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The Enhancement of Earth Science Laboratories and Activities through Inquiry, Discovery and Hands-on Methods

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THE ENHANCEMENT OF EARTH SCIENCE LABORATORIES AND ACTIVITIES THROUGH INQUIRY, DISCOVERY AND HANDS-ONS METHODS

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by

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The central objective of this project is to enhance the middle school eighth-grade Earth Science curriculum by developing or adapting existing laboratory activities to model hands-on, inquiry, and discovery learning methods. These laboratory activities are designed to encourage independent student-centered learning as opposed to teacher-centered and directed activities.

The project also explored the nature of the science laboratory as it exists in classrooms today and how it can be improved through an understanding of the nature and process of science.

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CHAPTER 1

Introduction

Significance of the Project

On October 4, 1957 the Soviets launched Sputnik I and served as a catalyst for the first of several major shifts in science education in the United States. A crisis in American science education had been identified earlier in the 1950s, but with the launch of Sputnik Americans took a serious look at science education and found a disparity between existing science courses and the rapid advances being made in science and technology. The educational system was neither keeping pace with these advances in science nor with the demands of society to produce more scientists. What followed, in an attempt to meet these demands, was a burst of creative activity that resulted in new and innovative science education programs.

Over the next decade science education, and the way science was defined, took on new meaning. No longer was science just a body of knowledge. Science was now something you did. The emphasis of science education shifted towards the nature and processes of science.

By the 1970s, many believed by public school personnel that the objectives of the 50s and 60s had been met and that the task of reforming science education had been accomplished. We now had a surplus of scientists and engineers and had surpassed the Soviets in space technology. Many science educators, however, seemed to believe that the task had only been partially fulfilled. These educators realized that science was still not meaningful or useful for all students (Holdzcom & Lutz, 1986).

Statement of the Problem

Research in the 1980s indicates that another crisis in science education exists. Student achievement and interest in science were shown to be declining and student attitudes towards science were poor. Recent studies show that students fail to see the value of an education in science and how the knowledge gained through science relates to their lives. Curriculum is still textbook oriented with little emphasis on concept development or problem solving. The textbook is used as the authority on science information and as the guide to learning science. Science teaching methods are still found to be lecture/demonstration oriented with little opportunity for the student to experience science for themselves through exploratory and open ended laboratory activities. Laboratory activities are too often verification exercises of known and proven concepts or phenomena (Holdzcom & Lutz, 1986). The students role is all too often that of a passive observer instead of an active participant. Research also indicates that there is a shortage of teachers trained in science and science research skills at all grade levels.

Importance of the Project

These problems have initiated another reform movement in science education. The major goals that emerged focused on the need for new perspectives for science teaching (Anderson, 1976). Science courses today must stress the inter-relationship between science, technology, and society on a national and global scale (Holdzcom & Lutz, 1986). Methods, programs, and laboratories that actively engage the student in the learning process should be developed to meet these goals. Active student involvement is the key to the success of these new programs. Science programs at all levels will emphasize hands-on science, inquiry strategies, and student decision making. Laboratories designed around these strategies should encourage students to become investigators of science. Students would to learn how scientists solve problems by becoming problem solvers themselves (Bybee, Carlson, & McCormick, 1984).

Effective science education is active student participation in the 'doing' of science. For students to become active participants in the process of science there must be opportunities for scientific exploration and research (Yager, 1983). This exploration and research is effectively carried out through the use of the science laboratory. The use of science laboratory activities is an integral part of the science curriculum (Rakow, 1989). Yager (1983) believes that laboratory activities must go beyond verification exercises and encourage the student to search for answers and solutions to scientific and environmental problems.

Objectives of the Project

The central objective of this project is to enhance the middle school eighth grade Earth Science curriculum by developing or adapting existing laboratory activities to model inquiry, discovery, and hands-on learning methods. These laboratory activities are designed to encourage independent student-centered learning as opposed to teacher-centered and directed activities. The author also believes these labs and activities will aid in the development of higher level thinking skills such as problem analysis, synthesis, and transfer to related problem areas.

Limitations of the Project

This project will be limited by the following factors:

1. The typical grade level that Earth Science is typically taught in the middle school at grade 8. Therefore these labs and activities are written to the Merrill, *Focus on Earth Science*, 8th grade 1987 edition textbook and curriculum.

2. The labs and activities will be limited to four in the field of astronomy, three on air, two each on topography, geology, and internal processes, and one each on matter, oceanography, and crystals.

Definition of Terms

To add clarity to this project a number of terms require definition:

Science: Science is a body of knowledge, an understanding of nature in an objective way, and an ongoing humanistic endeavor (Collette & Chiappetta, 1984).

It is a process for observing, studying, and attempting to explain our world (Hesser & Leach, 1987). It is a way of doing things and thinking about things.

Earth Science: Earth Science is the study of the earth and its place in space (Hesser & Leach, 1987). It comprises parts of what has traditionally been known as geology, astronomy, oceanography, geography, and meteorology (Yager, 1983). It requires some knowledge of chemistry and biology.

Science Education: Science Education is the process by which the school systems lead students to become scientifically literate individuals with a firm understanding of the nature of science and an understanding of how science, technology, and society influence one another (Collette & Chiappetta, 1984).

Inquiry: Inquiry is the pursuit of meaning through the process of seeking information and understanding (Anderson, 1976). Inquiry focuses on how students process information rather than what they process (Carin & Sund, 1989).

Inquiry Activities: Inquiry activities are student-centered with minimum step-by-step teacher-directed learning experiences (Holdzkom & Lutz, 1986). These types of activities require the student to ask questions and to attempt to figure things out for themselves through the processes of science.

Discovery: Discovery involved finding concepts, associations, or rules through the discovery process with little teacher intervention (Gagne, 1977). Discovery is the process by which the learner uses their mind in logical and ordered ways to organize and internalize concepts (Carin & Sund, 1989).

Guided Inquiry/Discovery Activities: These are methods of teaching science that are a combination of teacher-centered and student-centered techniques. These activities contain varying degrees of teacher involvement determined by the activity and student readiness (Carin & Sund, 1989). The role of the teacher remains that of a facilitator.

Discrepant Event: A discrepant event is a situation centered on the presentation and observance of phenomena which go counter to what a person thinks will occur. The discrepant event results in a state of conflict which requires that students assimilate what is unknown into their pre-existing cognitive structures (Leim, 1987).

Hands-on Activities: Hands-on activities provide students with sensory experiences necessary to construct meaning and understanding of science (Saunders & Jones, 1988). Hands-on refers to manipulative activities that require the student to construct, handle, operate, or in some way work or practice with physical objects as part of the learning process.

CHAPTER 2

Review of the Literature

The role of the laboratory has been widely researched and developed over the last two decades. Science has always been viewed as the quest for knowledge and the ideal place to conduct this quest is the laboratory (Renner, 1986). This chapter will deal with the science laboratory: how laboratory science is defined, the state of laboratory science activities today, the rationale and goals of laboratory work as an integral part of the science curriculum, the components of a laboratory activity, and the types of laboratories as defined in Chapter 1.

Laboratory Science Activities Defined

The writer has found that any discussion of laboratories must start with an adequate understanding and definition of laboratory science. Washington State lacks an official description or definition of laboratory science. Kennedy (1981) found that the only reference to laboratory work or instruction in the Revised Code of Washington (RCW) and the Washington Administrative Code (WAC) referred to traffic safety instruction.

Kennedy notes that the privilege of defining laboratory science has been left to school districts on an individual basis and is usually defined in terms of a percentage of yearly time, usually no less than 40% of the total time spent teaching science. Kennedy offers the science teachers of Washington State the following operational definition or description of what laboratory science should be:

> Laboratory science contributes first-hand mental and physical experience to deepen the learner's understanding of science and its technological applications. The laboratory provides that portion of a class which allows a student to manipulate the stuff of science by performing as an active investigator, asking questions, recognizing and formulating problems, seeking answers by applying science process skills, and reporting the results of these practical experiences (p.13).

Tamir (1977) agrees with Kennedy and adds that the science laboratory experience should engage students in hands-on activities such as observation, experimentation, and opportunities to delve into the process of investigation and inquiry.

A more detailed description of laboratory science/activities comes from a monograph in *What Research Says to the Science Teacher* (1981). Laboratory work was viewed as experiential and experimental. Activities should require students to locate information from a variety of sources. When different methods of investigation were used they had to be justified in terms of the problem. Quite often laboratory problems were found to be issue or value oriented and would result not in expected conclusions, but in decisions or consensus based on the moral and ethical context of the problem. Hurd (1981), who wrote the monograph, wanted to see laboratory activities in which students were put into conflict or confrontation with societal issues and personal problems, with facts viewed as a means of investigation not merely the end of an investigative process. A worthy laboratory investigation would involve decision making, taking action, interpretation, identification of the true problem, application, and concept formation.

Collette and Chiappetta (1984) view the laboratory as an instructional approach unique and central to the teaching of science because it serves many purposes. Laboratory activities should involve students in scientific enterprise permitting them to participate in investigations in which they should be asked to do their own thinking and to draw their own conclusions.

The State of Laboratory Science Activities Today

The focus and function of the laboratory experience has changed over the past two decades. Traditional science instruction was based on the theory that for students to learn they had to first be informed of what it was they were expected to learn (Bryant & Marek, 1987). Courses previously had presented highly directed activities where students did little more than verify results already presented in their text (Bates, 1978). The reforms initiated in the 60s and 70s described a curriculum that was problem-centered, flexible, and culturally as well as scientifically valid. These curriculum reforms were lab oriented and tended to get away from the much used practice of verification. They leaned more towards a problem-solving, discovery-oriented approach (Hounshell, 1989).

Despite the reform movement, science curriculum often remains textbook-centered, inflexible, and only valid in a scientific sense (Yager, 1983). Yager indicated there was virtually no evidence of science being learned by direct experience, that nearly all science teachers presented science via lectures, demonstrations, or question and answer sessions, and that over 90% of science teachers viewed their goals for teaching science in connection with specific content. National reports found that 90% of all science teachers used a textbook 95% of the time. We expected students to learn science without actually doing science (Bryant & Marek, 1987).

A survey of 2000 ninth grade science students revealed that 42% did laboratory work as part of their science lessons, 66% used their textbook for their lessons, and 42% never were assigned write up reports of laboratory and project work. The majority of students indicated that they studied science in the traditional way — listening to lecutres, copying notes, reading the text, seeing demonstrations, and taking tests (Jacobson & Doran, 1986).

Similarly, a random survey of Washington State science teachers revealed a concern for the nature of laboratory activities that were included in textbooks. The survey found that most textbooks lacked inquiry activities that allowed students to experience scientific discovery. All of those surveyed suggested improvements in science would follow from less reliance on textbooks and an increase in the use of hands-on, minds-on instruction that included quality laboratory experiences (Rakow, 1989).

Tamir (1989) agrees and adds that teachers too often offer their students laboratory exercises taken from commercial textbooks without really considering the nature of these exercises and what the students are actually learning from them.

The problems found in some textbooks directly contradict the goals established by the curriculum committees during the reform years. A study conducted by Goodlad (1983) concluded that when students were exposed only to textbook lab activities they did not appear to develop any of the abilities commonly associated with "intellectual development", intellectual curiosity, creativity, or the desire and ability to engage in rational thinking and pursue higher knowledge. Students were found to possess information without a level of understanding of the implications of the information. The students also lacked the ability to apply or explore the applications of science information. The study added, that at this time in our history, enhancement of critical thinking skills should be considered imperative, and that these skills were being neglected.

Bybee (1984) suggests that without intellectual development students would not understand how scientific concepts relate to societal and global problems. Considering the scope of the global, societal, and environmental problems society may face in the years to come, the development of science process skills becomes imperative. In order to address the earth's major problems: population growth, war, world hunger, air quality, and water resources; students must have a knowledge of global problems and the ability to solve them. Bybee et al.

proposed that these skills be developed through performance; specifically the through use of laboratory and field experiences.

Rationale and Goals of Laboratory Activities

The NSTA Commission on Professional Standards and Practices (1970) stated that:

> The time is past when science teachers must plead the case for school laboratories. It is now widely recognized that science is a process and an activity as much as it is an organized body of knowledge and that, therefore, it cannot be learned in any deep and meaningful way by reading and discussion alone (p. 3).

Laboratory activities have been found to be ideal for involving students in the investigative nature of science as it relates to the environment. The laboratory experience has been shown to be a unique learning experience that enhances the student's awareness of the orderly view humans hold of nature, the creativity we use to explain our natural environment, and our ability to think about natural phenomena in rational ways (Anderson, 1976).

Laboratory activities were also found to develop and reinforce knowledge gathering skills that improved students' ability to understand the environment. Collette and Chiappetta (1984) found that laboratory work also developed attitudes that helped young people speculate on the possible causes of events and the accuracy of their findings. Anderson (1976) viewed the laboratory as an excellent setting for building student confidence. Tamir (1974) observed that the laboratory has always been the most distinctive feature of science instruction that in connection with the new curricula has acquired a central role not as a means for demonstration, but rather as the core of the science learning process. The laboratory experience, when properly organized, should provide a rare opportunity for students to gain skills in gathering, ordering, and explaining sensory data — an opportunity that few other school activities can offer (Anderson, 1976).

Both Anderson (1976) and Renner (1986) agreed that experiences in the laboratory were essential to effective science programs. Similarly, Bryant and Marek (1987) added that the processes of science can only be experienced in the classroom. A group of teachers who attended one of their workshops agreed on several strengths provided by the use of laboratory activities. The teachers decided that the use of laboratory activities (a) extensively involved students in the learning process, (b) matched the natural learning process which led students to invent for themselves the concepts being investigated, (c) produced deeper understanding and greater retention of concepts, (d) developed students' thinking and communication skills, (e) taught science process as well as content, (f) were based on comprehensive learning theory supported by empirical data, and (g) made science relevant and meaningful to students.

Helgeson (1989) includes increased opportunities for problem-solving as a strenght of lab activities. He suggests that laboratory activities should include concrete representations and hands-on experiences since few adolescents consistently operate at the formal operational level. By offering concrete, manipulative experiences, problem-solving and cognitive skills would be developed.

Bates (1978) summarized 5 major goals related to science laboratory activities as proposed by Schulman and Tamir in their book *Research on Teaching in the Natural Sciences* (1973):

1. Skills: for example, manipulative, inquiry, investigative, organizational, and communicative;
2. Concepts: for example, hypothesis, theoretical models, and taxonomic categorization;
3. Cognitive abilities: for example, critical thinking, problem solving, application, analysis, synthesis, evaluation, decision making, and creativity;
4. Understanding the nature of science: for example the scientific enterprise, scientists and how they work, scientific methods, interrelationship between science and technology and among the various science disciplines;
5. Attitudes: for example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverance, responsibility, personal satisfaction, and a liking for science (p. 57).

Components of Laboratory Activities

Holdzcom and Lutz (1986) concur that the activities of scientists are procedures of investigation by which knowledge of natural phenomena is gained. These procedures of investigation are the tactics and strategies of science -- the way scientists behave in their pursuit of understanding. An understanding of the processes of science as used by scientists and how they can be included in the science curriculum is essential if teachers intend to help students ask questions. The following process skills will be found in laboratory activities designed to meet the goals of laboratory science. Abruscato (1988); Holdzcom and Lutz (1986); and Rowe (1978) believed that every laboratory activity should include one or more of these skills: manipulating materials, observing, classifying, using space/time relationships, using numbers, measuring, communication, predicting, and inferring.

Carin and Sund (1989); Collette and Chiappetta (1984); and Abruscato (1988) added a few integrated skills students might develop through laboratory activities. They identified these skills as identifying and controlling variables, interpreting data, hypothesis formulation, experimenting, and questioning.

These are the basic skills to be considered in developing or choosing laboratory activities. Carin and Sund (1989) also encourage creating models, making decisions, and replicating experiments to this list. They note that the desired outcomes of the laboratory activity determined what type of skills would be used.

Types of Laboratory Activities

Most science teachers today believe that laboratory experiences are essential to the learning of science. Yet many laboratory guides and textbooks leave the impression that the purpose of the lab is to verify something that the teacher, textbook, or some other scientist had already done.

Dr. Don Orlich of Washington State University believes that textbook publishers are the enemies of public education because they fail to promote science as a "contact sport" where students are given time to "mess around" with science discovery (Waterman, Lisoskie, & Schulz, 1989).

Washington State teachers could improve science teaching by emphasizing less reliance on textbooks and increasing involvement in hands-on and minds-on instruction (Rakow, 1989). Hands-on activities have been shown to provide students with a variety of sensory experiences necessary to construct meaning and understanding of science.

A study conducted by Glasson (1989) provided evidence that the ability to solve problems on procedural knowledge tests was increased if reasoning strategies were employed in the course of performing an experiment. Students who engaged in hands-on laboratory activities were found to do better on tests measuring procedural knowledge because they had been actively involved in operations on the variables and in reasoning how things worked by actual contact with the objects. The study also showed that all students, regardless of reasoning ability, benefited from hands-on laboratory instruction on the measure of procedural knowledge. Hands-on activities also promoted peer interaction where students were free to argue, make mistakes, challenge, and help each other.

Fisher and Lipson (1986) found that students learned from the errors they made. Students who only observed teacher demonstrations were more likely to be passive learners and were less motivated to solve problems independently. Indeed, hands-on type activities were found to be a major component of many of the types of laboratory activities discussed and presented in this project.

Welch (1981) noted that it was important to remember that hands-on activities usually involved the lower level skills, such as measuring, and were not characterized by true problem-solving.

The reforms initiated in the 1960s were in part necessary because at that time the traditional approach to science gave students the false idea that science consisted of unalterable truths and that science was complete. Students therefore gained an erroneous idea of the nature of scientific enterprise. This resulted in students who never learned that the knowledge gained from science was obtained through questions, problems, data, experiments, and mistakes (Collette & Chiappetta, 1984). Inquiry was one method that was often used to promote the 'doing' of science.

Inquiry is defined as a general process by which we seek information or understanding. Teaching science through inquiry requires students to ask questions and attempt to figure things out for themselves. As a process it stresses the investigative method that is used by scientists in their work (Collette & Chiappetta, 1984). Observing, measuring, formulating problems and finding solutions to them are some of the ways inquiry is used in science. Effective teachers value inquiry, encourage inquiry in others, and possess skills in enabling the student to understand inquiry as a way of knowing. Inquiry classrooms have science objects in use, with equipment and supplies organized and available for student investigations (Aikenhead, 1983).

Inquiry teaching is found to be process-oriented, and more student-centered than it is teacher-centered. Laboratory activities that were inquiry based place the student in the role of active participant rather than that of passive spectator (McGlathery, 1978).

The inquiry level of the laboratory has been shown to be determined by the behavior of the students and the teacher. In a typical verification laboratory, the teacher identifies the problem and relates it to previous work, conducts appropriate demonstrations, and gives direct instructions which are to be carried out by the students. The inquiry laboratory asks the students to formulate the problems, identify the procedures to be used, collect data, predict the results, and draw conclusions if possible (Tamir, 1977).

Richard Suchmann (1966), who developed the Inquiry Development Program in the 1960s for middle schools, offered six rules for inquiry sessions that reflect the openness and freedom he believed students needed in order to develop their inquiry skills. The first rule was that students should be encouraged to ask questions and phrase those questions so that they could be answered either yes or no with a minimum of teacher response. This prevented the teacher from explaining the problem under study and encouraged students to seek more information. The second rule was to allow students to ask as many questions as they want. This gave the students a chance to gather a great deal of information through questioning. The third rule was to avoid evaluating the accuracy of explanations that students gave to problems or events. The students should test out their own ideas from data they gather instead of the teacher making judgments about the students' reasoning ability. The fourth rule stressed that students be allowed to test an idea at any time; any ideas or theories that had been presented were fair game for testing. The fifth rule was to encourage interaction and discussion among students. This type of communication gave the students opportunities to share their ideas and increased their involvement. The sixth rule allowed students to informally interact with lots of materials connected with the given inquiry activity.

The Biological Science Curriculum Study (1970) program presented five ways to approach science as inquiry that were different than those offered by Suchmann. First, some statements within the program were made to emphasize the uncertainty and incompleteness of scienc, such as: "We do not know," and "We have been unable to discover how this happens." Second, the textbooks utilized a narrative of inquiry where major topics were described through a description of how this knowledge evolved through the data gathering, experimentation, and interpretive process. Third, some of the laboratory activities were investigative. They demanded that the students gather data to answer questions whose answers or solutions do not appear in the book. Fourth, some extensive laboratory investigations were suggested for students to pursue. This allowed students to focus on a real problem and approach the discovery of new knowledge without specific time constraints. Finally, there were "Invitations to Enquiry" units within the program that involved the students in different segments of the inquiry process. These units focused on developing skills in several areas of the investigative process.

The use of inquiry as a method of teaching science and presenting science activities has been found to have yet another value. Research indicates that the inquiry oriented approach to science has a great influence on the students' attitudes towards science. According to Holdzcom and Lutz (1986), a drastic attitudinal difference existed between those who participated in inquiry oriented science curricula and those who remained in process oriented programs. Those students who were exposed to inquiry methods for one year wanted more science, desired more kinds of science, and found their school science fun, exciting, interesting, and intellectually stimulating.

Carin and Sund (1989) noted that inquiry was often referred to as free discovery, a method that was very student oriented. Discovery and guided discovery methods offered a blend of both teacher-centered and student-centered learning methods.

Gagne (1977) noted that through the process of discovery students were encouraged to find concepts, associations, or rules through the inquiry process. When the teacher acted as a facilitator and led the students in the learning process the method was more closely associated with guided discovery. These laboratory methods were found to be so novel and new to students that one important way the teacher could act as a facilitator was in giving directions. Rowe (1978) agrees and adds that since these activities involved a great deal of student-centered action it was imperative that directions be brief, clear, concise, and easy to understand.

Gagne (1977) described the act of discovery as figuring out something for one's self, whether it be a new concept, rule, or association. McGlathery (1978) adds that the discovery lesson gives the students an opportunity to apply new concepts, and to transfer them to new problem or other content areas.

Discovery learning was found to be a valid method to use for laboratory activities because it enabled students to solve future problems with confidence in their abilities to seek out solutions, patterns, and relationships. The students' motivation also shifted from extrinsic to intrinsic as failure and success came to be viewed as information rather than as punishment or reward. Discovery learning also aided in the memory process as information integrated into their cognitive structure became more retrievable (Bruner, 1961).

Guided discovery may be a more practical and appropriate approach than free discovery activities as more of us are familiar and comfortable with expository teaching. Expository teaching was the type of teaching most of us were exposed to in our education. Once a teacher becomes comfortable with the expository method, diversification will follow into inquiry and free discovery. According to Carin and Sund (1989), through the process of guided discovery students become more autonomous, self-directed, and responsible for their own learning. They found verification laboratory activities were deductive in nature;

discovery laboratory activities were shown to be inductive. The inductive laboratory provided students the opportunity to form concepts, principles, and laws through actual experiences. Collette and Chiappetta (1984) noted that the inductive approach gave students a chance to form concepts for themselves and allowed them to explore and pursue ideas.

Carin and Sund (1989) noted that free discovery and guided discovery activities should have enough structure to ensure that the students are using their minds to discover the desired concept or principle. Students also must be able to discover the concept or principle under investigation which means they either must have, or be taught, the prerequisite skills. The objectives and goals must be broad enough, relevant, and not too difficult to ensure student success.

Collette and Chiappetta (1989) believe that the most useful 'tool' to successful discovery laboratory activities is the use of the discrepant event. A discrepant event is one that puzzles the observer, and leaves him/her at a loss for an explanation to the event.

Waetjen (1969) describes the discrepant event as a dissonant situation which results in an arousal of conflict with a consequent need for the learner to assimilate or articulate the unknown, incongruous, unfamiliar material into his/her cognitive structure. To do this the student engages in exploratory behavior.

Piaget (1971) believes that this state of confusion and doubt was a necessary first step towards learning. He found the discrepant event to be an excellent activity that would encourage thinking skills because the unsettling nature of these events and causes change or adaptation to student's prior ways of thinking. He also supported the use of the discrepant event as a valid instructional method. Situations contrary to what was expected caused the student to wonder what was taking place. With proper guidance the student was found to be willing to try to figure out the discrepancy and attempt to find an explanation for it. When a suitable explanation was found, the student arrives at a new cognitive level. The student is then believed to be better equipped mentally to attack new situations that cause puzzlement and curiosity.

The discrepant event might be a teacher demonstration, or a laboratory activity used to encourage student motivation. Liem (1987) reported that the use of the discrepant event created in the student the "eager want" to know more about the event. He offered teachers three procedures to be followed in using discrepant events successfully.

1. Presentation — Present the learner or involve the learner with the discrepant event describing or commenting on the names of objects and operations only and not mentioning the reasons for the occurrence.
2. Interaction — Ask the learner questions that eventually will lead to the reason for the occurrence. In doing this the students would be engaged in science inquiry and actually practicing the science processes of observing, measuring, inferring, predicting, interpreting data, identifying and controlling variables, hypothesizing, and experimenting.

3. Involvement — Involve the learner in similar discrepant events or counter-intuitive activities illustrating and based on the same science concept. This would reinforce the learning and retention of that particular concept (p. xxxvi).

No one method for teaching science is best for all students. Carin and Sund (1989) advocate the use of all science teaching methods and strategies. Hands-on, inquiry, and discovery methods however, have been proven through research to be particularly effective. They reported on three studies that showed that students involved in inquiry/discovery oriented learning and activities performed better on measures of general science achievement, process skills, analytical skills, and mathematics. They also found that discipline problems were reduced because students had the opportunity to select and explore alternatives.

In conclusion, literature and research has well established the fact that laboratory experiences are valuable and beneficial in the teaching of science. The science laboratory is central to science teaching because it serves many purposes. Laboratory activities involve students in scientific enterprise, encourage the development of problem-solving and higher-level thinking skills. These activities permit students to participate in investigations in which they do their own thinking, draw their own conclusions, and participate in concrete learning experiences where they can explore new ideas and relate concepts and theories to data gathered by personal observation. Laboratory activities also play an important role in helping students develop positive attitudes toward science.

The laboratory experience, when properly selected and organized, provides a rare opportunity for students to gain skills in gathering, ordering, and explaining sensory experiences — an opportunity that few other school activities can offer.

CHAPTER 3

Description of Procedures

The purpose of this project was to Earth Science laboratory activities for an eighth-grade class using hands-on, discovery, and inquiry methods. It became apparent to the writer that the majority of laboratory activities supplied by the textbook company were workbook type laboratories where students looked at graphs, filled in the appropriate blanks on the paper, or repeated procedures and steps that resulted in expected and easily verifiable results obtained by others. These laboratories when used, failed to motivate or interest students in the Earth Science concepts being studied, did not actively involve them in process skills, did not initiate higher levels of thinking and questioning, or reinforce the reason the concept was considered important to the field. As such, they failed to meet the criteria for quality laboratory experiences as established by science educators.

The scope of the laboratory activities developed in this project was limited to the field of Earth Science as presented to an eighth grade middle school class. A lack of materials and equipment for students was also considered to be a limiting factor. Therefore it became important to develop laboratories that could be done with every day materials and a minimum of complex equipment. The amount of time in any given class period was also a limiting factor. Class periods typically last 46 minutes with an actual time involved on any laboratory of approximately 36 minutes. To counter the time shortage some of the laboratory activities in this project were designed to take more than one class period. The labs presented in this project also presume that the teacher will adequately conduct appropriate pre-lab and post-lab discussions or debriefings. Therefore this project is limited in the depth to which each laboratory activity is discussed in the teacher's guide. This project also assumes that the students have the necessary prerequisite information and basic skills. A search of all available lab manuals and books was used to compile lab activities covered in most Earth Science classes. These activities were chosen on the basis of personal preference for activities that focused on core curriculum areas.

All of the laboratory activities developed and found in this project were chosen with the following criteria in mind: a hands-on or discovery mode of laboratory, low teacher involvement, active student involvement, a structured system of questioning that endeavored to promote higher level thinking skills and problem solving, clear and concise directions that do not confuse the average eighth grade student, incorporation of more than one process skill, and a format that does not resemble science workbooks and is complete within itself. No additional paper should be needed. It was equally important that the laboratories be high interest since the typical eighth grade Earth Science student is more involved in meeting needs that are not academic in nature.

These laboratory activities come from a wide variety of sources and many have been greatly altered or expanded from the original. In several cases the activity is a compilation of several related activities or ideas from other the authors. Credit is given to the authors of any laboratory activity whenever possible.

CHAPTER 4

Sixteen Earth Science Laboratory Activities

This project consists of sixteen Earth Science laboratory activities. Each laboratory in this project includes a teacher's guide, student sheets with questions, templates, and all charts necessary to perform the laboratory activity.

It is assumed that the teacher who uses this material will conduct appropriate pre-lab and post-lab discussions or activities. It is also assumed that the teacher possesses some knowledge of the subject.

Some of the materials in these projects have been reduced in size to accommodate the required margins associated with this document. In all cases the reduction percentage has been noted and they can easily be enlarged to better facilitate the activity.

The laboratories are grouped below according to the four major disciplines of Earth Science: astronomy, meteorology, geology, and oceanography. There are four labs on the subject of astronomy, three related to the field of meteorology, eight related to geology, and one on oceanography.

The four astronomy labs are: Apparent Motion of the Stars (Scannel, 1988), Constructing a Constellation Finder, Variation in Solar Energy Related to Changes in Sun Angle (Cranson, 1989), and Constructing a Scale Model of the Solar System.

The three meteorology labs are: The Balloon in the Bottle (Liem, 1987), Why the Winds Blow, and Air — Expansion by Heat (Liem , 1987).

The eight labs related to the field of geology are: Introduction to Topographic Maps, Constructing Topographic Models of Mt. St. Helens Before and After the May 1980 Eruption (Christman, 1984), Sedimentation (Carpenter, 1986), Model of Earth's Layered Structure, Plate Tectonics and Types of Volcanoes (Carpenter, 1986), Specific Gravity of Matter, Mineral Identification, and Crystal Formation by Evaporation and Supersaturation.

The final oceanography lab is entitled Sea Water Density (Carpenter, 1986).

TEACHER'S GUIDE

APPARENT MOTION OF THE STARS

The purpose of this lab is to construct an astrolabe and use it to discover how the apparent motion of the stars is really related to the rotation of the earth.

Before this lab is done the students need to know how apparent motion is defined. They must also have the ability to find at least 4 different stars in the night sky. How to use a star chart is a recommended prerequisite to this lab. The stars actually used may depend on the time of the year this lab is undertaken. Other stars to use might be Alkaid (the last star in the handle of the big dipper) and Caph (at the upper corner of Cassiopia).

The students should also know how to use the altitude measuring system. This lab can be further adapted to measure not only the altitude but also the azimuth of the star. The azimuth is the stars compass direction, measured as an angle clockwise from north.

If possible, the students will need to take readings every hour for approximately 3 to 4 hours on a clear, cloudless night, preferably one where the moon is least visible. Thus, this lab works best in the winter.

APPARENT MOTION OF THE STARS

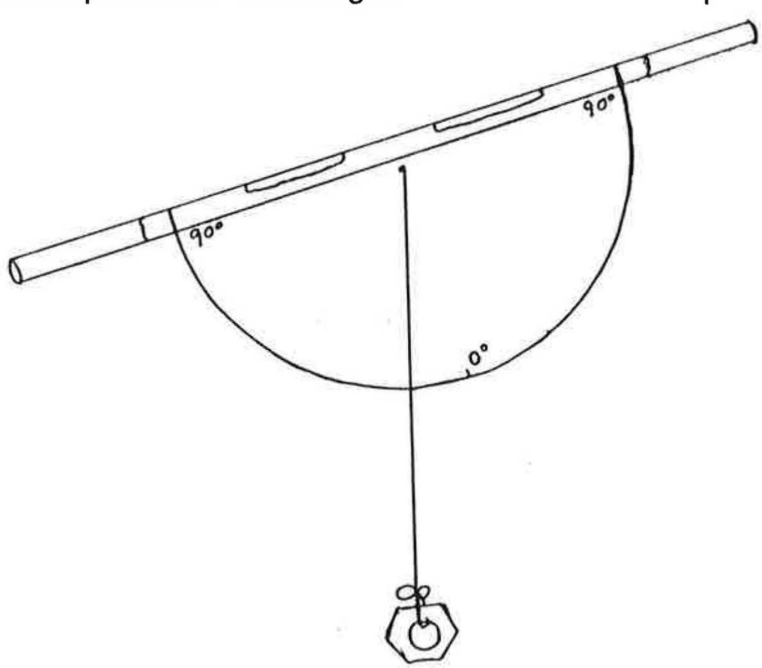
PURPOSE: To construct a simple astrolabe for use in measuring the horizon of classroom objects and stars in the night sky.

OBJECTIVE: To discover the relationship between the apparent motion of the stars and the rotation of the earth.

MATERIALS:
1 photocopy of a protractor
1 piece of tagboard slightly larger than protractor
1 plastic drinking straw
20 cm of string
1 1/2" to 1/3" in diameter washer
6" of tape
1 pair of scissors

Construction Procedures:

1. Cut out the copy of the protractor.
2. Cut out a piece of tagboard the same size as the copy of the protractor.
3. Tape the protractor to the tagboard---follow the example below.



4. Tie the washer to the end of the string.

5. Insert the string into a hole made in the center of the protractor and either tie it in place or tape it securely.

6. Use the tape to attach the straw to the back side of the protractor as shown in the diagram on the preceding page. The straw should be lined up with the 90 degree line and the hole in the protractor. The protractor should be placed close to one end of the straw.

7. Make sure that the string and the washer are free to hang down along the protractor.

8. When the astrolabe is held with the straw parallel to the floor, the string will fall across the 0 degree mark.

Operating Procedures:

1. To measure the altitude of objects above the horizon hold the astrolabe up to your eye and while looking down the straw, sight an object in the classroom. Carefully put a finger on the string to hold it in place and read the degree measure on the protractor.

   You will have read the degrees the object is above the horizon. If the object was sighted at 45 degrees then we say it is at 45 degrees north and we record it as 45 north. This measurement represents an angle of elevation above your horizon.

2. Take the astrolabe outside and make several measurements of objects in the distance. Record the object and its angle of elevation on the chart below.

OBJECT	ANGLE OF ELEVATION
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

3. Now take the astrolabe home and use it on the night sky. Locate and take measurements on the stars below.

STAR	ANGLE OF ELEVATION	ANGLE OF ELEVATION 2 OR 3 HOURS LATER
Polaris	________________	________________
Belelgeuse	________________	________________
Antares	________________	________________
Spica	________________	________________

Questions to Answer

1. Compare the star angles of elevation that you recorded in your chart. What is different about Polaris?

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2. What is the apparent motion of the stars you recorded?

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3. How does the apparent motion of the stars compare to the apparent motion of the sun across the sky?

4. What is the apparent motion of Polaris?
   Explain the reason for your answer.

5. The motion of the stars and the sun to observers on earth is in apparent motion. Using the definition given in class of apparent motion, do the stars actually move across the sky every night?

   What then is the reason the stars appear to move across the sky every night? Is this the same reason the sun appears to move across the sky every day?

6. How might an astrolabe have been useful to early explorers and navigators?

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7. How might an astrolabe be of use to us today?

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8. Would you consider an astrolabe to be an accurate measuring device? Why or why not?

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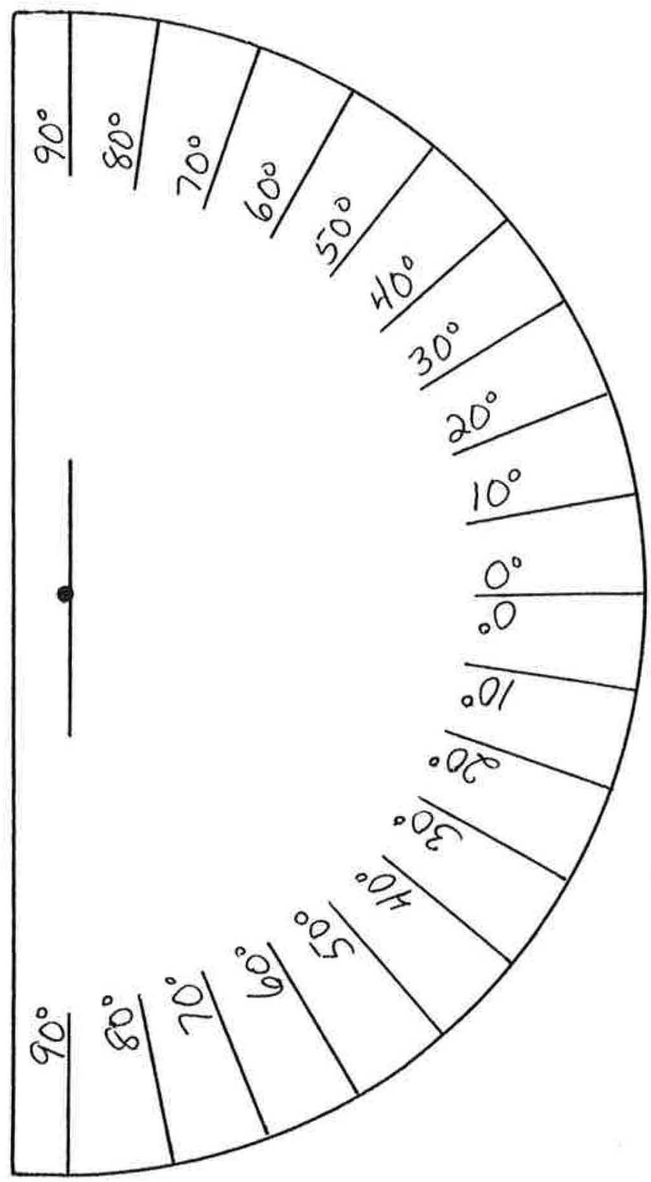
PROTRACTOR TEMPLATE



TEACHER'S GUIDE

CONSTRUCTING A CONSTELLATION FINDER

Basic to any astronomy unit is the constellations. This activity is designed to be hands-on with the students actually constructing a device they can use at home any month of the year, any day, and any time.

This lab can be extended and enhanced by discussions about the constellations, the history and mythology behind those that can be readily identified by the student. It has been found, quite surprisingly, that after a presentation on the mythology of the constellations more students are motivated to go home and actually use the constellation finder.

No questions are included with this activity. Questions regarding location of specific constellations is dependent on the time of the year this activity is done and those constellations of particular interest to the students and teacher. Therefore this lab is non-evaluative unless questions are either devised by the teacher or if evaluation is made on the ability to follow directions and construct a good looking constellation finder.

Note: Diagrams have been reduced 25%.

CONSTRUCTING A CONSTELLATION FINDER

PURPOSE: To construct a constellation finder and located constellations in the night sky by month, day, and hour.

MATERIALS:
1 constellation star map
1 copy of the constellation frame
1 piece of dark construction paper
6 inches of clear tape
2 punched hole reinforcers
1 1/2 inch paper fastener/brad
1 pair of pointed tip scissors

Construction Procedures:

1. Carefully cut out the star map and set it aside.

2. Cut out the constellation frame along the solid lines only.

3. Cut out a piece of paper from the construction paper that is exactly the same size and shape as the constellation frame. This piece of paper will form the back piece of the constellation finder.

4. **VERY IMPORTANT — READ CAREFULLY!** Put the constellation frame and the back piece on top of each other with the frame on top. Carefully make a small hole (pinpoint) through both at the center mark. This will make it possible to exactly center the star map.

5. Place a punched hole reinforcer around the center mark you made on the back piece of the constellation finder.

6. Take the constellation frame and carefully cut out all remaining areas enclosed by dashed lines. Follow these lines as closely and accurately as possible.

7. Find the center mark on the star map (near Polaris). Using the paper fastener, carefully push it through this point. Place a punched hole reinforcer over this hole on the ***back side of the map***.

8. Push the fastener through the center mark on the back piece and connect the star map to the back piece. Spread the ends apart to hold both pieces securely. The star map should turn freely around the fastener.

9. Place the constellation frame over the star map and back piece and line them up. Carefully tape the edges. It is important to make sure that the constellation frame is not taped to the star map. The star map must turn freely.

Operating Procedures:

1. We will use March 15th at 8:00 p.m. to learn how to use the constellation finder.

2. Line up March 15th directly over the desired time (8:00 p.m.)

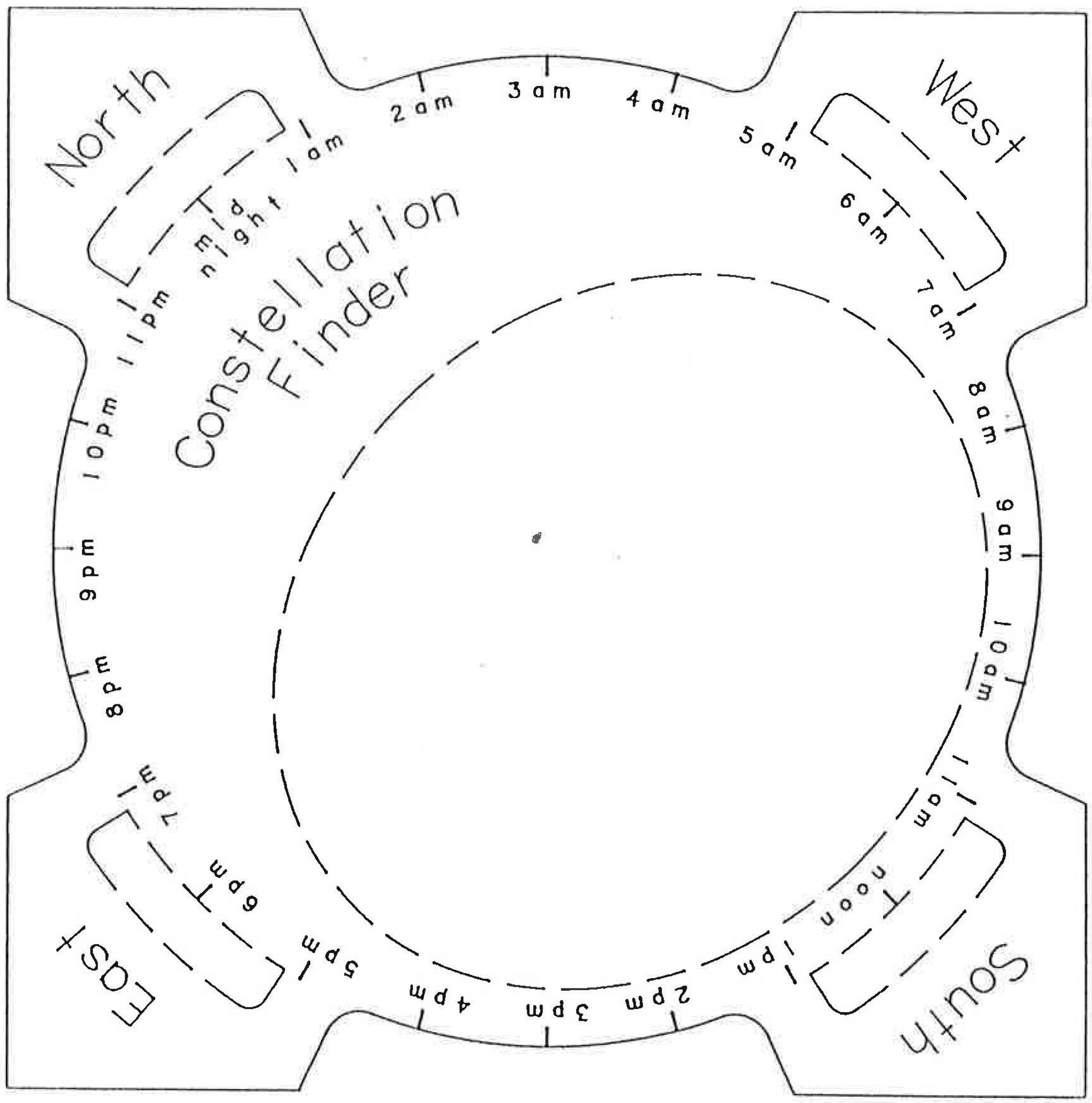
3. With your back to the north and your face towards south, hold the constellation finder up over your head with the star map facing you. The eastern horizon will be to your left and the western horizon will be to the right.

4. Polaris, the North Star, will be slightly behind you along with the Big Dipper. As you look at the chart you will see all the constellations in the sky on March 15th at exactly 8:00 p.m.. The constellations on the map will be exactly what you will find in the sky to the north, east, south, and west of your position.

5. You can now change dates and times at will and see accurate representations of the constellations visible in the night sky.

CONSTELLATION FINDER FRAME — TEMPLATE

25% Reduction



STAR MAP TEMPLATE

TEACHER'S GUIDE

VARIATIONS IN SOLAR ENERGY RELATED TO CHANGES IN SUN ANGLE

Most scientists believe that the amount of solar energy emitted by the sun generally remains the same. However, the amount of solar energy received at a particular latitude on earth varies. As it revolves about the sun, the earth rotates on its axis, which is tilted 23.5 degrees from the perpendicular to earth's orbital plane. Seasons occur because the tilt of earth on its axis causes the length of daylight to vary and the angle at which the sun's energy strikes a given location to change throughout the year.

This laboratory activity is designed to illustrate how a unit of sunlight is distributed over the earth's surface at various times of the year or at various latitudes. The students will perform a series of experiments, make measurements, estimate, and complete a data table using some mathematical calculations.

NOTE:

Students should be advised to use a pencil while working on this lab.

It may be necessary to review the mathematics of finding areas using squaring and estimation.

Parts I and II of this lab are straight forward data collection and interpretation of the acquired data.

Part III may require the use of the flashlights and globes to relate the three dimensional aspect of sun angle to the data gathered. Low-ability students will need more help in abstracting or relating sun angle to the dimensionality of a sphere and the earth's seasons.

To increase the discovery aspect of this lab all three parts should be completed BEFORE a discussion of the tilt of the earth, its orbital plane, or seasons. This may also increase the difficulty some students will have with Part III.

VARIATIONS IN SOLAR ENERGY RELATED TO CHANGES IN SUN ANGLE

PURPOSE: This laboratory activity is designed to illustrate how a unit of sunlight is distributed over the earth's surface at various times of the year or at various latitudes.

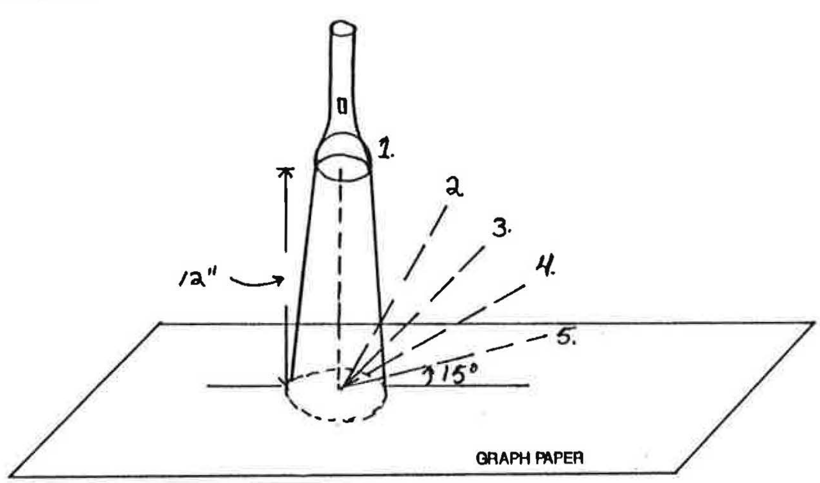
OBJECTIVE: To determine how sun angle is related to seasonal differences on earth.

MATERIALS:
1 flashlight
1 ruler
1 protractor
1 sheet of 1/2 centimeter graph paper
1 globe of the earth (optional)
1 calculator (optional)

Procedures:

PART I: Experiments, Measurements, & Data Collection

1. Set-up the experiment for the 1st position as shown on the figure below. While one student holds the light steady in the proper position, the other student must carefully trace the outline of the flashlight beam on the graph paper.



2. Label the outline as #1.

3. Determine the area enclosed within the outline by counting the 1/2 cm squares. It will be necessary to estimate those that are only partially inside the outline.

4. Record your results in the appropriate space (area) on Table 1 remembering that the number represents square centimeters of area.

5. Repeat this same procedure for the other four positions as shown on the figure being careful to establish the proper angle and distance as accurately as possible.

   NOTE: The various angles that you are using produce varying outlines. These angles are also called **angles of inclination or angle of incidence**.

TABLE 1 DATA---INCLINATION ANGLE vs. AREA OF LIGHT BEAM

POSITION	ANGLE	AREA	CHANGE*	PERCENT**	ENERGY/AREA#
1	90	____	____	____	____
2	60	____	____	____	____
3	45	____	____	____	____
4	30	____	____	____	____
5	15	____	____	____	____

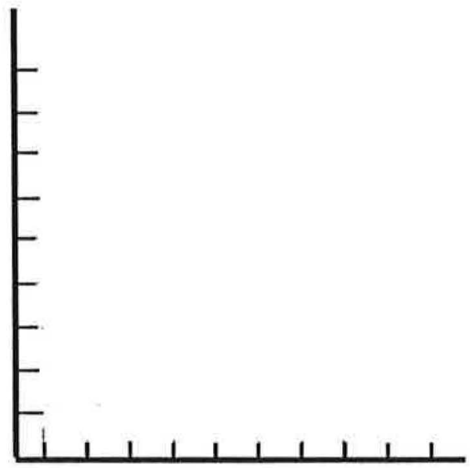
Calculations:

* Area of position being measured - area of position 1
** % = (area of position being measured)/(area position 1) x 100
\# = let the amount of energy in the light beam = 100 units, and calculate the energy/area as shown below:

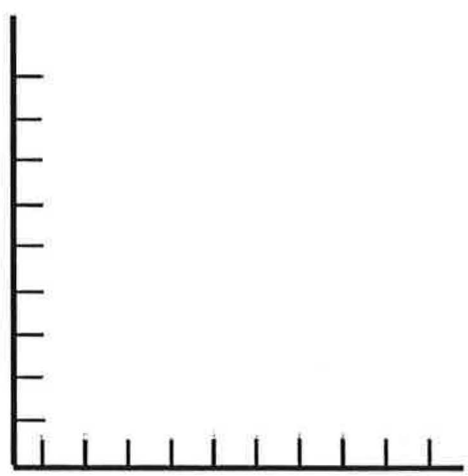
energy/area = (100 units)/(area of position being measured)

PART II: Interpretation of Data

1) Using the data collected and the graph below, plot the angle of inclination (degrees) vs. the area.



2) Use the graph below to plot the angle of inclination vs. the Energy/Area for each measurement.



3) Study the Data Table and your graph from 2 above and state your conclusions regarding the relationship of the angle of inclination (degrees) and the surface area covered by the light beam.

4. Describe what happens to your percentages as the angle of inclination decreases.

5. Why do you suppose the percentages change?

6. Describe how the Energy/Area changes as the angle of inclination decreases.

PART III: Relation to the Sun-Earth System

1) Describe how your findings in this series of experiments and your interpretation illustrates how sunlight strikes the earth's surface.

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2. Assuming the beam of light from the flashlight is one unit of sunlight, take the flashlight and shine it on a globe of the earth from a number of positions about one foot away.

   a) Where do you find the unit of light the brightest? Why?

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   b) Where do you find the unit of light to be the least intense? Why?

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3) Your discussion in 1 and 2 Part 3 above should lead you to propose why there are seasons on earth. Using this information describe the relationship between earth's seasons and angle of incidence of sunlight.

4. Are other reasons why earth has seasons? List below any other reasons you can think of.

PART IV: Experimental Design

There are a number of changes that could be made to improve the accuracy of the experiments you carried out. List ideas your lab group would suggest to improve the experimental design and indicate why your ideas should improve the accuracy of the results.

TEACHER'S GUIDE

CONSTRUCTING A SCALE MODEL OF THE SOLAR SYSTEM

The purpose of this activity is to discover the relative sizes of the planets and the Sun; and provide the students with perhaps their first opportunity to work with scaling and models.

The planets of the solar system fall into two categories — the terrestrial planets, also called planets of fire, and the Jovian planets, called planets of ice. The four planets closest to the Sun (Mercury, Venus, Earth, and Mars) are all rocky, dense, relatively small, and therefore earth-like or terrestrial. The Jovian planets consist of the next four planets out beyond Mars. These planets (Jupiter, Saturn, Uranus, and Neptune) are large, less dense, and gaseous in composition. Pluto is not included as either terrestrial or Jovian but is apparently more like the terrestrial planets.

Each planet is roughly twice as far from the Sun as the next inner one, leading to what is known as the Titius-Bode rule. This rule holds true, except for an apparent missing planet between Mars and Jupiter. It is here where we find the asteroid belt. This asteroid belt has lead many scientists to think that the asteroids are either a planet that exploded, or a small mass that never accreted the way the other planets did.

This lab requires that a variety of different art materials be on hand. Once the initial scaling is done and the planets are in position, have the students be as creative as possible in giving the planets characteristics, like rings, moons, clouds, and what ever information they can dig up on the planets by looking in their books or other reference material. Actual pictures of each planet also enhances their creativity.

ADDITIONAL INSTRUCTIONS

1. Students should work in pairs or small groups.
2. The teacher might construct a partial model of the sun.
3. Attach the partial model of the sun to one wall, and allow each groups final scale model to radiate away from it.
4. Stress to the students that while both the relative sizes of the planets is to scale, and the distance from the Sun is to scale, that the two scales are different. If the scale for the planetary distances was identical to the scale for the planetary diameters, the distances between the model planets would be much greater.

CONSTRUCTING A SCALE MODEL OF THE SOLAR SYSTEM

PURPOSE: To construct a model of the solar system using scaled distances.

OBJECTIVE: To see the relationship between the sizes of the planets and the Sun.

MATERIALS:
3 meters of adding machine tape
1 compass
1 meter stick
2 scissors
1 glue or tape
various art materials---construction paper, markers, crayons, pens, tinsel, etc.

Procedures:

1. Draw circles on the construction paper to represent the 9 planets. Use the scale given below to draw the correct diameters.

   NOTE: some of the diameters are too small to use the compass. Use the meter stick to see the length of the diameter and estimate your circle from it.

   Remember: to use a compass you must know the of the circle. To find the radius, divide the diameter by two.

PLANETARY DIAMETER SCALE

Planet	**Diameter (km)**	**Scale Diameter (cm)**
Mercury	4,880	0.5
Venus	12,108	1.2
Earth	12,760	1.3
Mars	6,600	0.7
Jupiter	143,200	14.3
Saturn	120,000	12.0
Uranus	50,000	5.0
Neptune	49,400	4.9
Pluto	2,900	0.3

2. Glue the 'planets' onto the adding machine tape in the correct order, using the distances listed in the chart below.

PLANETARY DISTANCE SCALE

Planet	Distance from the Sun (km) (millions of km)	Scale Distance (cm)
Mercury	58	2.9
Venus	108	5.4
Earth	150	7.5
Mars	228	11.5
Jupiter	778	39.0
Saturn	1420	71.0
Uranus	2870	143.0
Neptune	4490	225.0
Pluto	5980	300.0

3. Show the position of the asteroid belt on the adding machine tape.

4. Next to each planet, write two particular facts about the planet.

5. Be creative, use any reference source to have to add to your planet (moons, color, features, rings, etc.)

Questions to Answer

1. Calculate the scale used for planet sizes.

2. What is the scale used for planetary distances?

3. Four of the planets are called 'planets of fire', and four are called 'planets of ice'. Which of the planets do you think are planets of fire? Which are planets of ice?

4. Why are they called planets of fire and ice?

5. Why have most of our efforts to find extra-terrestrial life in the solar system focused on Mars? In other words, what makes it a more likely candidate than the other planets?

6. Name the four terrestrial planets.

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7. Name the four Jovian planets.

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8. Describe in your own words the differences between the terrestrial planets and the Jovian planets.

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9. What is unusual about the size, density, and location of Pluto?

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TEACHER'S GUIDE

THE BALLOON IN THE BOTTLE

This laboratory activity is ***definitely*** a discovery oriented lab with a discrepant event. The degree to which the discovery aspect is enhanced will depend entirely on the approach the teacher takes in presenting it.

This activity ideally begins with a teacher initiated activity. As the students enter the classroom they find a glass bottle on their desk. Over the neck of the bottle is stretched an ordinary balloon. But the balloon body is ***inside*** the bottle and is slightly inflated. Students must be advised not to touch the rim of the bottle or in any way poke or try to dislodge the balloon. Instead they are to make as many observations as possible. They may ask the teacher as many questions as they like but the only response should be a yes, or a no. Try not to give the secret away. They should come up with several hypotheses as to how the bottle got into the bottle in an inverted position. When all student generated possibilities are exhausted, give them a lab sheet and let them try the lab on their own, either testing their own hypothesis or using one of the methods below.

There are several ways to actually do the lab. These different ways are listed below:

1. Heat chemical glassware over a Bunsen burner or hot plate and then put the balloon over the rim. Let it cool.

2. Put any type of bottle with a narrow rim in a pan of hot water, let sit for a few minutes, and then put the balloon in place and let it cool.

3. Pour hot water into a bottle, let sit for a few minutes, then pour the water out and put the balloon in place and let it cool.

4. Put the balloon on the bottle first, heat the bottle and observe what happens. Then put the bottle in ice cold water and make more observations.

5. Repeat #4 only use chemical glassware and the Bunsen burner.

   Above all HAVE THE STUDENTS USE CAUTION AS THEY ARE WORKING WITH HOT MATERIALS. Have a supply of mitts or pot-holders available.

THE BALLOON IN THE BOTTLE

PURPOSE: To discover how the balloon got into the bottle.

OBJECTIVE: To show that air pressure always attempts to equalize.

MATERIALS:
1 glass bottle (small soda bottle)
1 10" round balloon (blown up once to stretch)
1 container of hot water to pour into bottle
1 container of hot water to place the bottle in
1 container of cold water to place the bottle in
2 pot-holders

Procedures: *Trial #1*

1. Get a container of hot water, as hot as you can safely handle it.
2. Pour the hot water carefully into the glass bottle all the way to the top. Let it sit for approximately 2 minutes.
3. Quickly and carefully (using the pot-holders) pour the hot water out and immediately place a balloon over the rim of the bottle.
4. List your observations on the data sheet.

Procedures: *Trial #2*

1. Get a container of hot water large enough to place the bottle in to a depth approximately 3/4 of its height.
2. Place the balloon over the rim of the bottle and put it into the container of hot water.
3. List your observations on the data sheet.
4. After 4 minutes take the bottle out of the water and let it cool down for 5 minutes. Make observations on your data sheet.
5. Place the bottle into another container of cold/ice water. Make observations on your data sheet.

Procedures: *Trial #3*

1. Repeat the above experiment only this time do not put the balloon on the bottle until it has been in the water for 5 minutes.

DATA SHEET

TRIAL #1

TRIAL #2

TRIAL #3

Questions to Answer

1. Before you did the experiment: What was in the bottle?

2. In trial #2, why did the balloon inflate itself?

3. What caused the balloon to deflate?

4. What does air do when it is heated?

5. Think carefully! Is there more or less air in the warm bottle compared to the cold bottle? Defend your answer.

6. When the bottles have been warmed and the balloon is in place, where is air pressure the greatest?

7. Why does the balloon appear to inflate itself inside out inside the bottle? How does this relate to air pressure?

TEACHER'S GUIDE

WHY THE WINDS BLOW

Air touches all parts of the surface of the earth. And because the surface of the earth heats unevenly, the air touching it is heated unevenly also. Cold air is more dense than an equal volume of warm air, so the cold air is pushed down by gravity toward the earth more strongly than the warm air. As the cold air is pushed down, it pushes the warm air out of the way and upward. This causes wind.

This laboratory activity is designed to support this fact. The students will construct a simple convection chamber, make hypotheses, and then test their hypothesis.

Care must be taken in this activity to prevent the clear plastic material used from coming in contact with the flame. If this happens, the plastic will melt.

WHY THE WINDS BLOW

PURPOSE: To show that air is in constant motion.

OBJECTIVE: To demonstrate convection currents in the air by constructing a simple convection chamber.

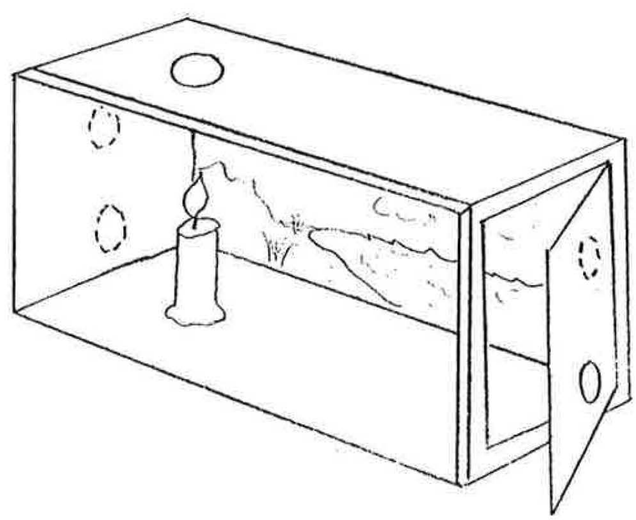
MATERIALS:
1 medium shoe box (lid not required)
1 1.5 inch tall candle or birthday candle
1 1.5 square feet of cellophane or plastic wrap
2 paper towels
1 sharp knife
1 set of colored markers
1 book of matches
1 roll of cellophane tape

Procedures:

1. On the inside bottom of the box draw and color a scene of a seacoast showing both land and water.

2. Cut the end of the box by the water to make a hinged door. Opening must be large enough for you to put your hand in.

3. Using a drop or two of candle wax position the candle in place approximately 1.5 to 2 inches from the land end of the box. Refer to the diagram below.



4. Cut two holes the size of quarters, one directly over the candle, and the other near the bottom of the hinged door. If the candle falls off, replace it after cutting the holes.

5. Cover the top of the box with cellophane or plastic. Try to keep it stretched as tight as possible. Tape it in place on all sides.

6. Carefully light a match, extend it into the box being careful not to touch the plastic. Close the hinged door as tightly as possible. If the door does not fit snugly, seal it with some tape.

ANSWER ANY QUESTIONS BELOW AS YOU PERFORM THE EXPERIMENT

7. Dampen a paper towel SLIGHTLY by sprinkling it with some water, and set it on fire for a moment.

8. Blow out the flame. The dampened towel will smolder and give off smoke.

What do you think will happen as you hold the paper towel by the opening in the bottom of the door? Write your answer in the form of a hypothesis.

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9. Hold the smoldering paper near the hole in the bottom of the door. List your observations below.

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10. Did you support or did not support your hypothesis from 8 above?

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Write a new hypothesis if necessary and repeat the experiment.

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Questions to Answer

1. What happens to the air over the land?

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2. What caused the smoke to enter the chamber and be pushed up and out the top?

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3. Describe the difference between air over land and air over the water during the day. Why does this difference occur?

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4. Describe any relationship between the movements of the smoke in the box and the wind outside.

LABORATORY EXTENSIONS

If time permits try the following variations. Make a prediction of what you will observe ***before*** you actually try these. Remember that you must blow the candle out making ***before*** any adjustments to the model.

1. Cover the hole in the door. Make a hole in the top of the door and repeat this experiment.

2. Cover all the holes in the door. Make a hole on the other side of the box at the bottom. Repeat the experiment.

3. Cover the hole in the bottom (on the land side) and make a hole at the top. Repeat the experiment.

Question to Answer

1. Make a general statement to explain what you observed in all the different ways this experiment was done. One statement for all four variations combined.

TEACHER'S GUIDE

AIR — EXPANSION BY HEAT

This laboratory activity will explore how heated air expands and the resulting air pressure effects.

The burning candle under the glass causes the air inside the glass to heat up. The molecules of air in this state are not as closely packed together than they were at room temperature as they expand in response to the change in temperature. At this point the students will observe bubbles of air escaping underneath the glass. The expanded air is forced out of the glass. Then, when the candle goes out, the air inside the glass immediately starts to cool off. This causes a decrease in air pressure as the volume of air begins to cool and contract. But there is now less air in the glass than there was at the start of the experiment. The cooling and contraction of the remaining air in the glass causes the water to be pushed up under the glass. The water will replace the volume of air lost due to heating and expansion.

Note: It is true that the flame of the candle burns the oxygen in the glass. But the by-products of combustion; carbon dioxide, water vapor, and smoke, replace the oxygen lost by combustion. Therefore, the oxygen loss is not responsible for the water being pushed up into the glass.

This lab is best presented as a discovery lab. Depending on the knowledge of the students, the first observation made falls neatly into the category of the discrepant event. Most students do not expect the water to be sucked up under the glass. Students will want to do several trials of this activity to see if they can make the water rise even higher. It is strongly advised that they be allowed to do so.

AIR — EXPANSION BY HEAT

PURPOSE: To discover what happens when air is heated in a confined space.

OBJECTIVE: To determine the relationship heat has on air pressure

MATERIALS:
3 identical shallow flat bottomed plates
3 glasses or pint jars (lip must be smooth)
7 birthday candles
1 book of matches
60 ml colored water (may need to be remade during the lab)

Procedures:

1. Attach the candle to the bottom of the plate in the center with a drop of melted wax.
2. Fill the plate with approximately 20 ml of colored water.
3. Light the candle, invert the glass, and cover the candle immediately with the glass. Observe carefully!
4. Draw a sketch below showing the experiment before you lit the lit the candle and after the flame went out.

5. List below all the observations you made of the experimental results. Observe very carefully and record everything you notice.

6. State a hypothesis to explain what you observed.

7. Try the experiment 2 or 3 times more to verify your observations. If you wish to change your hypothesis restate your new hypothesis below.

Questions to Answer

1. Why did the water level under the glass rise?

2. What does the candle need in order for it to burn?

3. Did the water level under the glass rise immediately after covering? Why?

4. What did the heat of the flame do to the air under the cup?

NOTE: Air is matter and because of this it has both volume and mass. The force that air exerts on an object per unit area is called air pressure.

5. After the flame goes out where is the air pressure the greatest? the least?

EXPERIMENT EXTENSIONS

1. Try the lab again but this time set up 3 plates and jars. Place one candle in the center of one plate, two candles in the center of another, and three candles in the last plate.

2. State a hypothesis of what you expect to happen in each of the glasses.

3. Place 30 ml of colored water in each plate.

4. Light all six of the candles and wait for them to burn evenly.

5. Invert the glasses and place all three over the candles at same time.

6. Record your observations below.

Questions to Answer

1. Under which glass does the water level rise the highest?

2. Why did we use identical plates, glasses, and candles?

3. Why do we need to use the same amount of water in each of the plates?

4. Compare each of the three lab set-ups before you. Which of the experimental variables is changed from one to another?

5. Above which plate did heat develop most? Why?

6. Was the amount of air trapped under the cups the same for all three? Why?

7. Why do you think the water level rose the highest under the glass with three candles?

8. Under which glass was the air pressure the least? Why?

TEACHER'S GUIDE

INTRODUCTION TO TOPOGRAPHIC MAPS

Topographic maps are small scale drawings of a part of the earth's surface. Each topographic map shows location, elevation, and landscape features as well as cultural features. Landscape features include, rivers, lakes, hills, valleys, and plains. Cultural features are man-made features like dams, roads, bridges, cities, and mines. The most important symbol on a topographic map is the contour line. A contour line connects points of the same elevation on the map. If you could walk along a contour line you would never increase or decrease your elevation.

The purpose of this laboratory activity is to actually involve the student in making a scaled topographic map and analyzing an actual topographic map. Topographic maps are especially useful in understanding terrain as well as geologic features. They can often provide clues as to how the land was formed. This activity will provide the students with experience in measurement, scale reading, and contour lines.

The materials needed for this lab are a contour tank. If several are not available any vertical walled clear container will do. The students must be able to mark scale lines up the side of the tank. Students must also be provided with an object to map. Preferably a rock or other object that is irregular in size and shape.

An interesting extension of this lab is to have the students mix up the maps and trade them. Then have them try to match each map with the appropriate model.

INTRODUCTION TO TOPOGRAPHIC MAPS

PURPOSE: To construct and evaluate a scale model of a topographic map. To evaluate actual topographic maps.

OBJECTIVE: To locate and analyze landscape, relief, and cultural features found on topographic maps.

MATERIALS:
1 contour tank with lid and model or rock
1 overhead projector pen
2 transparency sheets
1 cm ruler
4-5 drops of food coloring (optional)
water — enough to fill tank to top
1 copy of a topographic map (preferably your area)

Procedures:

Part I: Making a Topographic Map

1. Take the overhead projector pen and the ruler and mark the side of the tank in 1 cm increments.

2. Make a small mark on each corner of the tank lid. Put the transparency sheet on top of the lid and make marks on it that correspond to the marks on the lid. This will ensure that the plastic is lined up every time with its original position on the lid.

3. Put the model in the tank and fill the cylinder with water. Then fill the tank with water to the 1 cm mark. Add a few drops of food coloring if instructed. This often makes it easier to see the contours.

4. Put the lid on the tank and place the transparency sheet on top of the lid.

5. Observe where the water touches the model. Carefully trace around the line make where the water comes in contact with the model. BE SURE NOT TO GET THE TIP OF THE PEN WET.

6. Take the lid off the tank and add another 1 cm of water

7. Repeat the procedures above until the tank is full or until the model is entirely covered with water.

Questions to Answer

Examine your contour map and compare it to the model you traced around to make it.

1. What happens to the land when the contour lines get close together?

____

____

____

2. What happens to the land when the contour lines get farther and farther apart?

____

____

____

3. If you could walk around on one of your contour lines, would you increase or decrease your elevation as you made one continuous walk around your map? Why?

____

____

____

4. Why doesn't the map you made look exactly like your model?

____

____

____

5. How do you explain why the map came out looking like concentric circles?

____

____

____

Procedures:

Part II: Analyzing a Topographic Map

1. Obtain a copy of a topographic map from your teacher and answer the questions below.

   a) What color are the contour lines, water, vegetation, roads, township lines, and cultural features?

   ____

   ____

   ____

   ____

   b) Find a hill or mountain on your map. Tops of hills or mountains can be identified by closed loops at the end of a rising series of contours. Where contour lines are close together, the slope of the ground is steep. Where lines are far apart, the slope of the ground is gentle. How high is the hill or mountain on your map?

   ____

   ____

   ____

   c) What major symbols are used on the map to show the location of cultural features such as houses, schools, and churches?

   ____

   ____

   ____

d) Look for other symbols. What interesting symbols can you find on your map?

____

____

____

e) In what direction do the streams flow? (Wherever contour lines cross a stream, they bend upstream.)

____

____

2. How far above sea level would you be if you climbed to the highest point shown on your map?

____

3. Where is the lowest point?

____

4. Traveling by road, what is the distance between the highest point and the lowest point?

____

5. How many feet would you descend if you walked from the highest point to the lowest point?

____

6. Where is the steepest slope shown on your map?

____

7. In which direction does the largest stream on your map flow?

____

8. How many feet does the smallest stream on your map descend?

---

9. Take the other sheet of transparency plastic and place it over a stream. On the sheet, using the overhead projector pen, outline the land area that would be flooded if the stream rose 50 feet.

TEACHER'S GUIDE

CONSTRUCTING TOPOGRAPHIC MODELS OF MT. ST. HELENS BEFORE AND AFTER THE MAY 1980 ERUPTION

It takes time to cut out the contour templates. Therefore this lab takes several days. If time is a factor you might consider having half the class make the 'before" model and half the class make the 'after' model. Recommended group size is 4 and at least half the group members should have an Exacto knife.

This lab is a useful tool for teaching a unit on contour maps and provides the students with a way to visualize the meaning of contour lines. It actually serves a dual purpose in that it can be used to teach contour lines and volcanic features and processes. The students will be making both a 3-dimensional and 2-dimensional model of Mt. St. Helens.

The directions are a bit complicated and the post-eruption model involves some tricky maneuvers since the center point is template. Therefore this point should be stressed in the pre-lab discussion.

This lab has been reduced 30%. Should you wish to, it can be enlarged back to its original size. This will make it fit exactly onto a 1:24000 topographic map of the mountain.

CONSTRUCTING A TOPOGRAPHIC OF MT. ST. HELENS BEFORE AND AFTER THE MAY 1980 ERUPTION

PURPOSE: To construct a true to scale, three dimensional model of Mt. St. Helens before and after the May 1980 eruption.

OBJECTIVE: To discover the relationship between a 2-dimensional contour map and a 3-D model of the map.

MATERIALS:
1 set of templates (pre and post-eruptive)
1 12" by 12" piece of 1/4" cardboard
1 24" by 36" sheet of 1/8" cardboard
2 to 3 Exacto knives
1 bottle of glue
2 pairs of scissors
1 ruler
2 pencils
1 5" nail
1 toothpick

Procedures:

Part 1: Constructing the Models

SAVE ALL PAPER TEMPLATES FOR PART II

THE PRE-ERUPTION MODEL

1. The models you are about to make are true-to-scale. This means that they will have no vertical exaggeration, and will provide you with an excellent representation of the mountain before and after the eruption.

   NOTE: Your model will start at the 4,700 ft. level.

2. Cut out a 12" by 12" piece of 1/4" cardboard, this will be the base contour (4,700 ft.). On one face of the cardboard, draw two lines which divide it into four equal quadrants (lines intersect at right angles, each line is 6" from the edge).

3. Label one line at the top of the cardboard "N" for north.

4. In the intersection of the two lines stick the nail up through the cardboard perpendicular to the board. Your cardboard templates will be placed over this nail.

5. Cut out the contour templates for the 5,200 West and East. CUT OUT ONLY THE PRE-ERUPTION TEMPLATES!

6. Place the 5200 West contour on the 1/8" cardboard and trace the outline on the board. Label this "5,200 ft. West" on the inside of the tracing. Be sure to trace the north arrow and the centering mark.

7. Repeat this for the 5,200 Ft. East. (Both west and east pieces could be done as one if your cardboard is big enough).

8. Cut out the cardboard along your tracing line. Gently push the a toothpick through the centering mark to make a small opening.

9. Place both of the 5,200 ft. cut-outs on to the mountain base and center the opening over the nail. Align the north arrows of the cut-outs with the north arrow on the mountain base.

10. Glue these pieces to the base.

11. Repeat steps 5 through 10 for each successive contour template. Save all paper templates!

THE POST-ERUPTION MODEL (4,700 TO 6,200 FT.)

1. Follow steps 2 through 5 above.

2. CUT OUT ONLY THE POST-ERUPTION TEMPLATES. Cut the templates from the 5,200 ft. level to the (and including) 6,200 ft. level. Trace the contours onto the 1/4" cardboard, cut along the tracing line, and label
each one as you did in the "Pre-eruption" model.

3. Using the centering marks and north arrows, position each of these contours onto the mountain base.

POST ERUPTION MODEL (6,700 FT. TO 8,200 FT.)

4. Cut out the 6,700 ft. template, BEING CAREFUL TO PRESERVE THE ENTIRE CENTERING MARK (IT IS OUTSIDE THE TEMPLATE) BY CUTTING ALONG THE DOTTED LINE. Trace the actual contour (solid lines) onto the cardboard, cut along the tracing line, and label.

5. Place the piece of paper with the template centering hole over the nail, aligning the template with north, and position the cardboard contour carefully within its cut-out boundaries. Lightly mark where the cardboard contour piece will go on the piece below and then remove the paper.

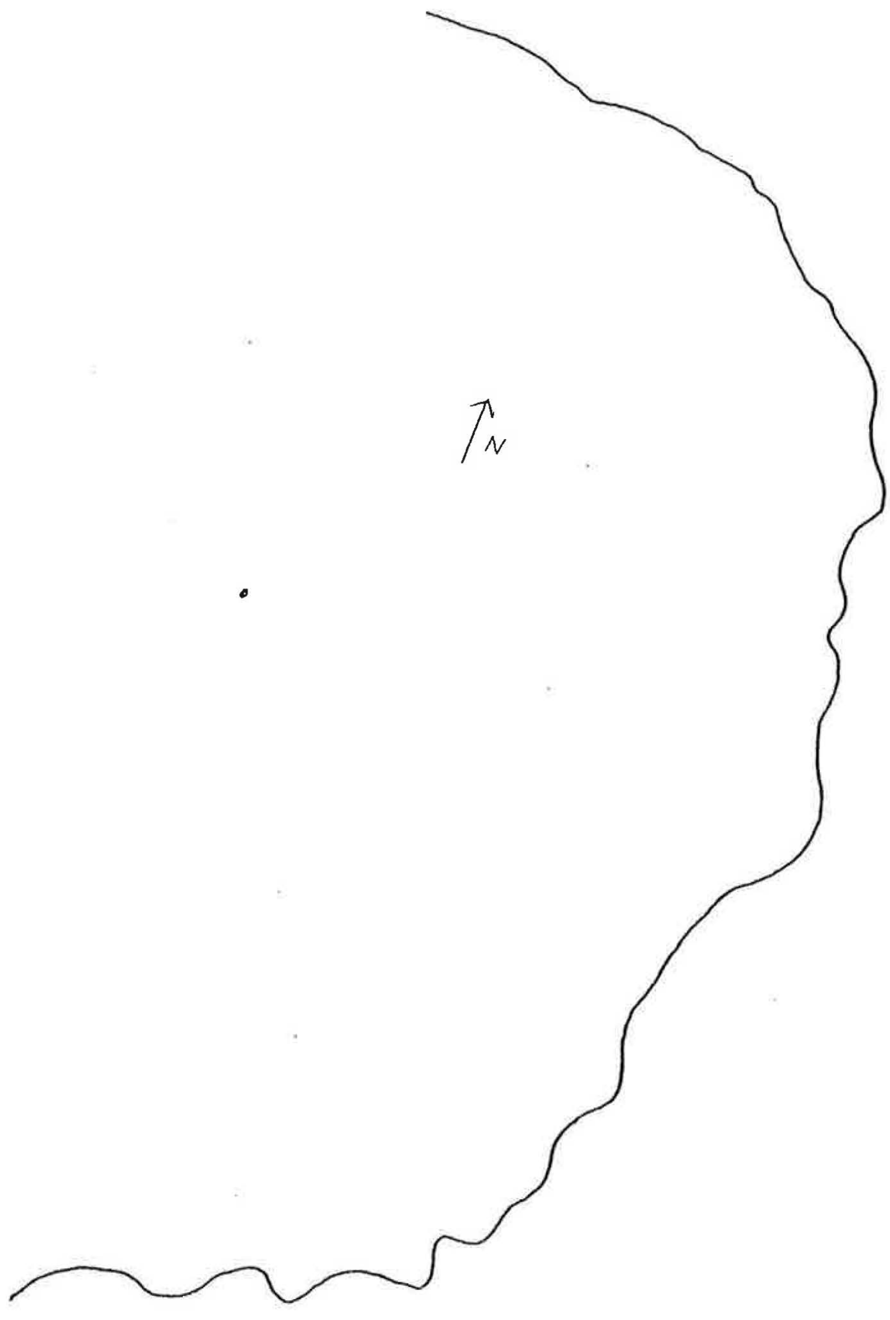
6. Continue this with each template until you have placed the 8,200 ft. cut-out.

Part II: Constructing the 2-dimensional model

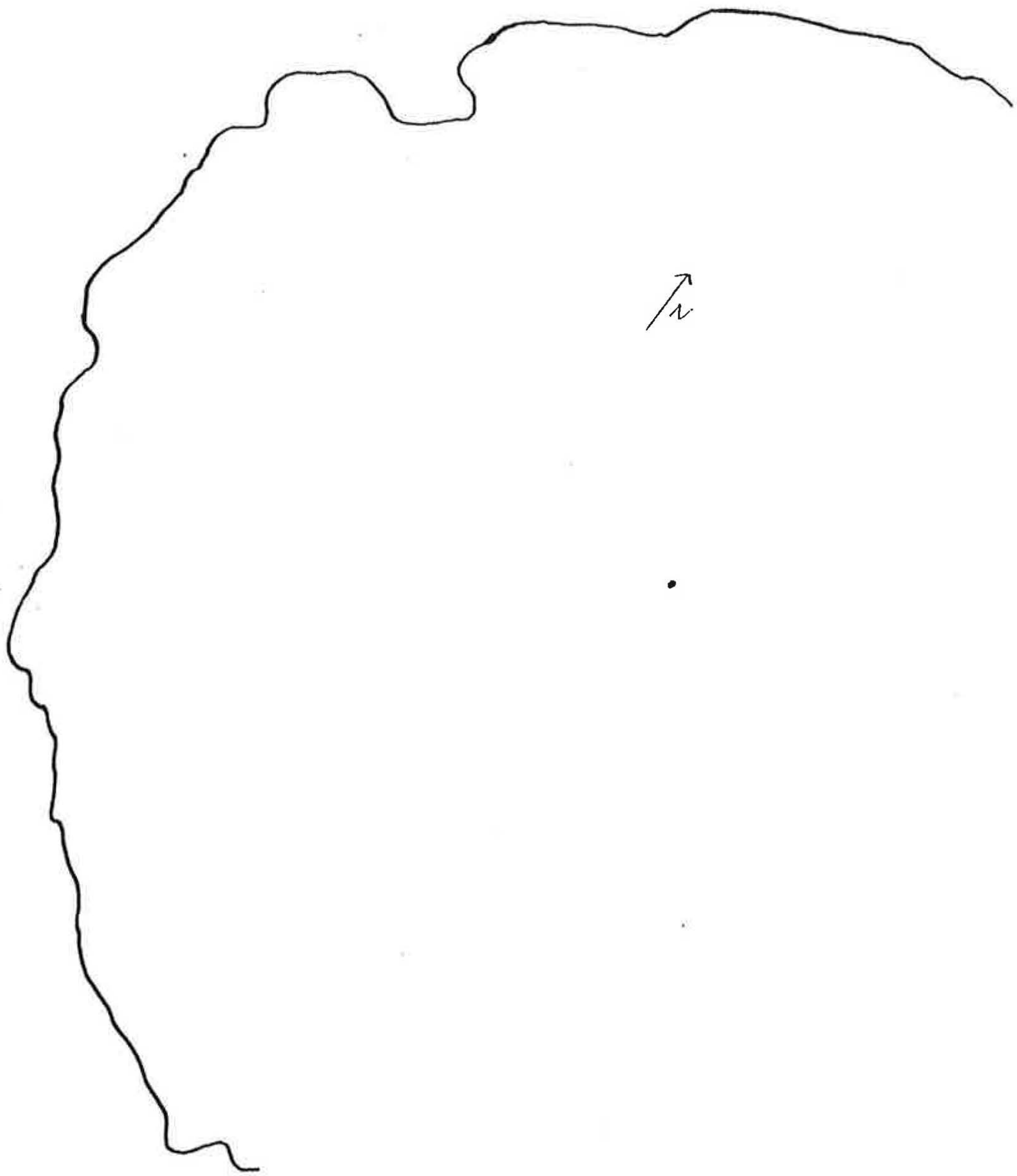
1. Using the center mark and north arrows as guides, tape together all of the pre-eruption templates.

2. Using the center mark and north arrows as guides, tape together all of the post-eruption templates.

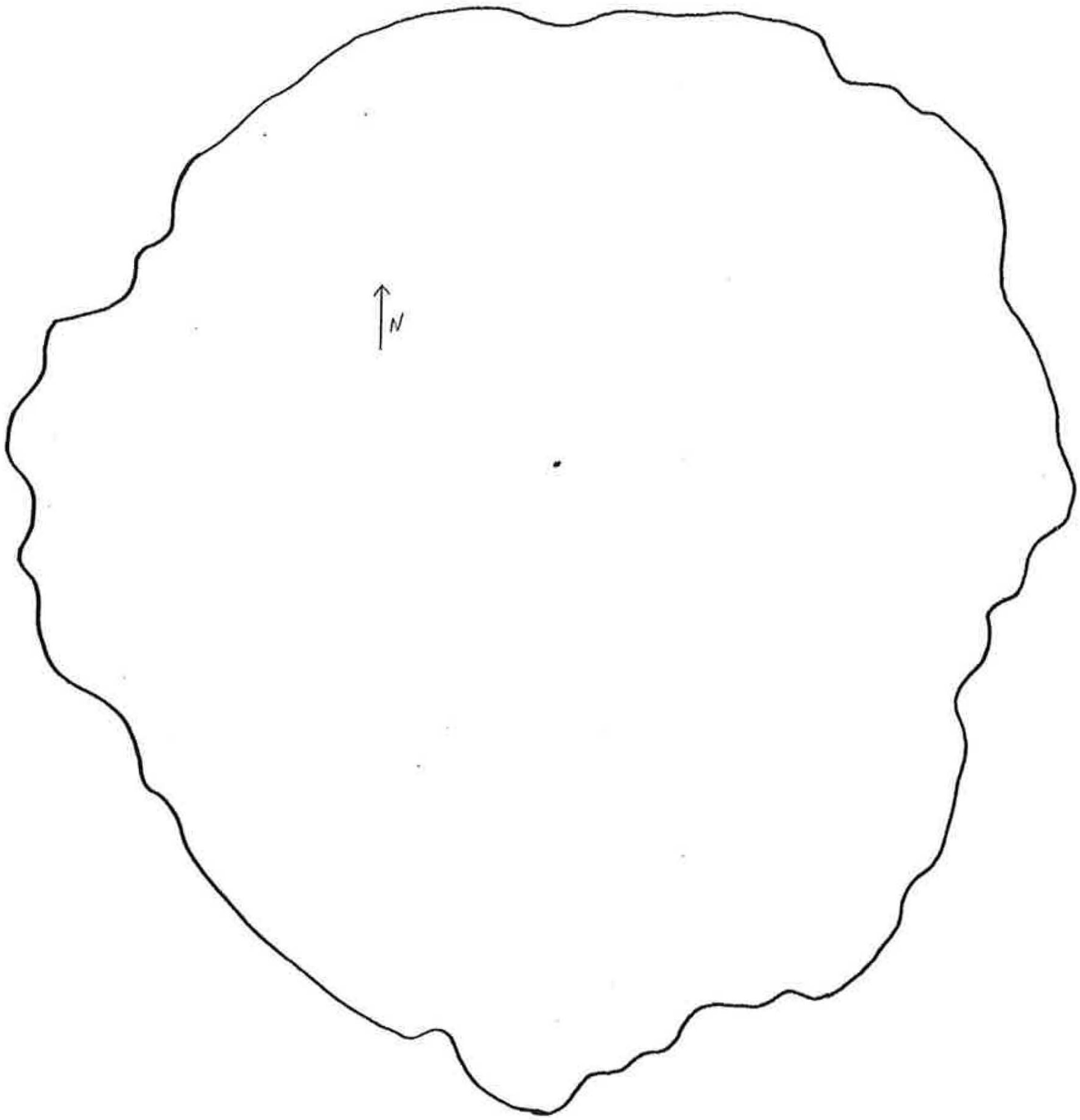
PRE-ERUPTIVE TEMPLATE



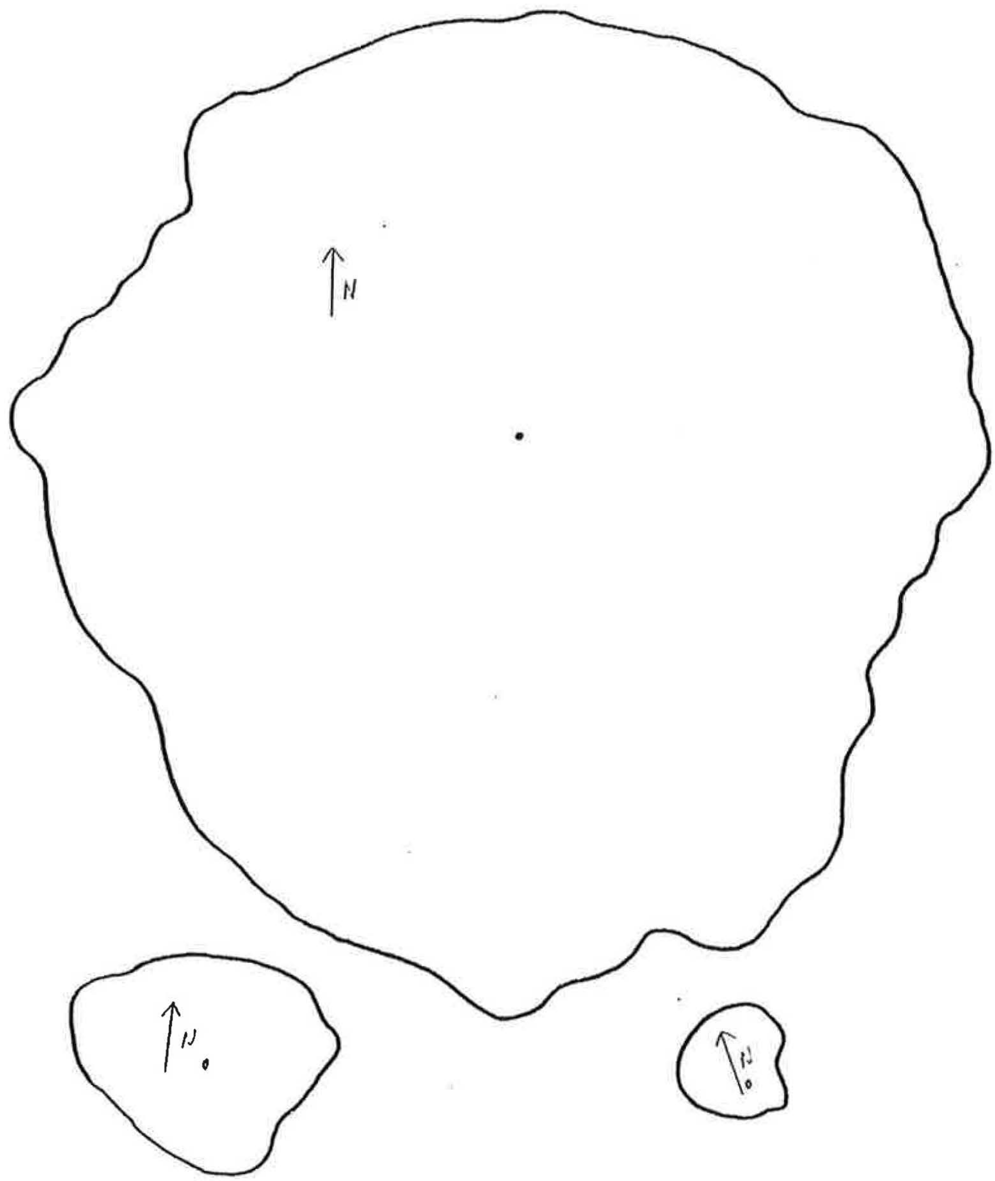
PRE-ERUPTIVE TEMPLATE



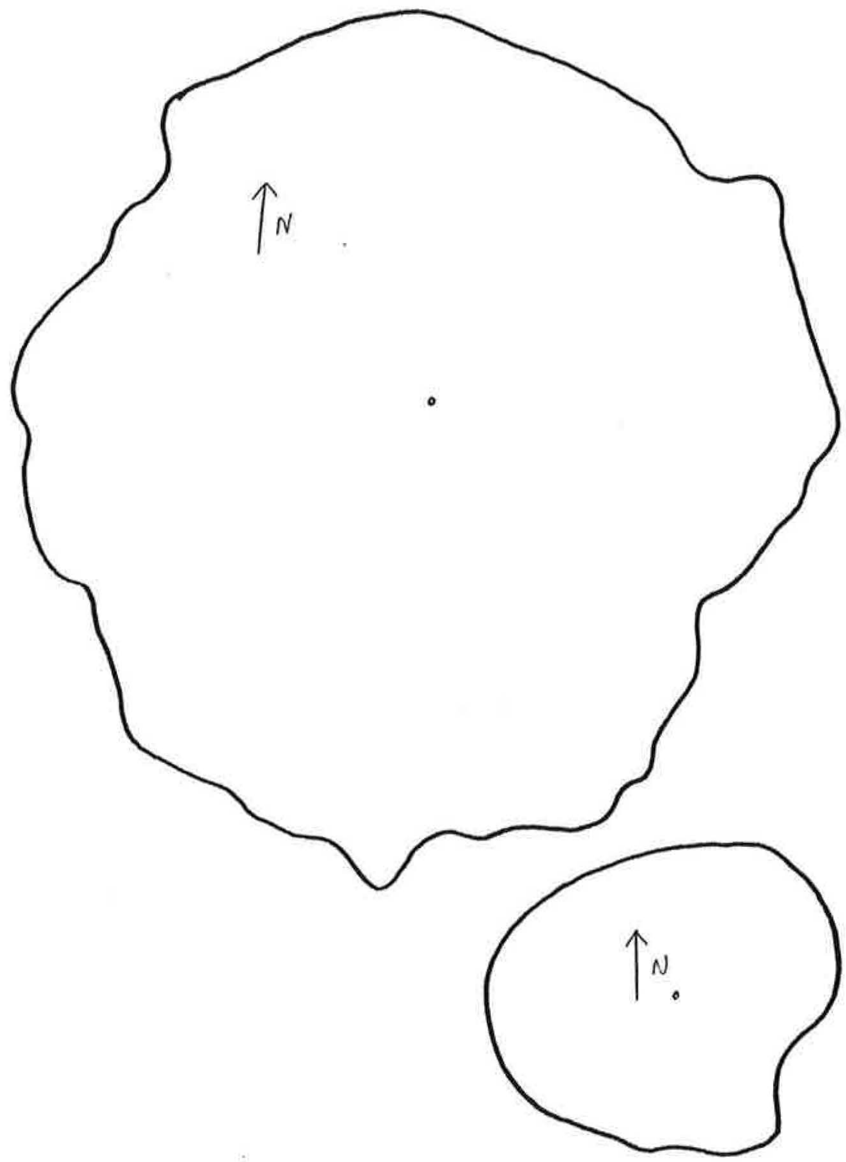
PRE-ERUPTIVE TEMPLATE



PRE-ERUPTIVE TEMPLATE



PRE-ERUPTIVE TEMPLATE



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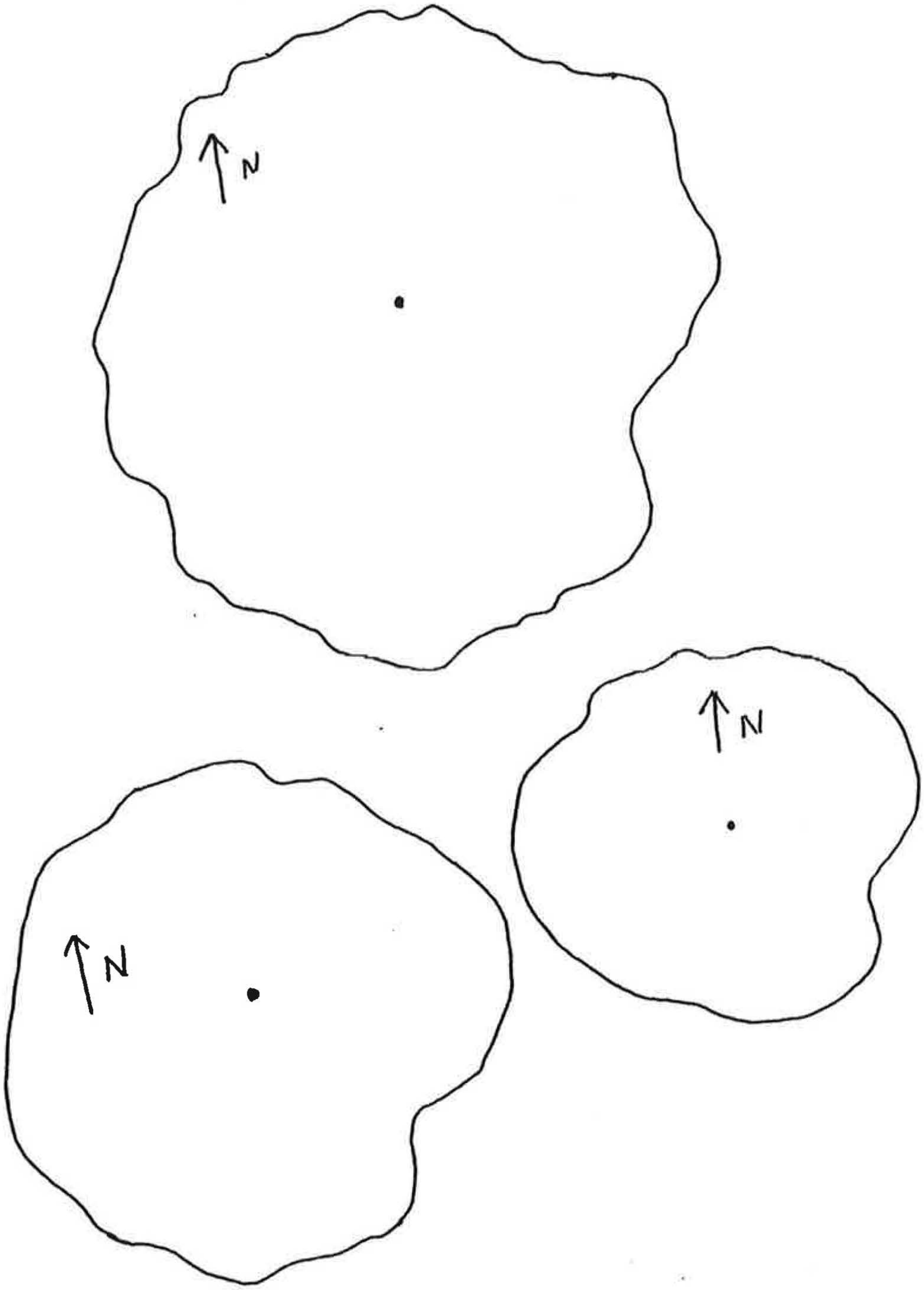
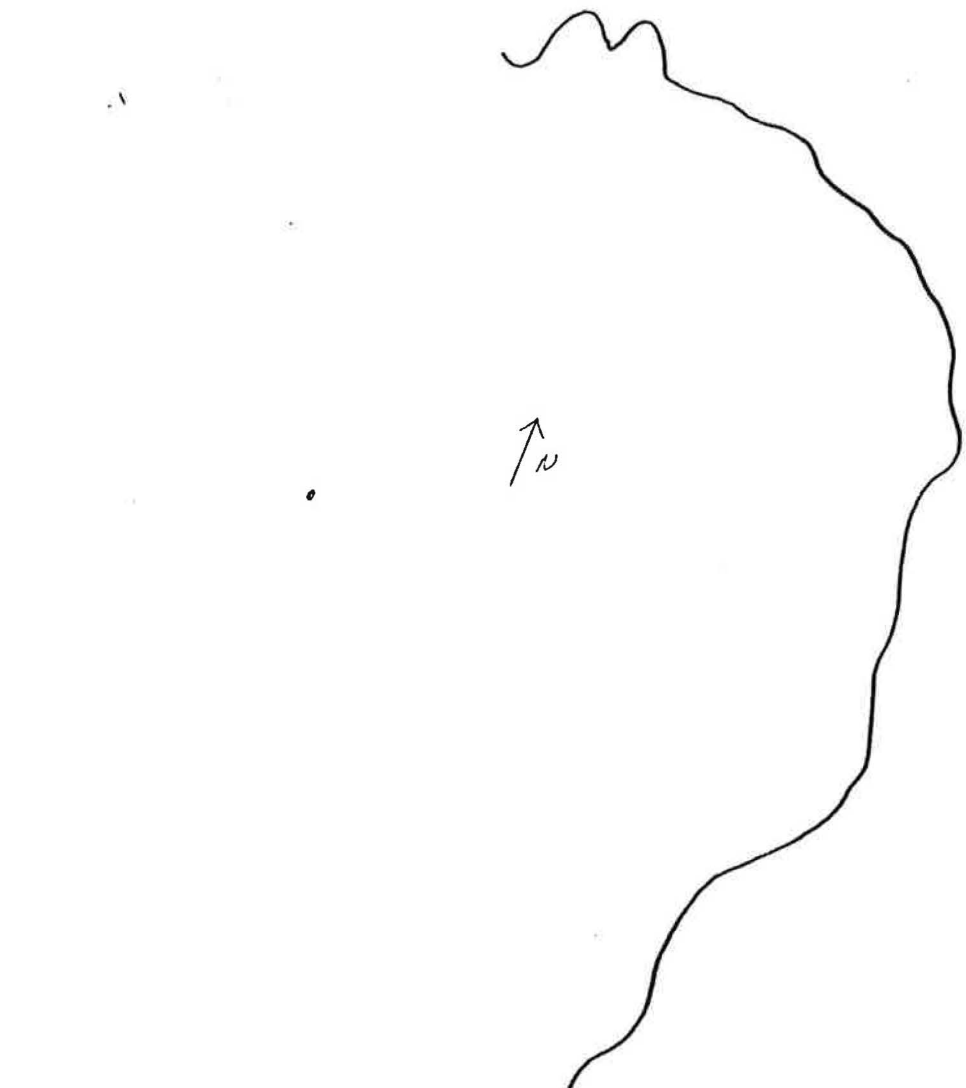
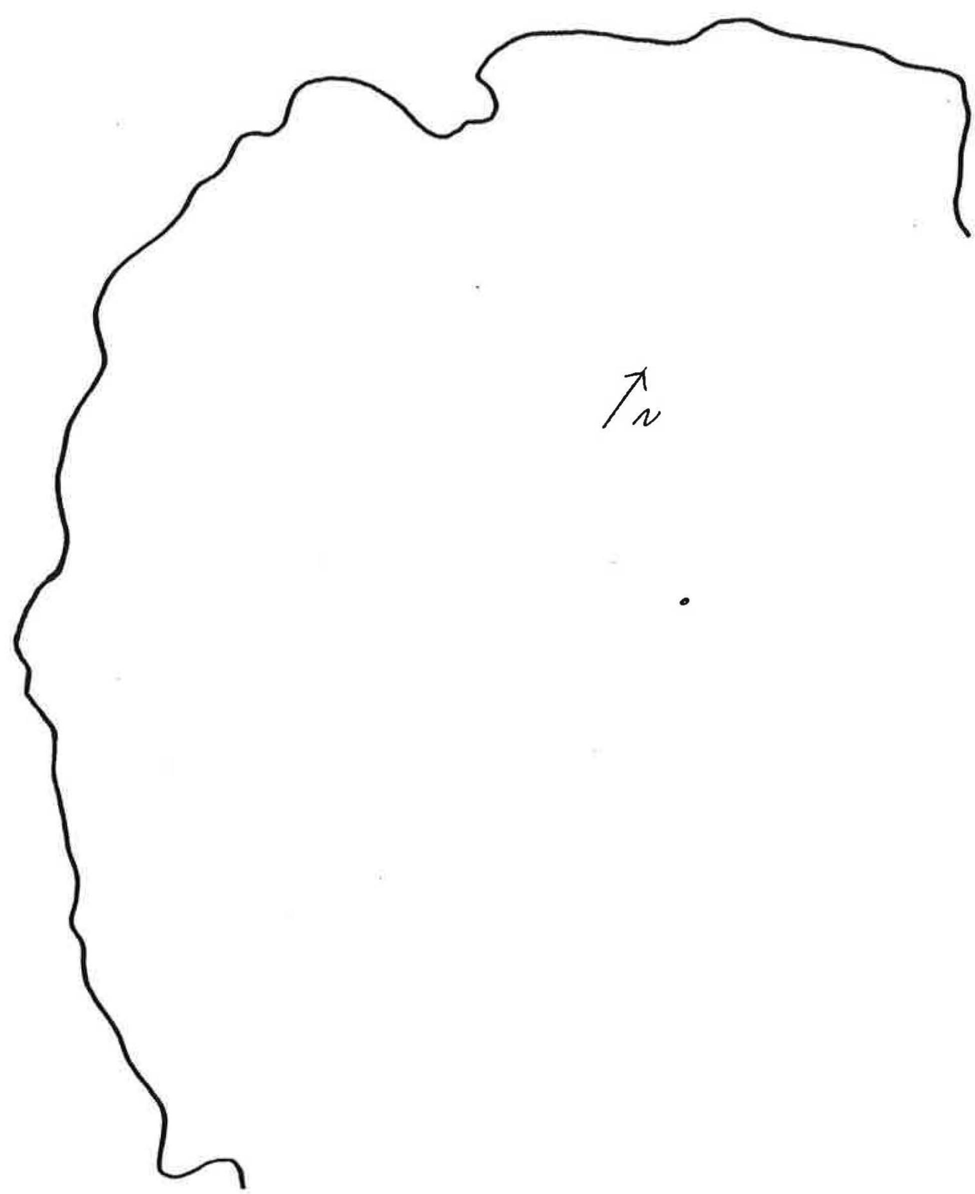


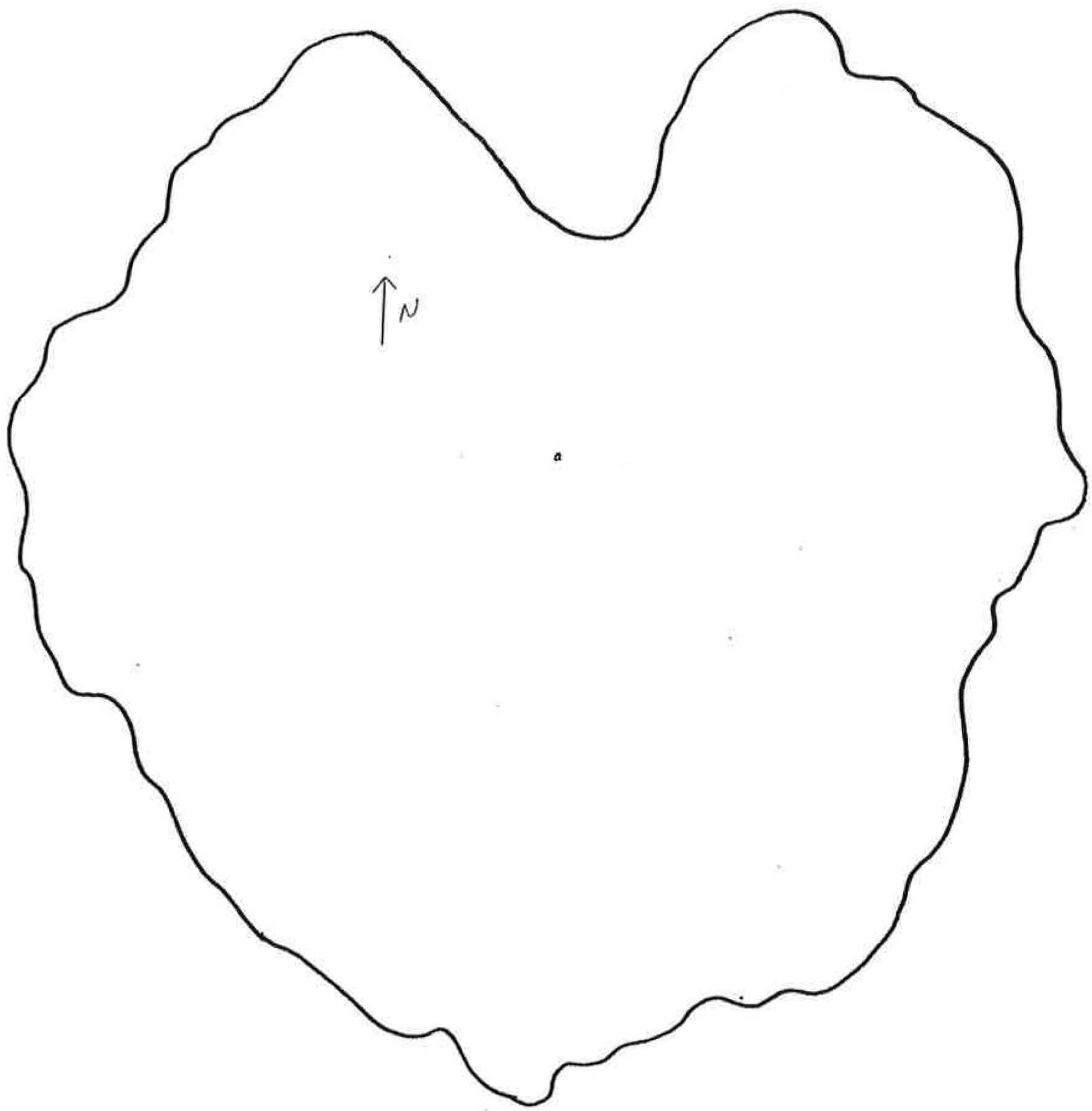
POST-ERUPTIVE TEMPLATE



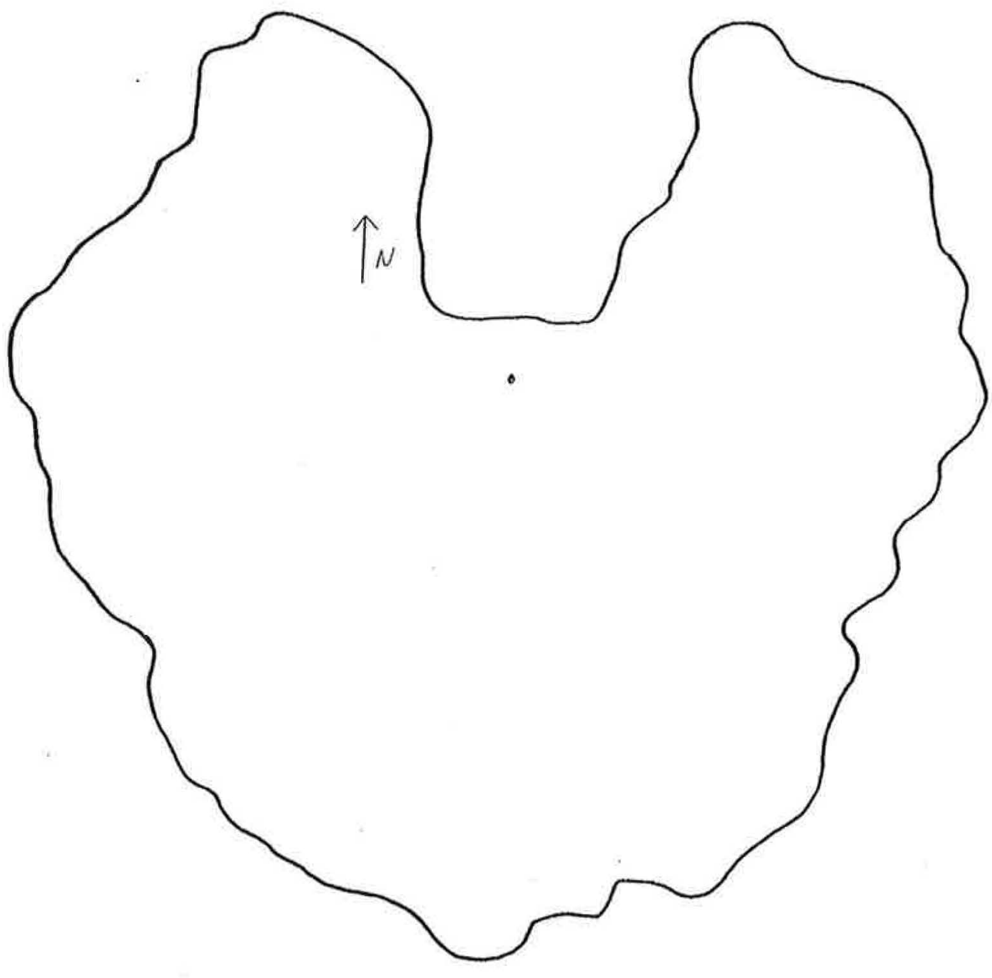
POST-ERUPTIVE TEMPLATE



POST-ERUPTIVE TEMPLATE



POST-ERUPTIVE TEMPLATE



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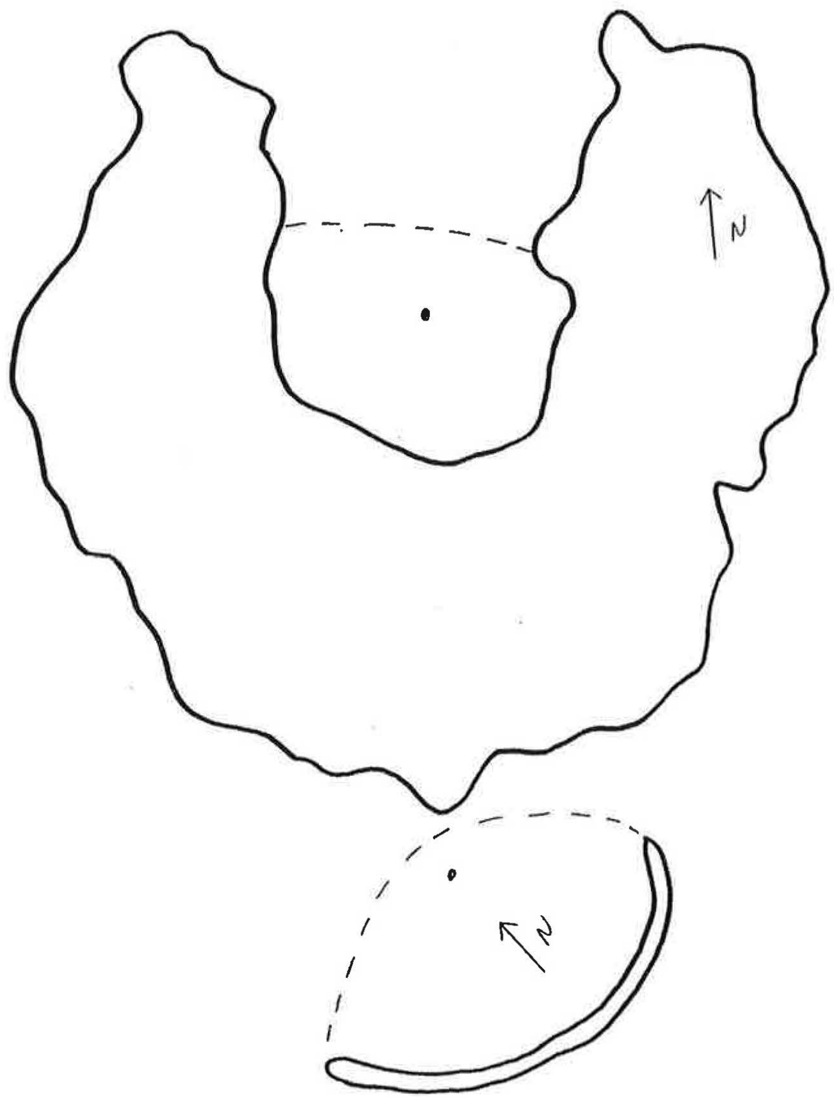

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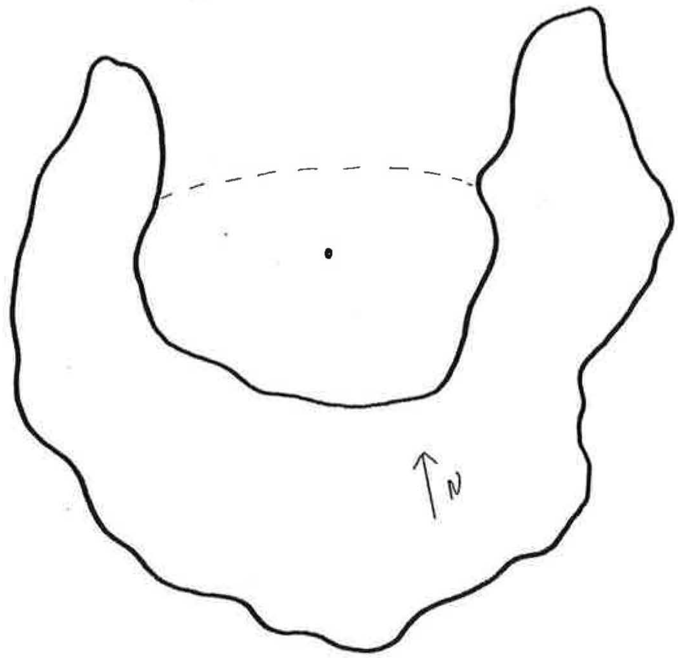
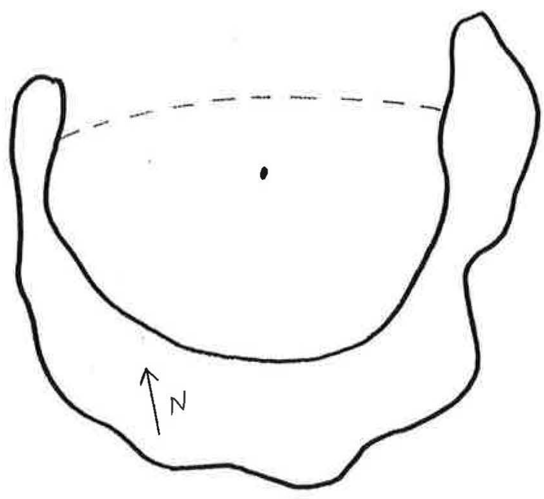




TEACHER'S GUIDE

SEDIMENTATION

The purpose of this lab is to learn about physical properties that control the deposition of sediments. Depending on your students, this lab may take more than one class period.

Sedimentary rocks form as the result of sediments settling through water from rivers, lakes, or oceans. These sediments are often pieces of pre-existing rocks, but they may also be in the form of microscopic shelled organisms from the oceans. Different sediments have different properties of density, size and shape which affect their rate of settling in water. The varying compositions of sediments combined with their different settling properties results in many types of clastic sedimentary deposits. If these sediments become consolidated, they form clastic sedimentary rocks.

When a mixture of sediment types is dumped into a still body of water, the different settling rates tend to sort out the sediments and the resulting deposits are layered according to sediment properties. With sediments of approximately the same composition, size will control the settling rate and the largest particles will reach the bottom first, followed by progressively smaller sized sediments. This layering effect is referred to as 'graded bedding' and can occur in quiet lakes where heavy loads of sediment are suddenly dumped into the water. In the case where sediments are of similar size, but vary in density, the denser sediments will deposit first. Size affects sediment deposition in that spheres settle the fastest, and platey sediments settle the slowest.

SPECIAL PROCEDURES AND SAFETY INSTRUCTIONS

1. You may want to explain the importance of keeping good records of the events being observed. Repeating each experiment is advised.

2. Part I may be conducted either as a demonstration or by the students. For this part use a vertical walled jar or cylinder instead of a settling tube.

3. You will need to prepare a mixed sediment sample to use in Part I. Try to find sediments that range from coarse to fine. Each group should have enough sediment to fill the bottom of the jar at least 2 inches.

4. If settling tubes are not available, use any clear glass or plastic cylindrical tube of approximately 500 to 1000 ml capacity. Use as large as a tube as you have available. If necessary, large test tubes can be used but they will have to be emptied and refilled often. It should be marked with two lines, one near the top and one near the bottom. These lines should be about 10 cm apart and will serve as start and finish lines during the timing.

5. Most objects fall through water very fast and this makes them hard to time. Use an inexpensive shampoo which is thicker than water. This will slow the settling velocity of the objects being measured and make it easier to calculate settling rates. It will also enable the students to be more accurate and make comparisons between the various settling times more obvious.

6. Settling tubes should be periodically emptied so that there is room enough on the bottom for objects to land.

7. Settling rates are usually measured in cm/sec. This laboratory activity is designed for students to determine the relative settling rates of falling objects. You may, as an extension, choose to have them actually calculate the settling rates. To do this they will use the distance between the start and finish lines as their distance.

SEDIMENTATION

PURPOSE: To discover all the physical properties that control the deposition of sediments.

OBJECTIVE: Sedimentation is dependent on the type, density, size, and shape of individual particles.

MATERIALS:
1 mixed sediment sample
1 small jar of water
1 settling tube or large test tube
Shampoo (enough to fill tube)
3 plastic spheres of different sizes
2 spheres of different materials, same size
(glass marble and plastic sphere)
1 small ball of plasticene clay
1 piece of paper
1 stopwatch

***Procedures**: Part I*

1. Your teacher will provide you with a mixed sediment sample. Do Part I in an area that will not be disturbed because you will leave it alone for awhile and return to it later.

2. Using the piece of paper, make a funnel that has a bottom opening approximately the same size as your jar containing the water and place it over the jar. Rapidly dump the sediment sample into the funnel. DO NOT PICK UP THE JAR OR DISTURB THE SAMPLE AFTER YOU HAVE RELEASED THE SEDIMENTS. Leave the jar and sediment alone and continue to Part II. At the end of Part II, observe the deposited sediments.

Procedures: *Part II*

In this part of the activity you will observe sediments of varying properties (size, shape, and density) settling in a fluid. As each object drops through the settling tube, someone in your group will measure the time it takes for each object to fall from the top mark on your tube to the bottom mark. Each test should be run at least two times so that you can be confident of your timing skills. When you have collected and recorded your data, draw some conclusions about the relative importance of each of the properties you tested.

1. Property being tested: ***sediment size***

Method: same — Test the settling times of three spheres composed of the material but of different sizes.

Materials: Settling tube filled with shampoo and 3 plastic spheres of different sizes.

Size of Sphere	Time 1st test	Time 2nd test	Time 3rd test
large	________	________	________
medium	________	________	________
small	________	________	________

Which sphere fell the fastest? ______________

the slowest? ______________

2. Property being tested: ***sediment density***

Method: but — Test settling times of spheres of similar size and shape, with different masses.

Materials: Glass marble and plastic sphere of same size.

Relative density of sphere	**Time** 1st test	2nd test	3rd test
more dense	________	________	________
less dense	________	________	________

Which sphere had the greatest mass? ____________________

Which sphere had the greatest density? ____________________

How did you determine which sphere had the greatest density?

____

Which sphere fell faster? ____________________________

3. Property being tested: ***sediment shape***

Method: Test the settling times of two or more objects with different shapes, keeping the size and density constant. To do this, divide your clay into two pieces of approximately the same size as the marble (roll into a ball to see if the sizes are the same). Then mold one piece into the shape of a disc or plate and leave theother as a sphere. Test other shapes as well.

Shape of clay	**Time** 1st test	2nd test	3rd test
sphere	________	________	________
disc	________	________	________
other	________	________	________
other	________	________	________

Sketch any additional shapes you tested:

Which shape fell the fastest? _______________ Draw this shape:

Which shape fell the slowest? _______________ Draw this shape:

4. Return to your jar of water and sediment from Part I.

   Is the water clear? _____________________________

   Sketch what you see:

Questions to Answer

1. What do you conclude about the relationship of particles\ of the same density and shape on settling time?

____

____

____

____

2. What do you conclude about the relationship of particles of the same size and shape on settling time?

____

____

____

____

3. What do you conclude about the relationship of particles of the same density and size on settling time?

4. Explain how settling time influenced the distribution of sediments in your jar.

5. The type of deposit found in your jar is known as graded bedding. Why do you think this term is used?

6. Where in the environment might you find evidence of graded bedding?

7. Why was the water in the jar with graded bedding still NOT clear after it had sat for a class period?

8. How would you expect this water to look tomorrow? Why?

9. What sediment property do you think is most influential of important in determining which sediment reaches the bottom first? Why?

TEACHER'S GUIDE

MODEL OF EARTH'S LAYERED STRUCTURE

In this activity the students will construct a scale model of a cross section of earth's layered internal structure. This activity could be used as an introduction to studying this structure so that students would correctly visualize the relative thicknesses and order of the layers.

Geologists have suggested that the earth's matter is distributed in layers. This idea is based on earthquake wave data. If we could drill all the way from the surface to the center of the earth, we would find that each of these layers is not uniform in thickness, physical properties, or composition. First we would drill through the crust, the thinnest of the earth's layers. Next, we would drill through the mantle. There are both solid and plastic sub-layers of the mantle. It is more dense than the crust and probably made of a type of rock not commonly found in the crust. To date, there has been no success in drilling through the crust to the mantle. The center of the earth contains the core, the thickest and most dense layer. The core also has two layers; a liquid outer layer, and a solid inner layer. Both of these layers are believed to consist of metallic iron and nickel. The core is also believed to be responsible for the earth's magnetic field.

This lab can be altered or enhanced by the following:

1. Introduce this activity with minimal discussion of the earth's layered structure.

2. Follow up this activity with detailed study of the earth's layered structure.

3. Follow or precede this activity with one on earthquake waves.

4. Use this lab in conjunction with one on the specific layers of the atmosphere where students can not only construct the layers but place various objects in the atmosphere at their appropriate altitude; like weather balloons, birds, lightening, types of clouds, etc. Then attach this model to the earth's layered structure model.

MODEL OF EARTH'S LAYERED STRUCTURE

PURPOSE: To construct a scale model of a cross-section of the earth's layered structure.

OBJECTIVE: The earth's internal structure is not entirely solid, or uniform in thickness, composition, or physical properties.

MATERIALS:
1.5 m of adding machine tape
1 meter stick
5 colored pencils (green, yellow, red, blue, purple)
2" scotch tape
1 pencil

Procedures:

Think of a jaw breaker. When you break open a jaw breaker you find successive layers of different colors of candy. Not all of the layers are the same size. If the jaw breaker is broken neatly in half, each of the layers appears to be concentric circles around the middle dot of candy.

The structure of the earth can be thought of as a central ball (sphere in three dimensions), surrounded by other spherical layers. If we could drill from the earth's surface down to its center, and continue drilling through the center to the opposite side of the earth, these successive spheres would appear as stripes of drilled core samples. In this activity, you will use the information of the earth's layers and their thicknesses given below to construct a drawn-to-scale diameter slice of the earth on a piece of adding machine tape. Keep in mind that some of the earth's layers are so thin relative to others that you may need to represent them by a thin line instead of a layer with a top and bottom.

Be sure to color and label all layers and take note of the scale. Draw your cross-section as though you were drilling from Yakima, through the earth to Russia.

Scale: 1 cm = 100 km

LAYER	THICKNESS	COLOR
Continental Crust	0 - 25 km	green
Oceanic Crust	25 - 35 km	green
Mantle (plastic)	35 - 700 km	yellow
Mantle (solid)	700 - 2900 km	yellow
Outer Core (liquid)	2900 - 4890 km	red
Inner Core (solid)*	4890 - 6370 km	blue

* from the Outer Core to the center of the earth

Next, incorporate the following data onto your model and label:

ZONE	DISTANCE FROM EARTH'S SURFACE	COLOR
Top of Lithosphere	0 km	dot with
Bottom of Lithosphere	90 km	lead pencil
Top of Asthenosphere	90 km	dot with
Bottom of Asthenosphere	700 km	purple pencil

Questions to Answer

1. Is your model of the earth a physical or mental model? Why?

____

____

____

____

____

____

____

____

2. Which of the earth's layers is the thinnest?

____

____

3. If you combined the inner core and the outer core to form one layer, the core, which layer would be the thickest?

4. Which of the earth's layers is the thickest?

5. In which of the earth's layers do you find the asthenosphere?

6. If you drew a cross-section of the earth from pole to pole and then drew a cross-section of the earth through the equator, would these two cross-sections be the same? Explain why or why not.

Would these cross-sections be equal? Explain your answer.

7. List several reasons why you think man has not been able to drill down through the crust to the mantle.

8. If man can't drill to the mantle then how do you think scientists have learned about these layers we cannot see?

TEACHER'S GUIDE

PLATE TECTONICS AND TYPES OF VOLCANOES

The purpose of this laboratory activity is to show graphically the relationship between types of volcanoes, their location, and the different types of plate boundaries associated with each.

Because volcanic igneous rocks are generally very fine-grained and are often glassy, it is difficult to determine with only a magnifying lens their mineralogical composition and be able to classify them. It has been found, however, that the overall color of a volcanic rock is a general reflection of its overall chemical composition. In general, the higher the silicon dioxide (SiO_2) content, the lower the iron oxide (FeO_2) content, the lighter the color of the volcanic rock will be. A simple classification system for the three most common volcanic rocks, based on silica composition and overall color is given below:

SILICA CONTENT	COLOR	ROCK NAME
High SiO_2 (>66%)	grey, pink	rhyolite
Medium SiO_2 (52% - 66%)	dark grey	andesite
Low SiO_2 (<52%)	black	basalt

Plate tectonics explains the existence and types of volcanoes. Keep in mind the different types of plates and how they move in relation to one another. Along **divergent boundaries** plates move away from one another, as is the case at spreading centers and rift zones. Generally, margins with a composition of basalt are produced at divergent boundaries and tend to be the result of partial melting of the mantle. At **convergent boundaries**, plates move toward each other. When a convergent boundary occurs between ocean plates or between an ocean plate and a continental plate, subduction occurs. This process leads to heating of the subducted plate material. Partial melting of this plate material generates magma with a composition of andesite. Sometimes, as andesite rises through continental crust, it reacts chemically with the crust and is altered to rhyolite.

Some volcanism is apparently not associated with plate boundaries, such as in the Hawaiian Islands. This is thought to be due to a "hot spot" in the mantle which continues to produce basaltic magma at the same spot within the mantle. As plates move over this spot, a chain of volcanoes is created.

PLATE TECTONICS AND TYPES OF VOLCANOES

PURPOSE: To show graphically the relationship between types of volcanoes, their locations, type of erupted material, and the associated plate boundary.

OBJECTIVE: The chemical composition of volcanic rock is associated with the plate boundaries at which they are formed.

MATERIALS: 3 colored pencils (red, blue, and green)
1 Data Sheet
1 World Map

Procedures:

For this activity you will use the World Map and Data Sheet I, both of which are included in your lab packet. You will be pinpointing locations of volcanoes on your map and marking them according to their rock type.

1. For all volcanoes listed on Data Sheet I:

   a. Find the coordinates (longitude and latitude) from the data sheet.

   b. Find the lava type of that volcano (either andesite, rhyolite, or basalt).

   c. Find the volcano's location on the World Map.

   d. Make a dot on the World Map using the appropriate color for the volcanic rock type associated with each volcano.

      Red = andesite
      Blue = rhyolite
      Green = basalt

Questions to Answer

1. Can you see any pattern to the distribution of the types of volcanoes? If yes, describe these patterns.

2. Do you see relationships between kinds of plate boundaries? If yes, describe these relationships in terms of plate boundaries and types of rock produced.

3. Are all the volcanoes located on plate boundaries?

4. What types of volcanoes seem not to be near plate boundaries?

5. What kind of volcanoes are found in the Hawaiian Islands? Are these volcanoes near a plate boundary?

6. How do you think it is possible for volcanoes to form in the middle of plates?

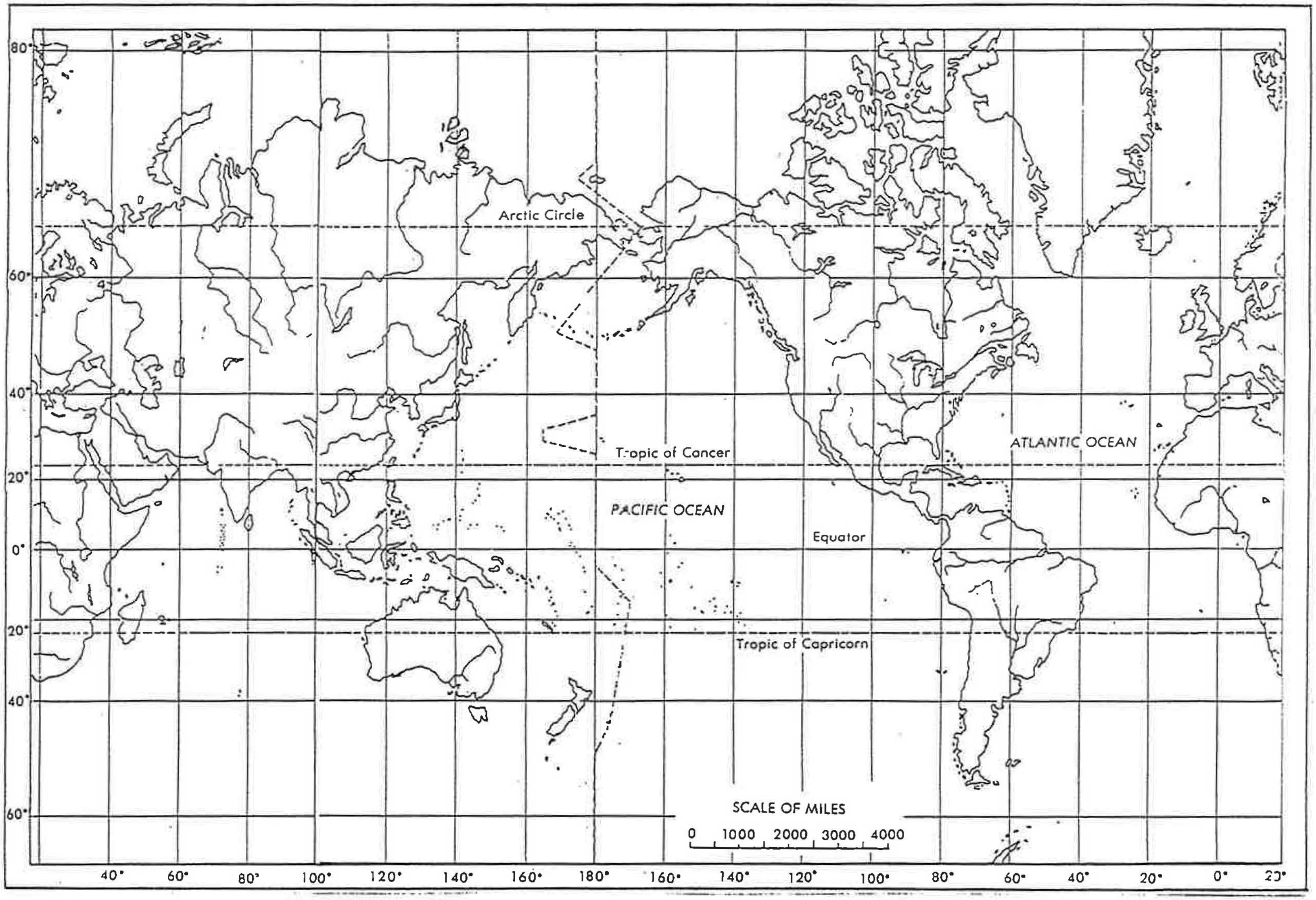
7. Is there a global pattern to the locations of all volcanoes? If yes, describe this pattern.

8. Most of the volcanoes that you plotted appear to be found along what type of plate boundary?

9. What happens at this type of boundary that might explain the large number of volcanoes?

DATA SHEET I

Location of Volcanoes	Latitude/Longitude (approximate)	Rock Type
Western United States (Pacific Border)		
Lassen, Ca.	40 N 121 W	Andesite
Crater Lake, Or.	43 N 122 W	Andesite
Mt. Ranier, Wa.	47 N 122 W	Andesite
Mr. Baker, Wa.	49 N 122 W	Andesite
Western United States (Western Interior)		
Yellowstone Park, Wy.	45 N 111 W	Rhyolite
Crater of the Moon, Ida.	43 N 114 W	Andesite
Central America & West Indies		
Paricutin, Mex.	19 N 102 W	Andesite
Popocatepetl, Mex.	19 N 98 W	Andesite
Mt. Pelee, Martinique	15 N 61 W	Andesite
Santa Maria, Guatamala	15 N 92 W	Andesite
South America		
Cotopaxi, Equador	1 S 78 W	Andesite
Misti, Peru	16 S 71 W	Andesite
Alaska & Aleutian Islands		
Katmai, Alas.	58 N 155 W	Rhyolite
Adak, Aleutians	52 N 177 W	Andesite
Umnak Island, Aleutians	53 N 169 W	Andesite
Kamchatka, USSR	57 N 160 E	Andesite
Japan		
Fuji, Honshu	5 N 139 E	Basalt
Izu-Hakone, Honshu	35 N 139 E	Andesite
East Indies		
Mayon, Philipines	13 N 124 E	Andesite
Krakatoa	6 S 105 E	Rhyolite
Karkar, New Guinea	5 S 146 E	Andesite
Central Pacific		
Mauna Loa, Hawaii	19 N 156 W	Basalt
Galapagos Islands	1 S 91 W	Basalt
Mariana Islands	16 N 145 E	Basalt
South Pacific		
Auckland, New Zealand	38 S 176 E	Basalt
Tahiti	18 S 149 W	Basalt
Samoa	13 S 172 W	Basalt
North Atlantic		
Surtsey, Iceland	63 N 20 W	Basalt
Mid-Ocean Ridge	60 N 18 W	Basalt
Africa		
Kilimanjaro, Tanzania	3 S 37 E	Basalt


80°
60°
40°
20°
0°
20°
40°
60°
Arctic Circle
Tropic of Cancer
PACIFIC OCEAN
ATLANTIC OCEAN
Equator
Tropic of Capricorn
SCALE OF MILES
0 1000 2000 3000 4000
40° 60° 80° 100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20°

TEACHER'S GUIDE

SPECIFIC GRAVITY OF MATTER

Matter is defined as anything that has mass and occupies space. Every material we know of is made of matter. All matter consists of elements and all elements are made up of atoms.

The physical properties of matter are characteristics that can be seen and measured without changing the chemical composition of the substance under study. One of these physical properties is specific gravity. Specific gravity is related to density. Specific gravity is a ratio or comparison between the density or mass of a substance and the density or mass of an equal volume of water. This ratio is not expressed in units as the units cancel out. It is important to note that the specific gravity of water is always 1.

The purpose of this lab is to acquaint the student with triple beam balances and their use is determining the specific gravity of various substances. This measurement technique can be used again in mineral identification labs.

To introduce this lab, tell the students the story of Archimedes, the King, and the gold crown. Eureka!!

This laboratory activity pre-supposes that the teacher knows how to set the triple beam balances up for specific gravity measurements. It is also necessary to have a variety of everyday objects to test. The specific gravity of each of these will need to be determined before hand.

To calculate specific gravity, the object must be weighed dry, then weighed suspended in water. The wet weight is then subtracted from the dry weight. Finally, this figure (dry minus wet) is divided into the dry weight. The resulting number is the specific gravity of the object.

SPECIFIC GRAVITY OF MATTER

PURPOSE: To calculate the specific gravity of various objects.

OBJECTIVE: Proficiency in the usage of triple beam balances to weigh matter in more than one way.

MATERIALS:
1 triple beam balance
1 ring stand (1" rod)
1 gallon container for water
1 calculator (optional)
1 lab sheet
2 to 3 feet of string
various objects (supplied by teacher)

Procedures:

1. The balances have been set up to allow for weighing an object dry and suspended in water.

2. Fill the container 3/4 full of water.

3. Check the slip knots to make sure they work. If they have become water logged they may need to be replaced.

4. Take the object given to you and record its object number on your lab sheet. Place the object (dry) on the platform. Carefully weigh it to the closest tenth of
a gram. Record this number on your lab sheet.

5. Secure the slip knot around the object and lower it into the water. Make sure it is entirely under water and not touching the sides or bottom of the container.
Carefully weigh it to the nearest tenth of a gram. Record this number on your lab sheet.

6. You are now ready to calculate the specific gravity.

7. Subtract the wet weight of the object from the dry weight. Record this number on your lab sheet.

8. Divide the number you just obtained into the dry weight of the object. This is the specific gravity of the object. Record it on your lab sheet.

9. Check your specific gravity with the teacher. If it is not accurate you will be asked to repeat the procedure in an attempt to strive for more accuracy.

10. Repeat the above steps until you have found the specific gravity for several objects or the number of objects specified by your teacher.

Questions to Answer

1. What is the relationship between density and specific gravity?

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2. What do you think you are actually measuring when you find the specific gravity of an object?

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3. You have a one centimeter cube of gold and a one meter cube of gold. Would there be a difference in their specific gravities? Why or Why not?

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SPECIFIC GRAVITY LAB SHEET

Object No. ____________

A = Dry Weight __________ grams

B = Wet Weight __________ grams

C = Dry - Wet __________ grams

Specific Gravity = A ÷ C

Specific Gravity = __________

Object No. ____________

A = Dry Weight __________ grams

B = Wet Weight __________ grams

C = Dry - Wet __________ grams

Specific Gravity = A ÷ C

Specific Gravity = __________

Object No. ____________

A = Dry Weight __________ grams

B = Wet Weight __________ grams

C = Dry - Wet __________ grams

Specific Gravity = A ÷ C

Specific Gravity = __________

Object No. ____________

A = Dry Weight __________ grams

B = Wet Weight __________ grams

C = Dry - Wet __________ grams

Specific Gravity = A ÷ C

Specific Gravity = __________

TEACHER'S GUIDE

MINERAL IDENTIFICATION

The purpose of this lab is to use various tests to identify unknown minerals by their physical properties. Pre-lab is essential for this laboratory activity. The students will need to possess knowledge of the properties of minerals and the tests they can use to identify the minerals. It is recommended that the properties and tests be presented to the students beforehand using sample minerals with obvious properties. Be sure to include some metallic minerals along with the non-metallic minerals.

For the lab, it will be necessary to provide the students with a variety of minerals that show a range of the different physical properties. Graphite, hematite, olivine, pyrite, quartz, limonite, lepidolite, and kaolinite are just a few of the many possibilities.

It will also be necessary to provide the students with a mineral identification chart. One is provided with the lab but others that list more minerals can be found in some textbooks.

Since testing for cleavage or fracture can rapidly degrade your mineral supply, it is advised to skip this test and use a visual determination instead.

Doing the test for specific gravity also takes time. If time is short, the lab works well even if the specific gravity is given to the students along with their mineral sample. In this case the specific gravity can come from the mineral identification chart or can be determined beforehand by the teacher. If the choice is to let the students determine the specific gravity then they should know how to do this test. A lab on specific gravity should therefore precede this lab.

MINERAL IDENTIFICATION

PURPOSE: To identify an unknown mineral by conducting tests related to their physical properties.

OBJECTIVE: Minerals can be identified by their physical properties.

MATERIALS: Numbered mineral samples (metallic/non-metallic)
1 mineral identification chart
1 penny
1 streak plate
1 glass bottle
1 steel knife
1 steel file
1 triple beam balance
1 pail for water
1 lab sheet (per person)

Procedures:

1. Set up the balance for the specific gravity test.

2. Get a mineral and record its number on the lab sheet.

3. Perform the tests **in the order below**, test results in the appropriate box on your lab sheet.

   Luster
   Color
   Cleavage or Fracture
   Streak
   Hardness (refer to chart in this lab)
   Specific Gravity

4. Once all the data for a given mineral has been collected, refer to the mineral identification chart.

5. Compare your data to that found in the chart and name your unknown mineral. Write this name in the space provided on your lab sheet.

6. Take your lab sheet to your teacher for verification. If your tests are inaccurate or you have been careless, you will be asked to check your data again by repeating some or all of the tests.

7. If your mineral has been correctly identified, exchange it for another unknown mineral and repeat the tests.

MOH'S SCALE OF HARDNESS — FIELD CHART

Hardness	Mineral Name	How determined
1	Talc	soft, greasy, flakes on fingers
2	Gypsum	scratched by fingernail
3	Calcite	can be scratched by penny
4	Fluorite	scratched easily by knife
5	Apatite	difficult to scratch w/knife
6	Orthoclase	scratched by steel or glass
7	Quartz	scratches glass
8	Topaz	scratches quartz
9	Corundum	scratches most minerals
10	Diamond	scratches all minerals

Questions to Answer

1. What mineral property was the most useful in identifying your minerals? Why?

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2. What mineral property was the least useful in identifying your minerals? Why?

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MINERALS WITH NON-METALLIC LUSTER

Color	Streak	Hardness	Mineral	Specific Gravity	Key Test
Colorless or white	Colorless or white	1	Talc	2.7 - 2.8	soapy feel
		1 - 3	Bauxite	2.0 - 2.5	earthy appearance
		2	Kaolinite	2.6 - 2.7	smells like clay
		2	Gypsum	2.3	softer than fingernail
		2.5	Halite	2.1	dissolves in water
		2.5	Muscovite	2.7 - 3.1	cleaves into thin plates
		3	Calcite	2	effervesces with HCL
		3	Anhydrite	2.88 - 2.9	organe flame color
		3	Barite	4.5	heavy white mineral
		3.5	Celestite	3.9 - 4.0	red flame color
		4	Flourite	3.1	perfect cleavage, octodedrons
		5	Smithsonite	4.3 - 4.4	usually in crusts
		5	Natrolite	2.2	masses of radiating needles
		5.5	Opal	1.9 - 2.2	conchoidal fracture
		5 - 6	Amphibole	3.0 - 3.3	cleaves at 60° angle
		6	Plagioclase	2.6 - 2/7	striated faces
		7	Quartz	2.6	conchoidal fracture
		8	Topaz	3.4 - 3.6	resembles broken glass
		9	Corundum	4	very hard mineral
yellow or brown	colorless or white	1.3	Sulfur	2.0 - 2.1	yellow; soft
		2.5 - 4.0	Serpentine	2.2	yellow, earthy
		2.5	Mica	2.8 - 3.2	brown, thin plates
		3	Calcite	2.7	yellow, effervesces w/HCL
		3.5	Sphalerite	3.9 - 4.1	rotten egg smell w/HCL
		4	Siderite	3.8 - 3.9	tan to brown
		4	Flourite	4	yellow octahedrons
		5	Apatite	3.0 - 3.2	yellow-brown
		5.5	Hematite	5.2	brown, red streak
	colored	1.5	Orpiment	3.4	yellow, yellow streak
		1 - 3.5	Limonite	3.6 - 4.0	yellow, brown streak
		6	Rutile	4.1 - 4.2	brown, yellow streak
reddish violet	colorless	1 - 3	Bauxite	2.0 - 2.5	earthy reddish
		2	Gypsum	2.3	softer than fingernail
		2 - 4	Lepidolite	2.8 - 3.0	lilac colored
		3.5	Rhodocrosite	3.4 - 3.6	pinkish
		4	Flourite	3.1	violet, perfect cleavage
		5	Rhodonite	3.5 - 3.7	pink
		6	Orthoclase	2.5	pinkish, striated faces
		7	Garnet	3.5 - 4.3	red, scratches glass
		7	Quartz	2.6	violet red, no cleavage
		9	Corundum	4	red, very hard mineral
	colorless	1.5	Realgar	3.4	red, garlic smell
		2	Cinnabar	8.1	red, scarlet streak
		3.5	Cuprite	6	deep red, red streak
		5.5	Hematite	4.2	red, red-brown streak
		6	Rutile	4.1 - 4.2	deep red, yellow streak

MINERALS WITH NON-METALLIC LUSTER

Color	Streak	Hardness	Mineral	Specific Gravity	Key Test
green or blue	colorless	1	Talc	2.7 - 2.8	soapy feel
		1.2	Chlorite	2.6 - 2.9	dark green, soft, flakey
		2.4	Serpentine	2.2	green, earthy
		4	Flourite	3.1	green, octahedral
		5	Apatite	3.1 - 3.2	blue-green
		5 - 6	Augite	3.2 - 3.4	dark green
		6	Prehnite	2.8 - 2.9	blue-green crust
		6.5	Olivine	3.2 - 3.3	green, resembles sugar
		6.7	Epidote	3.3 - 3.4	yellow to dark green
		7	Tourmaline	3.0 - 3.3	green crystals
	colored	2 - 4	Serpentine	2.2	dark green, earthy
		3.5	Azurite	3.7	blue, azure streak
		3.5	Malachite	3.9 - 4.0	dark/lt. green, green streak
		6	Turquoise	2.6 - 2.8	light blue, dull
grey or black	colorless	2.5	Biotite	2.8 - 3.2	black, cleaves into sheets
		3	Anhydrite	2.9	black, grey, orange flame
		5 - 6	Augite	3.2 - 3.4	black
		5 - 6	Hornblende	3.2	black, long crystals
		6	Plagioclase	2.6 - 2.7	grey, striated
		7	Garnet	3.5 - 4.3	black, scratches glass
	colored	1	Graphite	2.3	writes on paper
		1 - 2	Pyrolusite	4.7	black, earthy
		1 - 5	Limonite	3.6 - 4.0	black, yellow-brown streak

MINERALS WITH METALLIC LUSTER

black or grey	black	2	Stibnite	4.5 - 4.6	melts in flame
		2.5	Galena	7.4 - 7.6	perfect cubic cleavage
		4	Manganite	4.3	brown-black streak
		5.5	Chromite	4.6	brown streak
		6	Magnetite	3.1	magnetic
		6	Franklinite	3.1	usually with red zincite
	colored	2.3	Biotite	2.8 - 3.2	black elastic sheets
		3.5	Sphalerite	3.9 -4.1	rotten egg smell w/HCL
		5.5	Chromite	4.6	brown streak
		6	Hematite	5.2	red streak
lt. grey or silver		2.5	Silver	10.5	flattens with hammer
		5.5	Niccolite	7.7	heavy coppery look
		6	Marcasite	4.8	green-grey color
yellowish	black	3.5	Chlacopyrite	4.1 - 4.3	tarnished gold color
		3.5	Pyrrhotite	4.5 - 4.6	rotten egg smell w/HCL
		6	Marianite	4.8	green-grey color
	not black	2.5	Gold	16	flattens with hammer
		1 - 5.5	Limonite	3.6 - 4.0	yellow streak
red or brown	reddish	2.5 - 3	Realgar	3.4	red-orange streak
		2.5 - 3	Copper	8.9	copper color
		4	Cuprite	6	deep red streak
	not red	6	Hematite	5.2	red-brown streak
		3.5	Sphalerite	3.9 - 4.1	rotten egg smell w/HCL
		5	Wolframite	7.0 - 7.5	brown, heavy
		5.5	Niccolite	7.7	light coppery look
		6	Rutile	4.1 - 4.2	brown-yellow streak

TEACHER'S GUIDE

CRYSTAL FORMATION BY EVAPORATION AND SUPERSATURATION

This lab is designed to show how crystals can be formed by evaporation and supersaturation. Crystal structure will also be observed by the use of microscopes.

Crystals precipitate when solutions become supersaturated. To make a supersaturated solution, keep adding solute to hot water until no more will dissolve and just a little bit remains undissolved on the bottom. Potassium Dichromate forms orange crystal needles and Cupric Acetate forms blue diamond shapes. Many other chemicals can be used for this lab that produce interesting crystal shapes. Some interesting ones are Potassium Ferricyanide, Sodium Thiosulfate, Aluminum Potassium Sulfate, Mono-ammonium Phosphate, Potassium Chromate, and Cupric Sulfate.

Special Procedures and Safety Instructions

1. Because most classrooms have limited hot plates and other equipment, it is suggested that students work in groups of four or five. Hopefully you will be able to work in groups of three.
2. The teacher should make supersaturated solutions of Potassium Dichromate and Cupric Acetate before beginning Part I of this activity. If Part II is used, you may want to let the students make their own solutions.
3. Instruct students on proper use of the hot plates.
4. Caution students not to drink the solutions.
5. Insist that students wash their hands after the lab.

NOTE:

One of the most successful ways to grow large crystals is to place a rough rock in the bottom of a jar. Then pour the supersaturated solution into the jar and wait. Crystals will grow all over the rock. The students will get several large (but not perfect) crystals. Another method involves tying a string on a pencil and suspending the string in the supersaturated solution. While this method is often used, it is very difficult to produce a single, perfect crystal.

CRYSTAL FORMATION BY EVAPORATION AND SUPERSATURATION

PURPOSE: To show that crystals can form from a solution as water evaporates.

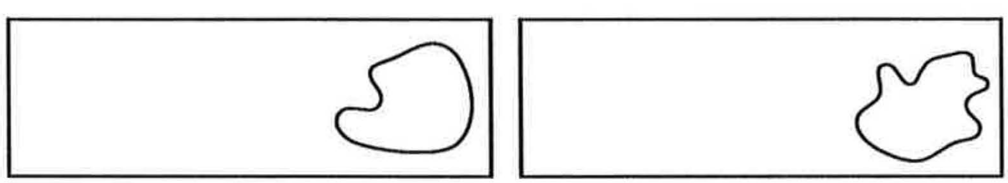
OBJECTIVE: To observe different crystal forms.

MATERIALS: (Per Class: Part I)
1 50 ml beaker of Potassium Dichromate solution
1 50 ml beaker of Cupric Acetate solution
1 eye dropper for each solution
Hot plates (as many as are available)

(Per Group: Part I)
1 drop of Potassium Dichromate solution
1 drop of Cupric Acetate solution
2 glass slides
1 microscope

Procedures: *Part 1 — Crystal Formation by Evaporation*

1. Using one eye dropper, place one drop of Potassium Dichromate solution near the end of one glass slide (see sketch below). Using the other eye dropper, place one drop of Cupric Acetate solution near the end of the other glass slide. DO NOT MIX THE SOLUTIONS OR SWITCH THE EYE DROPPERS.



2. The hot plate is on a low setting, less than 100 degrees, but DO NOT TOUCH THE HOT PLATE.

3. Place only the end of the slides with the solutions on them on the hot plates until the first crystals begin to form.

4. Remove slides from hot plate, allow to cool. Then place the slide on the microscope stage and observe the crystals. The crystals will continue to form as you observe them under the microscope. Sketch and label what you see in the space below.

5. Repeat this procedure until all members in your group have observed the crystals as they form.

Questions to Answer

1. What caused the crystals to begin to form?

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2. Why was a hot plate needed and how does heat affect crystal growth from a solution?

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3. Give an example of where you might find this sort of crystal forming process on the earth.

4. What do you think the crystal size would have been if the solutions on the slides where allowed to cool at room temperature?

5. If possible, verify your answer to number 4 above by conducting this investigation.

   Make a sketch of the crystals formed by cooling at room temperature below. Next to it, make a sketch of the crystals formed by evaporating the solution over the hot plate.

How do you explain the differences?

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Procedures: *Part II — Crystals from a Supersaturated Solution*

MATERIALS:
1 cup of chemicals supplied by the teacher (amount may vary)
1 cup of very hot water
1 straight sided jar or glass with a volume of less than 2 cups
1 clean rock, rough in texture (must easily fit in bottom of jar with 1/2 inch clearance on all sides)
2 spoons
1 piece of paper or cardboard to cover jar

1. Carefully pour 1 cup of very hot water into your jar.

2. Using one of the spoons, slowly add one spoonful at a time of your chemical to the hot water. Stir the solution with the other spoon.

   BE VERY CAREFUL NOT TO SWITCH THE SPOONS OR CONTAMINATE YOUR CHEMICALS WITH WATER.

   Make sure all the chemical is dissolved BEFORE you add another spoonful.

3. Continue to add chemical until no more will dissolve. Usually a small amount of the chemical will remain on the bottom of the jar undissolved.

   You have now made a supersaturated solution which means that it is not possible for the water to dissolve any more of the chemical.

   If you need more chemicals to make a supersaturated solution get them from the teacher.

4. Place your clean rock in the bottom of the jar.

5. Put a piece of paper or cardboard over the jar to keep dust and other foreign material out of the solution.

6. Allow to cool.

7. Make several sketches over the next few days of what you observe as crystals form over the rock.

TEACHER'S GUIDE

SEA WATER DENSITY

This lab is designed to demonstrate the relationship between the salt concentration of water and its density, and between the temperature of water and its density.

The presence of dissolved and suspended matter in water increases its density. Temperature also affects density — as the temperature of water increases, its density decreases.

Although 'normal' sea water contains 3.7% dissolved salts, in reality the concentration of dissolved salts in sea water varies considerably. Where sea water mixes with fresh water, the concentration of salts decreases. When sea water evaporates in a trapped basin, the fresh water is evaporated leaving behind all the dissolved salts in a smaller volume of water, this increases the concentration of dissolved salts and therefore the density of the remaining sea water.

In some places, water contains a large amount of suspended sediment which also increases its density. We see this in large overland rivers like the Mississippi and the Amazon. In oceans, underwater **turbidity currents** containing a great deal of suspended sediment, occasionally form and flow down the slope.

When bodies of water with different densities intersect, sometimes mixing occurs, but other times mixing, if it occurs, does so very slowly. This results in two different unmixed bodies of water. This can be seen in estuaries where fresh river water flows into a drowned river valley filled with sea water. The fresh water flows over and remains on top of the denser sea water. In other areas where sediment-laden rivers enter the ocean you can see the dense river water continuing to flow as an entity out into the ocean.

When the students do this lab have them work in pairs if at all possible.

NOTE:

Do not see modeling clay (plasticene) for this activity. Use clay soil instead. Kaopectate can be used as a substitute if clay cannot be found as it is a mixture of kaolinite clay and water.

SEA WATER DENSITY

PURPOSE: To demonstrate the relationship between the salt concentration of water and its density, and between the temperature of water and its density.

OBJECTIVE: Dissolved material, suspended matter, and temperature affect the density of liquids.

MATERIALS:
3 small styrofoam cups
1 clock or stopwatch
25 ml graduated cylinder
2 100 ml graduated cylinders (clear)
30 ml ice cold water
125 ml of mineral oil
60 ml water
1/2 tsp (2.5 ml) measure
1 eye dropper
red, blue, and yellow food coloring
clay

Procedures: *Part I*

1. Pour 20 ml of water into each of the three styrofoam cups. Label the cups A, B, and C.
2. To the cup labeled "A", add 5 ml (1 tsp) salt and two drops blue food coloring. To the cup labeled "B", add 2.5 ml (1/2 tsp) salt and two drops of yellow food coloring. Add no salt to the cup labeled "C", but add two drops of red food coloring.
3. Stir all three cups until the salt dissolves.
4. Put 100 ml of mineral oil in the 100 ml graduated cylinder.

You are going to add a few drops from each cup to the mineral oil in step 5 through 8. Before you go on, make a hypothesis on the lines below stating what you think you will observe.

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5. Using the eye dropper, squeeze 2 drops of water, one at a time, from cup "A" beneath the surface of the mineral oil. Be certain that the tip of the eye dropper is just below the surface before squeezing the drops. With the stop watch, time how long it takes each blue drop of water to sink from the 100 ml mark to the 5 ml mark.

   Average time for the blue drops to sink: ____________________

6. Repeat the process with water from cup "B".

   Average time for the yellow drops to sink: ____________________

7. Repeat the process with water from cup "C".

   Average time for the red drops to sink: ____________________

8. Which drops sank the fastest? ____________________

   Which drops sand the slowest? ____________________

   If you need to alter your original hypothesis, do so on the line below.

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   Explain why you think the drops sank at different rates.

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Procedures: *Part II*

1. Pour 20 ml of mineral oil from the 100 ml graduated cylinder into the second 100 ml graduated cylinder.

2. Holding the graduated cylinder with the 20 ml of mineral oil in it at a slight slant, pour water from cup "A" into the mineral oil. After the blue water has settled, pour water from cup "B" into the mineral oil. After it settles, pour water from cup "C" into the mineral oil. Sketch and label below what you observe in the graduated cylinder.

3. Why do you think the observed layering occurred?

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Procedures: *Part III*

1. Wash the cup labeled "C". Fill the cup 2/3 full of hot tap water. Put 25 ml of ice cold water into your graduated cylinder and add three drops of blue food coloring. Using the eye dropper, squeeze two drops of cold blue water beneath the surface of the hot water. Be certain that the tip of the eye dropper is just below the surface before squeezing the drops. Describe what happens.

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Procedures: *Part IV*

1. Wash out one of the 100 ml graduated cylinders.

2. Put about 70 ml of water into the 100 ml graduated cylinder.

3. Make a thick suspension of clay and water by mixing approximately 5 ml of dry clay into 20 ml of water in a cup. Mix the clay and water well. Without delay, pour the muddy water suspension into the clear water. Describe what happens.

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Questions to Answer

1. Define density.

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2. List the features you found that can affect the density water.

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3. Where on earth might you find density differences between to salt water and fresh water?

4. Where on earth might you find density differences in water caused by differences in temperature?

5. Where on earth might you find density differences that cause mixing like you observed in Part IV?

6. From the top of the ocean, to the bottom, do you think there is any difference in the density of ocean water? Why or why not?

7. Do you think there is any difference in the density of ocean water found at the poles compared to that found at the equator? Why or why not?

CHAPTER 5

Summary, Conclusions, and Recommendations

The intent of this project was to develop laboratory activities for the 8th grade earth science classroom. These activities include methods that are either hands-on, inquiry, or discovery oriented. These methods were chosen on the basis of the reform movements in science education. Studies have shown these methods to be successful in motivating students to want to do science and in making the student an active participant in the processes of scientific endeavor.

All sixteen laboratory activities used in this project were modified to enable them to enhance the laboratory experience of the students by incorporating one or more of the methods studied. All laboratories also contain one or more of the identified process skills of scientific research.

It was found that the adapted laboratory activities took up more paper space than the norm. This was found to be the result of student sheets that included the purpose, objective, a list of all materials required, step-by-step procedures, diagrams, and questions to be answered directly on the student lab sheets. Above all, procedures were not as brief as those examined in textbook manuals. The procedures on the labs included in the project leave no question as to what is required of the student.

In conclusion, this project has been immensely rewarding for the author. All labs were tested in the classroom and evaluated by the students through the use of a post-lab questionnaire. Ninety percent of the students indicated that they enjoyed the labs and would like to do additional activities. The 'packet' format, where questions are answered on the laboratory sheets handed out, proved to be a good idea. Lab write-ups handed in were generally more complete and better thought out than those done on notebook paper. Neatness was also shown to improve.

I would recommend that any teacher who is interested in quality laboratory experiences for their students take the time necessary to adapt their labs. Any lab, whether it comes from a manual, a resource book, or a text book, can be enhanced and adapted to make the laboratory experience more exciting and applicable. All that is necessary is a little time, knowledge of higher levels of questioning, access to as much paper as is needed, and the desire to enable the student as an active learner.

BIBLIOGRAPHY

Abruscato, J. (1988). *Teaching children science.* Englewood Cliffs, NJ: Prentice Hall.

Aikenhead, G.S. (1983). Science as inquiry: A desired state. In J.E. Penich, & J. Krajcek (Eds.), *Focus on excellence: Science as inquiry: Vol. 2. Middle school/junior high science,* (pp. 4-17). Iowa City: Science Education Center, University of Iowa.

Anderson, R.O. (1976). *The experience of science: A new perspective for laboratory teaching.* New York: Teacher College Press.

Bates, G.C. (1978). The role of the laboratory in secondary school science programs. In M.B. Rowe (Ed.), *What research says to the science teacher: Vol. 1.* (pp. 75-85). Washington D.C.: National Science Teachers Association.

Biological science curriculum study. (1970). New York: Wiley & Sons, Inc.

Bruner, J.S. (1961). The act of discovery. *Harvard Education Review,* 31(1), 21.

Bryant, R., & Marek, E.A. (1987). They like lab-centered science. The *Science Teacher,* 54(6), 42-45.

Bybee, R.W. (1984). Global problems and science education policy. In R.W. Bybee, J. Carlson, & A.J. McCormack, *NSTA yearbook--redesigning science technology education,* (pp. 60-75). Washington D.C.: National Science Teachers Association.

Carin, A.A., & Sund, R.B. (1989). *Teaching science through discovery.* Columbus, Ohio: Merrill.

Carpenter, J. R. (1986). *Earth science sourcebook.* South Carolina: Center for Science Education.

Christman, R. A. (1984). *Mount St. Helens science activities for secondary.* Bellingham, Washington: Creative Dimensions.

Collette, A., & Chiappetta, E. (1984). *Science instruction in the middle and secondary schools.* St. Louis, Missouri: Time Mirror/Mosby College.

Cranson, K. R. (1989). *Sun angle and variation in solar energy.* MESTA Shar-A-Thon.

Fisher, K.M., & Lipson, J.I. (1986). Twenty questions about student errors. *Journal of Research in Science Teaching,* 23, 783-803.

Gagne, R. (1977). *The conditions of learning.* New York: Holt, Rinehart, & Winston.

Glasson, G.E. (1989). The effects of hands-on and teacher demonstration lab methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching,* 26, 121-131.

Goodlad, J.I. (1983). *A place called school: Prospects for the future.* New York: McGraw-Hill.

Helgeson, S. (1989). Problem solving in the middle school. In D. Gabel (Ed.), *What Research Says to the Science Teacher: Vol. 5., Problem solving,* (pp. 13-34). Washington D.C.: National Science Teachers Association.

Hesser, D.T., & Leach S.S. (1987). *Focus on earth Science.* Columbus, Ohio: Merrill.

Holdzcom, D., & Lutz, P.B. (1986). *Research within reach: Science education a research guided response to the concerns of educators.* Washington D.C.: National Science Teachers Association.

Hounshell, P.B. (1989). Labs off limits. *The Science Teacher*, 56(4), 30-32.

Hurd, P. (1981). Biology education. In N.C. Harms, & R.E. Yager (Eds.), *What research says to the science teacher, Vol. 1*, (pp. 12-32). Washington D.C.: National Science Teachers Association.

Jacobson, W.J., & Doran, R.L. (1986). What do our ninth graders think of science and school? *The Science Teacher*, 53(5), 59-61.

Kennedy, D. (1981). Succinctly defining/describing the role of laboratory science. *Washington Science Teachers Journal*, 21(3), 13.

Liem, T.L. (1987). *Invitation to science inquiry.* Lexington, Mass.: Ginn Press.

McGlathery, G. (1978). Analyzing the questioning behavior of science teachers. In M.B. Rowe (Ed.), *What Research Says to the Science Teacher: Vol. 1*, (pp. 13-30). Washington D.C.: National Science Teachers Association.

NSTA Commission on Professional Standards and Practices. (1970). *Conditions for good science teaching in secondary schools.* Washington D.C.: National Science Teachers Association.

Piaget, J. (1971). *Biology and knowledge.* Chicago: University of Chicago Press.

Rakow, S.J. (1989). Middle/junior high science speaks out. *Science Scope,* 12(7), 24-30.

Renner, J.W. (1986). Rediscovering the lab. *The Science Teacher,* 53(1), 44-45.

Rowe, M.B. (1978). *Teaching science, a continuous inquiry: A basic.* New York: McGraw-Hill Book Co.

Saunders, W.L., & Jones, K.C. (1988, November). Hands-on science and uncommon sense. *Science Scope,* 12(3), 22.

Scannell, J. (1988). *Earth science research activities.* Maryland: Alpha Publishing Co.

Shulman, L., & Tamir, P. (1973). Research on teaching in the natural sciences. In R. Travers (Ed.), *Second handbook of research on teaching,* (pp. 1098-1148). Chicago: Rand McNally & Co.

Suchman, R. (1966). *Developing inquiry.* Chicago: ScienceResearch Associates.

Tamir, P. (1974). An inquiry oriented laboratory examination. *Journal of Educational Measurement,* 11, 25-33.