations for educators to incorporate more activities utilizing the science process skills. However, most instructors feel uncomfortable or unprepared to follow these directives. This handbook should provide a starting place for teachers to experiment and grow. It is hoped that these activities will be added to and adapted to accommodate other's ideas and creativity.

This researcher wishes to provide other recommendations for the next step. One idea is to ask educators to supply other hands-on science activity guides or handbooks. These books would help teachers design other activities to accommodate their curriculum guides. Teachers at other grade levels with different objectives and units of study would feel better prepared to design their own handbook of activities and share the wealth of ideas and creativity.

Another idea is to implement the handbook while keeping anecdotal journal entries for the first year. The teacher would date each activity and jot a quick note recording procedures, frustrations, amendments, and successes. Included in such a journal would be comments and projects from students participating in the program. After keeping the journal, the teacher could easily evaluate the success or failure of the program. The journal should help the teacher decide which activities need to be amended or reworked to better facilitate student understanding.

Finally, the handbook could be distributed to several teachers for implementation and evaluation in their classrooms. After a trial period, teachers would be assessed as to their attitudes, suggestions, frustrations, and successes with the program. The handbook could be supplemented with a compilation of suggestions and further activities to foster student development.

APPENDIX A

SCIENCE COURSE OF STUDY OBJECTIVES
GRADE FIVE

MAJOR CONCEPT	SUBJECT OBJECTIVES The student will . . .
Plants	1. Identify the cell as the basic unit of living things. 2. Identify the life process that all living things carry out to stay alive. 3. Name three things needed by all living things to stay alive. 4. List things needed by green plants to make food. 5. Describe the function of roots, stems and leaves in the transport of materials needed by green plants to make food. 6. Describe the process of photosynthesis. 7. Draw the movement of materials in and out of a leaf during photo-synthesis. 8. Describe the process of respiration. 9. Compare the processes of respiration and photosynthesis. 10. Identify the flower as the reproductive part of a flowering plant. 11. Describe the part of a flower and the role of each in reproduction. 12. Draw the events in the formation of a seed and its germination.
Living Communities	1. Identify the environment as everything that surrounds and affects a living thing. 2. Define the terms ecology and ecosystem.

<u>Living Communities</u>	3.	Describe how living and nonliving things interact in an ecosystem.
	4.	Describe a community as all plants and animals that live and interact with each other in a place.
	5.	Identify populations of living things.
	6.	Identify the factors that affect the size of a population.
	7.	Define the terms predator and prey.
	8.	Describe the term succession.
	9.	Describe succession in a forest after a fire and natural succession in a pond community.
	10.	Identify the pioneer and climax stages of succession.

<u>Animals Without A Backbone</u>	1.	Describe how scientists classify animals.
	2.	Identify vertebrates and invertebrates as the two main groups of animals.
	3.	Identify a sponge as an invertebrate with many cells.
	4.	Describe the structure of a sponge.
	5.	Identify animals that have stinging cells.
	6.	Describe how animals with stinging cells use the stinging cells to capture food.
	7.	List the three main groups of worms.
	8.	Describe how a planarian regenerates.
	9.	Compare the body structure of flatworms, roundworms, and segmented worms.
	10.	Identify an echinoderm based on body structure.
	11.	Describe the movement and food capturing behavior of a starfish.
	12.	Describe the appearance of different types of mollusks.

Animals Without A Backkbone	13.	Explain the function of various body parts of mollusks.
	14.	Name the main groups of arthropods
	15.	Describe characteristics of arthropods.
	16.	Classify different types of arthropods based on body structure.

Animals With A Backbone	1.	List the main characteristics of fish.
	2.	Describe the characteristics of a cold-blooded animal.
	3.	Describe how fish get oxygen under water.
	4.	Describe the main characteristics of an amphibian.
	5.	Draw the main stages in the life cycle of a frog.
	6.	Describe the main characteristics of reptiles.
	7.	List the four main groups of reptiles.
	8.	Identify the largest group of reptiles.
	9.	Describe the main characteristics of birds.
	10.	Compare a warm-blooded animal to a cold-blooded animal.
	11.	Describe the functions of feathers.
	12.	Give examples of different types of nests.
	13.	Describe the main characteristics of mammals.
	14.	Identify mammals as the most complex vertebrates.
	15.	Describe how mammals can be both helpful and harmful to people.

Sources of Energy	1.	Identify three fossil fuels and some ways in which they are used.

Sources of Energy

2. Describe the steps in the production of electricity from burning fossil fuels.
3. Identify problems with the use of fossil fuels.
4. Describe two ways in which energy is released from the nuclei of atoms.
5. Describe the steps in the production of electricity in a nuclear power plant.
6. Compare nuclear fuel with fossil fuels in terms of the amount of energy each produces.
7. Describe the greenhouse effect.
8. Describe two ways in which solar energy is used to produce electrical energy.
9. Identify problems in the use of solar energy.
10. Describe two ways in which the energy of moving water can be used to generate electricity.
11. Identify some problems in obtaining energy from moving water.
12. Define the term geothermal energy as energy from natural heat trapped beneath the earth's surface.
13. Describe how geothermal energy can be used to generate electricity.
14. Identify some problems in the use of geothermal energy.
15. Describe how energy from the wind can be used to generate electricity.
16. Define the term biomass and bioconversion.
17. Describe three ways in which living things or once-living things can be used to produce energy.

<u>Weather</u>	1.	Conclude that the earth's atmosphere is heated unevenly because the earth's surface is heated unevenly.
	2.	Identify three causes of the uneven heating of the earth's surface.
	3.	Identify the cause of winds.
	4.	Compare the movement of air in sea breezes and land breezes.
	5.	Identify the factors that cause global winds.
	6.	Define an air mass as a large body of air that has about the same temperature and moisture throughout.
	7.	Identify the four basic kinds of air masses and the type of region over which they form.
	8.	Define the term front.
	9.	Compare the movement of air masses at a cold front with the movement of air masses at a warm front.
	10.	Describe weather conditions that often accompany the movement of a warm front or a cold front into a region.
	11.	Identify cumulus, cirrus, and stratus clouds.
	12.	Describe weather conditions that are associated with cumulus, cirrus, and stratus clouds.

APPENDIX B

Science Materials Kit

Organizing science materials into their respective units of study is optional. The idea of kits is to have all the materials needed for a unit readily available before the activities start. This should cut down on preparation time and teacher frustration for implementing hands-on science learning. How each teacher organizes and collects the materials will vary, but the following suggestions will provide a starting point.

Use large labeled cardboard boxes to store kits. The under-the-bed kind work well. Copier paper boxes are another suggestion.

Ask for volunteers to bring in as many materials as possible.

Review materials list before starting lessons for those items that are perishable. Other items may need to be restocked.

Make an allowance in the science or classroom budget for any kit items that need to be purchased.

Recommended Kit Organization

THE FOREST

dry northern beans and corn
potted plants
collection of tree leaves
petroleum jelly
wide-necked funnel
pebbles
tree cookies
insect and animal containers
natural sponge
starfish
pH paper or soil test kit
colored pipe cleaners
assorted bird feathers - flight and downy
assorted bird nests

bird seed
grow light

ANIMAL LIFE CYCLES

large mealworm container
oatmeal or bran
vinegar

WEATHER

2-liter pop bottle
corrugated cardboard
empty thread spools
plastic beads
thread
cotton tube to cover thermometer bulb
empty waxed drink cartons
Ping-Pong balls
monofilament nylon line
bubble level
long sewing needles
large balloon
glass milk bottle
shoeboxes
dark and light sand
two oil lamp glass chimneys
candle
flashlight

ENERGY AND OUR ENVIRONMENT

round top from a metal can
large knitting needle with a flat top
rubber tubing
one-hole rubber stopper
plastic tubing bent at a right angle
insulated copper wire
voltmeter
bar magnet
sturdy box
toilet paper
4-inch squares of wire window screen

plastic bowls
dishpans or large tubs
vegetable oil
packing peanuts
liquid dish detergent

Recommended Classroom Supply Kit

MISCELLANEOUS SUPPLIES

2 - 3 aquariums
newspapers
paper towels
hand lens
clear plastic cups and Styrofoam cups
test tubes
beakers and flasks
baby food jars
glass baby bottles
food coloring
plastic utensils or old metal utensils
knife
aluminum foil
jars - assorted sizes
wooden matches
graduated cylinders
plastic ziplock bags
rulers and metric tapes
thermometers
string
popsicle sticks
aluminum pie tins
plastic drinking straws
microscope and slides
straight pins
hot plate
potting soil
cotton balls
bucket

APPENDIX C

STUDENT OBSERVATION SHEET

NAME____________________________________

DATE____________________________________

Today I looked at:

This is a picture of what I saw.

These are the things I noticed:

Here are my questions and what I would like to share:

APPENDIX D

Make a Weather Station

Rain Gauge

An instrument that measures the amount of precipitation that falls is called a rain gauge.

What will we need?

- 2-liter pop bottle
- scissors
- black marker

How will we construct our rain gauge?

1. Remove the labels from the 2-liter bottle.

2. Cut the top off the 2-liter bottle above the mark left from the label. If you have difficulty, ask your teacher to start a cut for you.

3. Invert the top of the bottle inside the bottom. Mark lines one inch apart on the side of the bottle with the black marker.

4. Put the rain gauge in the weather station.

Make a Weather Station

Wind Vane

A wind vane is an instrument that shows the direction from which the wind is blowing. Winds are named for the direction from which they blow. For example, a north wind is blowing from the north to the south.

What will we need?

- 1 square foot corrugated cardboard
- empty thread spool
- plastic drinking straw
- construction paper
- pencil with eraser
- glue
- scissors
- plastic bead
- red marker
- straight pin

How will we construct our wind vane?

1. Cut from construction paper an arrow-shaped point and tail fin, as shown in the diagram.

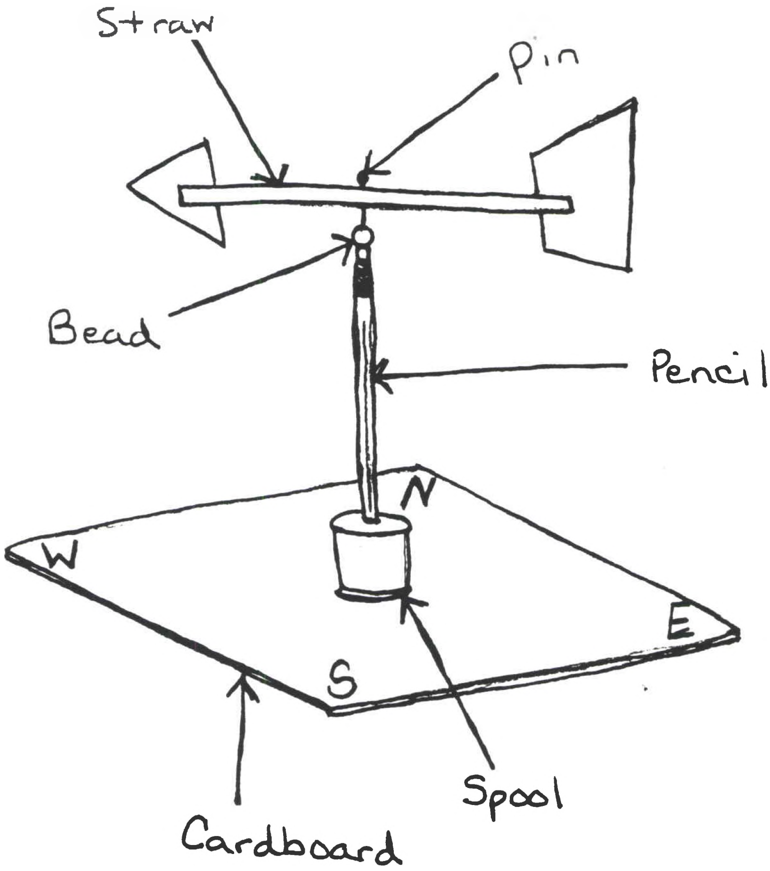
2. Attach the point and tail fin to the straw by cutting notches in both ends of the straw and gluing the cut-outs in place.

3. Attach the straw to a pencil by sticking the straight pin through the middle of the straw, through the bead, and into the pencil eraser. Make sure the straw can swing easily in all directions.

4. Glue the empty thread spool to the center of the corrugated cardboard and mark North, South, East, and West on the cardboard as shown in the diagram.

5. When the glue has dried, push the pencil into the hole of the spool and check to see that the straw moves easily. You now have a wind vane.

6. Put your wind vane in the weather station.


Straw
Pin
Bead
Pencil
N
W
E
S
Spool
Cardboard

Make a Weather Station

Hygrometer

An instrument that measures the relative humidity in the air is called a hygrometer. Relative humidity is the amount of water vapor actually contained in the atmosphere divided by the amount that could be contained in the same atmosphere.

What will we need?

- 2 thermometers
- small dish of water
- thread
- cotton tube
- empty waxed drink carton
- rubber bands

How will we construct our hygrometer?

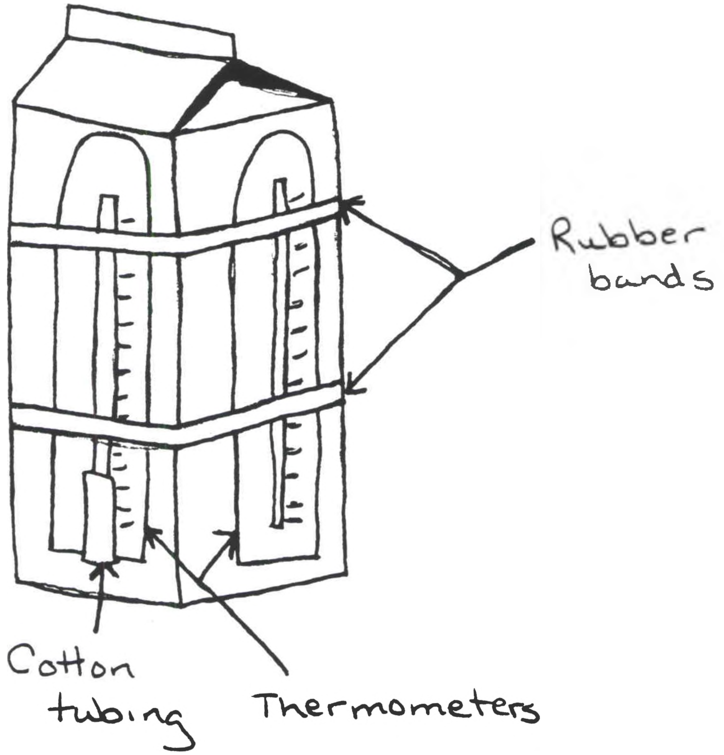
1. Slip the cotton tube over the bulb of one of the thermometers. Tie the tube section with thread above and below the bulb to hold the tube in place.

2. Allow the other end of the tube to rest in a small dish of water inside the wax carton.

3. Attach both thermometers to the wax carton as shown in the diagram.

4. The two thermometers should register the same temperature before the tube is placed over one of them; if not, the difference in readings must be considered a constant that is part of all computations.

5. Put your hygrometer in the weather station.


Rubber bands
Cotton tubing
Thermometers

Make a Weather Station

Anemometer

An anemometer is an instrument that shows wind speed.

What will we need?

- Ping-Pong ball
- 12" monofilament nylon line
- protractor
- bubble level
- glue
- scissors
- red marker
- tongue depressor
- long sewing needle
- tape

How will we construct our anemometer?

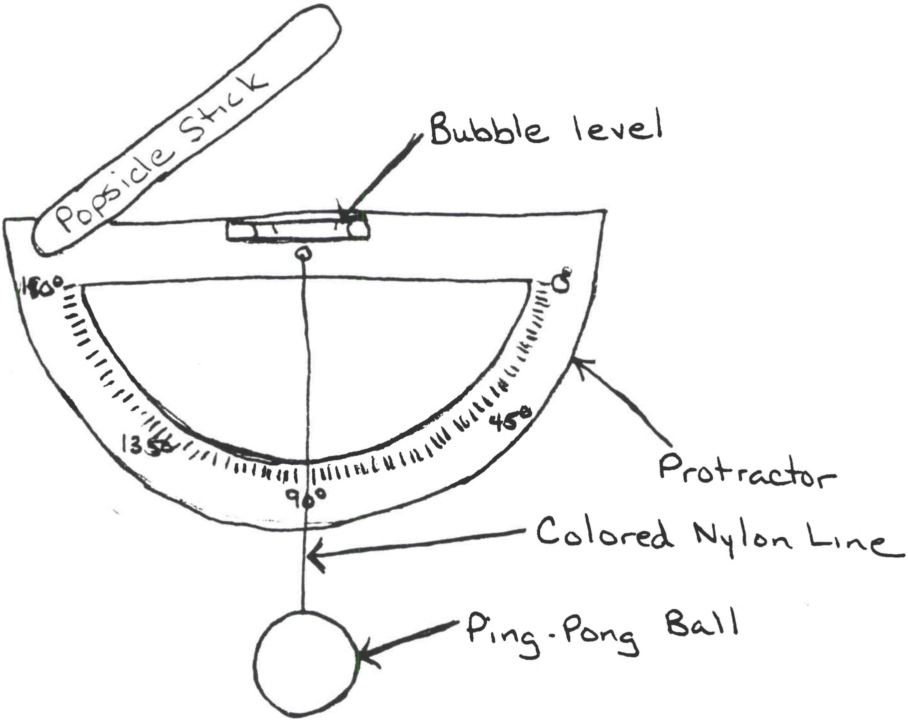
1. Thread a sewing needle with a 12" monofilament nylon line, push the needle through the Ping-Pong ball, and knot and glue the end of the line to the Ping-Pong ball.

2. Tape the other end of the line to the center of a protractor. With the marker, color the line red.

3. Tape a bubble level to the protractor as shown in the diagram.

4. Tape a tongue depressor to the protractor as a handle.

5. Place your anemometer in the weather station.



PROTRACTOR ANEMOMETER WIND SPEEDS			
String Angle	Wind Speed (Miles Per Hour)	String Angle	Wind Speed (Miles Per Hour)
90	0	50	18.0
85	5.8	45	19.6
80	8.2	40	21.9
75	10.1	35	23.4
70	11.8	30	25.8
65	13.4	25	28.7
60	14.9	20	32.5
55	16.4		

Make a Weather Station

Barometer

An instrument that measures changes in the air pressure is called a barometer.

What will we need?

- glass milk bottle
- large balloon
- rubber band
- plastic drinking straw
- wooden matchstick
- rubber cement
- index card mounted to block of wood
- scissors

How will we construct our barometer?

1. Cut out the dome-shaped end of the balloon. Stretch it tightly over the mouth of the milk bottle.

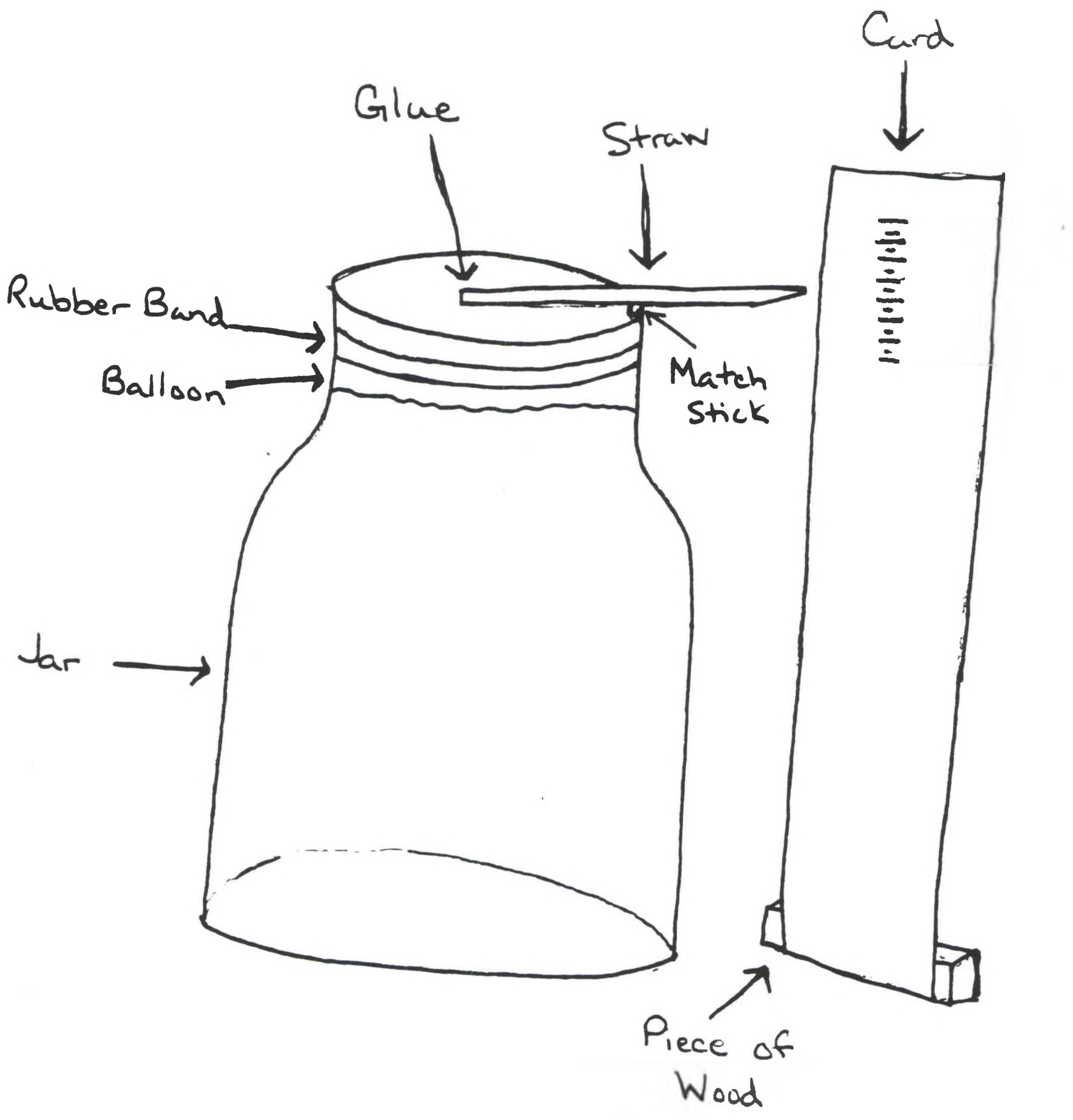
2. Secure the balloon with the rubber band.

3. Flatten both ends of the plastic straw. Cut one end into a point.

4. Place rubber cement on the flattened end of the straw. Glue the end to the center of the balloon.

5. Cut a tiny piece of wood from the matchstick and glue it at the edge of the milk bottle on the balloon. Rest the straw on the piece of wood.

6. Mark the index card in centimeters. Place the barometer and the index card in the weather station.


Card
Glue
Straw
Rubber Band
Balloon
Match Stick
Jar
Piece of Wood

APPENDIX E

NAME________________________________
DATE________________________________

How Do You View Nukes?
Nuclear Power Survey

How serious do you consider each of the following potential hazards that sometimes go with nuclear energy?

VS = very serious S = serious NS = not serious

1. Thermal pollution
   VS S NS

2. Radiation exposure from normal operation
   VS S NS

3. Explosion
   VS S NS

4. Theft of plutonium
   VS S NS

5. Disposal of radioactive waste
   VS S NS

Would you be willing to have each of the following energy producers built within 25 miles of your home?

Y = yes M = maybe N = no

1. Coal-burning power plant
   Y M N

2. Nuclear power plant
   Y M N

3. Dam with hydroelectric plant
   Y M N

4. Geothermal power plant
   Y M N

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