topic I

TOPIC I - OBSERVATION AND MEASUREMENT

How Can the Environment Be Investigated?

Time Emphasis: 5 days

TOPIC OUTLINE	INVESTIGATION		A-1a	A-1b	A-2a	B-1a	B-1b
	Estimated Time (Periods)		1½	1	1	3	2
	A. The local environment						
	A-1 Observation	*How Can the Local Environment Be Observed?*					
	A-1.1 Sensory perception	A-1.11	■	■	■		
	A-1.2 Sensory limitations	A-1.21	■	■			
		A-1.22	■	■			
	A-1.3 Inferences	A-1.31	■	■			
	A-2 Classification	*How Can Observations of the Environment Be Classified?*					
	A-2.1 A system of classification	A-2.11			■		
	A-2.2 Purpose	A-2.21					
	B. Properties of the environment						
	B-1 Measurement	*How Can Properties of the Environment Be Measured?*					
	B-1.1 Dimensional Quantities	B-1.11				■	
		B-1.12				■	
	B-1.2 Comparison	B-1.21				■	
	B-1.3 Error	B-1.31				■	
	B-2 Density	*What Are Some Characteristics of the Properties of the Environment?*					
	B-2.1 Variations	B-2.11				■	
		B-2.12					
		B-2.13					■
		B-2.14					■
PROCESS OF INQUIRY OBJECTIVES	Mathematical Skill	PIO-1				■	
	Measurement Skill	PIO-2				■	■
	Creating Models	PIO-3			■		
	Analysis of Error	PIO-4				■	■
	Data Analysis	PIO-5	■	■	■	■	■
TITLES	Multimedia: Check Multimedia Section of Supplement for reference to this topic.		Shoebox Observations	Puddle Observations	Classification	Density	Variable Density of Water

Easy (1.5)

I-A-1a: SHOEBOX OBSERVATIONS

QUESTION:

How can the local environment be observed?

MATERIALS:

One set of observation boxes made of cardboard or wood for every 10 students:

Box 1. top replaced with transparent food wrap; four or five objects, such as rocks, clay, coins, or a vial of liquid, cemented to the bottom. Objects should have some characteristics which are not observable by the sense of sight; attach a label which conforms with the student laboratory guide.

Box 2. one end of the box replaced with a cloth curtain, three doubled sandwich bags, each filled with different sized particles (e.g., cornmeal, sand, shot, flour). Attach the proper label.

Box 3. lid tightly taped shut; one or two familiar objects loose in box (e.g., tacks, paper clips, rubber stoppers). Attach the label.

Box 4. top with holes punched at regular intervals or replaced with pegboard; make available a dowel or knitting needle for poking through holes. A plastic mountain model or irregularly-shaped plaster model is placed in the box; label.

Box 5. top removed; place into the box plaster of paris in a paste form which will harden within the observation time or use a small lump of silly putty; label.

SUGGESTED APPROACH:

1. Explain procedures for the investigation; emphasize the observing of properties or characteristics rather than naming objects.
2. Set boxes at numbered stations; have students move from station to station, spending about 3 minutes at each one making observations.
3. After all observations have been made, compare students' observations; encourage students to challenge and comment on each others' observations; bring out the distinction between observations and interpretations, the range of properties observed by different students at the same station, the difference between identifying or naming an object and determining its properties, the comparison between the limitations imposed by the instructions at each station and those faced by earth scientists observing the earth.

REFERENCES:

Investigating the Earth, p. 4, Teachers Guide, pp. 20-22
Our Planet in Space, Chapter 1

I-A-1a: SHOEBOX OBSERVATIONS

QUESTION:

How can the local environment be observed?

INTRODUCTION:

As you examine several objects, you will make observations of their characteristics. Observation making is an activity that is basic to science.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. make and record observations.
2. explain why it is often desirable to use instruments in making observations.
3. make inferences based on observations.
4. distinguish between observations and inferences.

METHOD:

- Follow the directions on each box at each station
- Spend about 3 minutes at each of the five stations.

Station No. 1: DO NOT TOUCH THIS BOX. Look at the objects inside the box. Observe and describe as many properties of these objects as you can.

Station No. 2: DO NOT LIFT THIS BOX, REMOVE THE LID, OR LOOK INSIDE. Reach inside the box through the curtained opening at the end. From the feel of the materials, describe the <u>properties</u> of the objects in the box.

Station No. 3: DO NOT REMOVE THE LID FROM THIS BOX. You may lift, gently shake, or tip this box to observe the <u>properties</u> of the object, or objects, inside the box.

Station No. 4: DO NOT LIFT THIS BOX OR REMOVE THE LID. Poke the stick straight down through any 10 holes to determine the properties of the object or objects in the box.

Station No. 5: YOU MAY touch, smell, lift, or examine the material in this box in any way that will help you determine its properties.

QUESTIONS:

(A-1.11) 1. How did you make observations at each of the five stations?

(A-1.21) (A-1.22) 2. How were you able to extend your powers of observation at station No. 4? Why was it necessary?

(A-1.31) 3. What inferences can you make about the objects in each box based on your observations?

Challenging (1)

I-A-1b: PUDDLE OBSERVATIONS

QUESTION:

How can the local environment be observed?

MATERIALS:

One or more mud puddles, preferably partially dried up.
Optional - metric rulers, camera, cork borers for taking core samples, knives.

SUGGESTED APPROACH:

1. Take the class to a nearby puddle; raise one ~~question:~~ What has happened here?
2. Have students make careful observations of the puddle.
3. Have students discuss their observations and draw inferences.

MODIFICATIONS:

1. Have a student or a committee of students take a series of photographs of the puddle from the same location, in order to show changes in it over a period of time. Make a time-lapse movie if possible.
2. Relate the features and processes observed at the puddle with features and processes observed at a lake or pond. Note the similarities and differences between a pond and a puddle.
3. Have students begin a long-term investigation of a pond or lake to which they have access.
4. Prepare a series of "artificial puddles" in shallow trays or pans. Use a variety of colored silts to show depositional layering and runoff patterns--heat lamps may be used to hasten evaporation.

I-A-1b: PUDDLE OBSERVATIONS

QUESTION:

How can the local environment be observed?

INTRODUCTION:

To help you develop your powers of observation, carefully and thoughtfully examine a mud puddle. Use whatever means you can. You will then be able to use the observations to predict future events at the puddle site.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. make and record observations.
2. describe the purpose for the use of instruments in making observations.
3. make inferences based on observations.
4. distinguish between observations and inferences.

METHOD:

1. Carefully examine the puddle in any way you can. Record your observations.
2. Use your observations to explain, to the best of your ability, what has happened to the puddle site to make it appear as it does now.
3. Use your observations and interpretations to make predictions about the future of the puddle site.

QUESTIONS:

(A-1.11) 1. How did you make observations of the puddle?

2. What caused the puddle?

3. What determined the depth of the puddle?

4. What is the evidence that loose material in the puddle area has been moved?

(A-1.11) 5. How many events of rainfall can you determine have occurred? What is the evidence of wind?

6. What is the evidence of animal life?

7. What are some events that are likely to happen to this puddle in the future?

(A-1.31) 8. a) Which of your previous answers were observations?
b) Which were inferences?
c) Which were predictions?

(A-1.21)
(A-1.22) 9. What is the purpose of the use of instruments in a detailed investigation?

Easy (1)

I-A-2a: CLASSIFICATION

QUESTION:

How can the observations of the local environment be classified?

MATERIALS:

A wide variety of items representative of the students' local environment (e.g., pebbles, water, oil, air, slice of bread, Band-Aids, sand, potato, bottle of catsup, cucumbers, rubber stoppers, strips of metal, pieces of wood, boxes of detergent and cereal, apples, can of frozen juice, etc.).

SUGGESTED APPROACH:

1. Provide the students with samples of their environment and the student investigation sheet. The students should be asked to classify these samples in some way that is meaningful to them and to explain the basis for their classification system.

2. After all groups have completed their classifications, encourage them to challenge and defend each other's ideas.

3. Introduce a discussion based on "Why does man classify items in his environment?" Interject into the discussion the idea that classification probably exists because of man's inability to comprehend a large number of individual items; therefore, he is forced to categorize them.

PRECAUTIONS:

The teacher must be careful not to channel the student's thinking into a preconceived classification system. Encourage the students to arrive at their own system with as little guidance as possible.

MODIFICATIONS:

1. Make a pile of shoes by obtaining one from each student. Select one student to separate the pile by some classification system. Other students should identify the system being used. A second student may be called upon to repeat the procedure using a different system.

2. Students may be asked to bring small objects to school. The random assortment of items should prove interesting to classify.

3. If the classification of natural earth materials is desired, an assortment of pebbles obtained from beaches, gravel pits, along roadsides, and in stream beds may be used.

REFERENCES:

Investigating the Earth, pp. 36-38, Teachers Guide, pp. 69-70.
Our Planet in Space, pp. 64-68.

I-A-2a: CLASSIFICATION

QUESTION:

How can the observations of the local environment be classified?

INTRODUCTION:

Consciously or unconsciously we tend to classify all things into groups because it makes identification more convenient. Much of science is based on classification systems.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. given a group of objects, develop a classification system that can be used to classify a given group of objects.

2. describe the basis of your classification system and defend the placement of each object that has been categorized.

METHOD:

1. Carefully observe the properties of the samples provided.

2. Group the samples of similar properties and describe the basis for your classification system.

3. Using the same samples, derive a second system.

QUESTIONS:

(A-1.11) 1. How did you become aware of the properties of these items?

2. How many groups were necessary to classify your samples?

3. What properties did the objects in each group have in common?

(A-2.11) 4. What was the basis for your classification system?

I-B-la: DENSITY

QUESTION:

How can properties of the environment be measured?

MATERIALS:

Plastic column kits, graduated cylinders, water, alcohol, ice cubes, rock samples (e.g., granite and basalt), graph paper.

SUGGESTED APPROACH:

1. Have available a container of water labeled "Fluid A" and a similar container of alcohol labeled "Fluid B." Ask students how the volumes of these fluids could be determined. A variety of approaches to the problem may result and can be pursued as long as the method involves comparison to a standard. One approach might be to use a plastic column which the student can calibrate with a grease pencil. The basis can be either displacement of a fluid by a solid object of known volume or direct measurement of the tube dimensions and computation of volume.

2. Provide a number of variously shaped glass containers filled to different levels with "Fluid A" and "Fluid B." Ask students what kind of relationship, if any, exists between volumes and masses of the samples. Indicate that one way of determining this is to measure the relationship of a number of samples and prepare a graph of the results. Have half the class work with "Fluid A" and the other half with "Fluid B." At this time more accuracy can be achieved by using graduated cylinders instead of student-calibrated tubes.

3. Have students plot a curve for both "Fluid A" and "Fluid B" on the same graph.

4. Have students describe each curve and predict where points would occur for samples that are larger and smaller than those measured.

   They should also arrive at the conclusion that one line is steeper than the other. With the teacher's assistance, the students should develop the ability to describe the slopes numerically in terms of change in mass over change in volume, or rise to run (i.e., the alcohol curve should rise approximately 0.8 squares on a run of one square, producing a slope of $\frac{0.8}{1}$ or 0.8.

5. Inform students that the numerical value $\frac{\text{mass}}{\text{volume}}$ which is unique to the substance is called density.

6. Demonstrate that an ice cube dropped into "Fluid A" will float while an ice cube in "Fluid B" will sink. Ask the students to predict and sketch a line on their "Fluid A and B" graphs representing the density of ice.

   The students should be asked to <u>measure</u> the density of an ice cube. Allow them to pursue any reasonable technique. At the end of the exercise, point out that no measurements other than observing the demonstration would have been necessary to determine the approximate density. In effect, fluids "A" and "B" could have been used as standard densities and the ice compared to each (i.e., ice floated in "A" and is therefore less dense, ice sank in "B" and is therefore more dense).

7. Provide samples of common, solid earth materials (e.g., granite and basalt) and have students find the densities of the materials.

8. Have students determine standard densities of materials used (either by averaging their results or by referring to density tables) and compute the percentage of error. Have students compile a list of possible sources of error and discuss ways that the results could be improved.

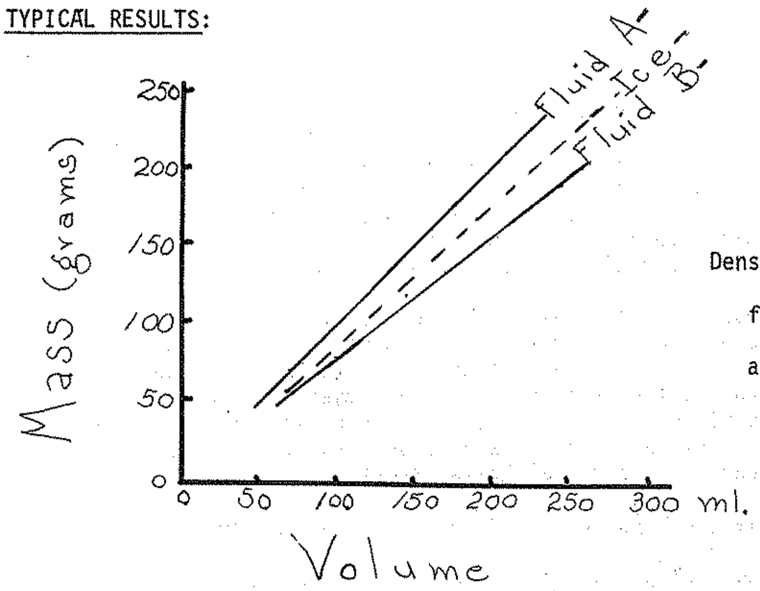
PRECAUTIONS:

1. This lab is not designed to be completed during one average class period. Convenient breaking points occur following Suggested Approaches 1, 5, and possibly 6.

2. If students are well versed in measurement from previous training, Suggested Approach #1 may be eliminated.

3. Duplicating fluid may be used in place of alcohol, but check its density.

TYPICAL RESULTS:



Density Graph - for Fluid A, Fluid B, and Ice

MODIFICATIONS:

1. Introduce the topic of density by using two identical appearing bottles as a demonstration. One should be filled with a low density material (i.e., air), the other with a high density material (i.e., sand). Give a bottle to each of two students on opposite sides of the room. Ask the students to describe the bottles to each other and the class. Have the students exchange bottles and make comparisons. Discuss how and why the bottles were different; point out the difference in density.

2. Have the students determine the densities of various given objects. Suggest that they record data in a table listing the name of the object, its mass, volume, and density.

3. After the students have determined the densities of the objects, record the densities on the blackboard. If values do not agree, have the students suggest reasons for differences.

4. Using the recorded densities, have students discuss the effect a difference in shape or size has on the density of the same material, and the effect a difference in material has on the density of materials of the same size and shape.

REFERENCES:

Investigating the Earth, pp. 6-7, Teacher's Guide, pp. 23-27

I-B-1a: DENSITY

QUESTION:

How can properties of the environment be measured?

INTRODUCTION:

You often hear statements like "lead is heavier than water" or "gold is the heaviest material on earth." These statements are not necessarily true, for if you had a barrel of water it would certainly be heavier than a lead shot. What is implied, of course, is that if the volumes of the two substances are identical, then the lead would be heavier. This property of matter is called density.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. determine the volume of a sample of a substance with reasonable accuracy.
2. measure the mass of a sample of a substance with reasonable accuracy.
3. determine the density of a substance from mass and volume data.
4. describe the relationship between the mass and volume of different samples of the same substance.
5. calculate the percentage error between calculated and standard values.
6. list some reasons for deviations between calculated and standard values in terms of experimental procedure.

METHOD:

1. Devise a method for measuring the volumes of fluids "A" and "B."
2. Investigate the relationship between volume and mass of the samples of liquids. Graphing may aid you in recognizing the relationship.
3. Based on your graph interpretation of fluids "A" and "B," make predictions concerning the masses of larger and smaller volumes than those used to construct the graph.
4. Describe the differences between the lines of the graph. How could you describe these differences numerically?

5. Find the approximate density of an ice cube, and sketch a line on your graph for the density of ice.

6. Find the densities of the samples of solid earth materials provided by your teacher. Compute the percentage of error, and discuss possible sources of the error.

QUESTIONS:

(B-1.11) 1. What are the least number of basic dimensional quantities you have used to describe all of the measurements you have made? List them.

(B-1.12) 2. Which of the properties of matter investigated were based on a mathematical combination of two or more basic quantities?

(B-1.21) 3. Which of the measurements made were direct comparisons with known standards?

(B-1.31) 4. Were any of the measurements accurate determinations of the absolute value of that quantity? Explain.

(B-2.11) 5. What effect does size or shape have on the density of objects made of the same material?

I-B-1b: VARIABLE DENSITY OF WATER

QUESTION:

How can properties of the environment be measured?

MATERIALS:

Plastic shoe boxes (or some other relatively large, transparent container), small ice cubes (preferably dyed with food coloring), at least three Celsius thermometers per group, timer, cold water (less than 10°C.).

SUGGESTED APPROACH:

1. Ask students: At what temperature does water have the greatest density? How could you find out? If you had a large body of water, where would the densest water be? Why? Lead them to the concepts that water is densest at some relatively cold temperature, that the densest water should be on the bottom, and that to find the temperature of the point of maximum density you must measure the temperature on the bottom.

2. Have each group almost completely fill a plastic shoebox with cold water (precool with ice or obtain from refrigerated drinking fountains); add small dyed ice cubes so that they make a layer about 2 cm. thick; suspend three thermometers so that one is in the ice, one is near the middle depth, and one is just above the bottom of the shoebox.

3. Temperature readings should be taken every 30 seconds and continued until several identical readings are observed.

4. Plot temperature vs. time curves, for each of the three thermometers, on the same graph.

5. Collect class data and lead students in a discussion of the original question: At what temperature is water the most dense? How do you know? To check understanding, you might ask students to predict what would happen if water had its greatest density at 0°C.

6. A demonstration, to show other substances reach maximum density in the solid phase, may be conducted (e.g., drop solid chunks of paraffin into a paraffin melt and observe them sinking to the bottom).

PRECAUTIONS:

1. If it is necessary to add more ice, do so very gently so that the thermal structure is not disturbed.

2. It is necessary to insulate the shoebox from the table top.

3. Once the investigation is set up, students have little to do beyond reading the thermometers for a relatively long period of time; it is advantageous to provide some other simultaneous activity.

4. The paraffin demonstration should be tried before class time to determine if it will work.

TYPICAL RESULTS:

Provided the water is not shaken or stirred, data should not vary more than ±1C° from 4°C.

MODIFICATIONS:

1. Repeat the procedure using sea water, or have one group of students simultaneously use sea water.

2. Do as a demonstration using a 5-gallon aquarium.

3. If it is impossible to obtain a sufficient quantity of dyed ice cubes, add a few drops of food coloring to the surface several minutes after the investigation has begun. Be sure to provide a control to show that it is not just the density of the dye which causes it to go to the bottom.

4. Suspend a plastic bag filled with water and sealed in a freezer and make periodic observations to determine where freezing occurs first.

5. Use a florence flask filled completely with water and fitted with a two-hole stopper. A thermometer and small bore tubing should be inserted in the stopper. As the flask of water is cooled, the volume, as indicated by the water level in the small bore tube, will decrease. A minimum volume should be observed at about 4°C.

REFERENCES:

Our Planet in Space, pp. 252-255

I-B-1b: VARIABLE DENSITY OF WATER

QUESTION:

How can properties of the environment be measured?

INTRODUCTION:

Have you ever noticed what happens to the temperature of water in a lake as you go deeper into it? Why should the deep water be colder? Where would you find the coldest water of all? Where would you find the densest water? How could you find out at what temperature water has the greatest density?

OBJECTIVES:

When you finish this investigation, you should be able to:

1. collect, graph, and interpret temperature data.
2. describe the relationship between temperature and water density.

METHOD:

1. Fill a plastic shoebox with very cold water and add enough small ice cubes to make a layer about 2 cm. thick. Suspend three thermometers so that one is in the ice layer, one is near the middle depth, and one is just above the bottom.
2. Read each of the thermometers every 30 seconds and record the temperatures. Do not move the thermometers! Continue the readings until the temperatures appear stable.
3. Make a graph of temperature vs. time for each of the three thermometers. Develop all three graphs on the same set of axes.
4. Compare your graphs and data with those of other students.

QUESTIONS:

1. What happened to the colored water from the melted ice cubes? Why?
2. Compare the bottom temperature with (a) the original temperature and (b) the surface temperature after 1, 5, 10, and 20 minutes. Do these comparisons change with time? Why?

(B-2.14) 3. What pattern were you able to infer for the variable density of water?

4. Why doesn't water at the bottom of a deep lake freeze?

5. What would be some of the consequences if the pattern of variable density of water was similar to that of other substances?

(B-2.13) 6. How does the variable density of paraffin wax compare to water?