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ABSTRACT

Included is a collection of earth science laboratory activities, which may provide the junior or senior high school science teacher with ideas for activities in his program. The included 48 experiments are grouped into these areas: properties of matter; evaporation; atmospheric moisture and condensation; precipitation; moving water, subsurface water; material dissolved in water, solid water, and others. The booklet is designed so that the teacher's notes appear on the left page, and are adjacent to the suggested student notes on the right page. The student notes generally outline the activities under these main headings: Preparation; Experiment; Concepts; and Open-Endedness. Included are lists of earth science library books, reference books, films, filmstrips, and kits. (PR)

EARTH SCIENCE

(A PROCESS APPROACH)

Section 1: The Water Cycle

by
Earth Science Curriculum Committee

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June, 1970

INTRODUCTION

The Biological and Physical Sciences lend themselves very well to many teaching techniques, including the inquiry approach. The Earth Sciences have remained sterile with respect to inquiry because the attitude has been that you can not work with the macroscopic quantities of the earth in a microscopic classroom. The Earth Science Committee wishes to dispel this attitude with this resource booklet.

The resource booklet contains ideas about what can be done in the lab with Earth Science. By no means do we suggest that this booklet is a complete Earth Science program to be used per se without lectures, films, filmstrips, literature research and student reports. As the name suggests, this booklet is a resource booklet from which ideas may be extracted and used in whatever framework the teacher has devised in teaching Earth Science.

Because of certain limitations, the committee was only able to gather and prepare investigations on two major cycles, the Water Cycle and the Rock Cycle. Each section contains sections which can be used in many Earth Science Processes. For example, in doing a unit on weather, all the investigations pertaining to relative humidity, evaporation, water in the atmosphere and condensation can be used. Of course, a complete unit on weather is not presented as such. It is up to the teacher using this resource booklet to decide which investigations he wishes to use.

The committee hopes that this resource booklet is of value to those who use it and it also wishes to express the desire that further committees add to and improve upon this committees endeavours.

TABLE OF CONTENTS

Materials Dissolved in Water

Water in Living Things

Water is Part of Some Solids

Water in Solid Form

LIBRARY BOOKS FOR EARTH SCIENCE

ASTRONOMY

- The Nine Planets, Branley, F. M. , Crowell
- Exploring the Moon, Gallant, Roy A., Garden City
- The Amateur Astronomer, Moore, P., Lutterworth
- Stars, Zim, Herbert S., Simon & Schuster
- Windows to Space, Pickering, James S.
- Making and Using a Telescope, Wilkins, H. P., & Moore, P., Eyre
- The Stars, Adler, Irving., Day
- The Universe, Bergamini, David, Time
- New Handbook of the Heavens, Bernhard, H. J., Bennett, D. & Rice, H. S.
- The Universe of Galileo and Newton, Bixby, William, Heritage
- Experiments in Sky Watching, Branley, F. M., Crowell
- Mars; Planet Number Four, Branley, F., Crowell
- Solar Energy, Franley, F. M., Crowell
- The Sun: Our Nearest Star, Branley, F. M., Crowell
- The A B C's of Astronomy, Gallant, Roy A., Doubleday
- Exploring the Planets, Gallant, Roy A
- Stars, Men and Atoms, Haber, Heinz, Golden Press
- Pictorial Guide to the Planets, Jackson, Joseph, Crowell
- Exploration of the Universe, King, H. C.
- Beyond the Solar System, Ley, Willy, Viking
- The Sky Observer's Guide, Mayall, M., Golden Press
- Conquering the Sun's Empire, Ordway, F., III & Wakeford, R., Dutton
- Life in Other Solar Systems, Ordway, F., Dutton
- Life Beyond our Planet, Posin, Dan, McGraw-Hill
- Astronomy, Rapport, Samuel & Wright, Helen
- Planets, Life Science Library, Sagan, C., & Leonard J. N.
- The Golden Book of Astronomy, Wyler, Rose, Golden Press
- Planet Earth, Ames, Gerald & Wyler, Rose, Golden Press

GEOLOGY AND WEATHER

- The Crust of the Earth, Keith Clayton, The Nature & Scientific Library, American Museum of Natural History
- The Earth, Beiser, Arthur, Time Magazine
- Earth Science, Bird, J. Brian, Van Nostrand
- The Earth, Planet Number Three, Branley, F. M., Crowell
- The Earth, Volume 2, Investigating Science with Children, Hubbell, L.
- Shape of the Earth, Lynch, Patrick B., St. Martins
- Prospecting in Canada, Lang, G. H., Queen's Printer
- Elementary Geology for Canada, Moore, E. S., Dent
- The Earth for Sam, Reed, W., Maxwell, Harcourt, Brace & World
- Rain, Rivers and Reservoirs: The Challenge of Running Water, Archer, Sellers, G., Coward
- The Life of the Ocean, Berrill, N. J., McGraw-Hill
- Busy Water, Black, Irma Simonton, Holiday
- The Rise and Fall of the Seas: The Story of the Tides Brindze, Ruth, Harcourt, Brace & World
- The Sea Around Us, Carson, Rachel L., Oxford
- Volcanoes: New and Old, Coleman, Satis N., Day

GEOLOGY AND WEATHER (cont'd)

- Geology, 3rd Edition, Pearl, R. M., Barnes, 1963
- How to Know the Minerals and Rocks, Pearl, R. M., McGraw-Hill
- Deep Sea World: The Story of Oceanography, Coombs, C., Morrow
- The Sea, Engel, Leonard, Time Magazine
- Earth's Adventures, Fenton, Carroll, Lane, Day
- Tropical Rain Forests, Goetz, Delia, Morrow
- Water for the World, Helfman, Elizabeth, McKay
- Deep Down, Hogg, Garry, Criterion
- How the Earth is Made, Hood, Peter, Oxford, 1954
- All About the Sea, Lane, Ferdinand, C., Random
- This Thirsty World; Water Supply and Problems Ahead, Lewis, A., McGraw-Hill
- The Earth Beneath Us, Mather, K., Random
- They Lived in the Ice Age, May, Julian, Holiday
- Water at Work, Meyer, Jerome S., World
- The Life of the Cave, Mohr, Charles E. & Poulson, T.
- Our Plundered Planet, Osborne, Fairfield, Little
- Our Earth: Geology and Geologists, Place, Marian, Putnam
- All About Volcanoes and Earthquakes, Pough, F., Random
- Sea for Sam, Reed, W., Maxwell & Wilfred S., Bronson, Harcourt
- Our Quaking Earth, Roberts, Elliott, Little
- Rocks, Rivers & The Changing Earth, Schneider, H., Scott
- The Life of Rivers and Streams, Usinger, Robert L., McGraw
- The Wonders of Water, Winchester, James H., Putnam
- The Story of Geology: Our Changing Earth Through the Ages
  Wyckoff, Jerome, Golden Press
- What's Inside the Earth? Zim, Herbert S., Morrow
- Volcanoes in Action: Science and Legend, Poole, L., & G., McGraw-Hill
- World Beneath the Oceans, Gaskell, T. F., Natural History Press
- The Desert, Leopold, A., Starker, Time Magazine
- Weather in your Life, Adler, Irving, Day
- Snow is Falling, Franley, F. M., Crowell
- Not Only for Ducks: The Story of Rain, Blough, Glenn O., McGraw-Hill
- Weather, Burnett, R. Will, Golden Press
- Exploring the Weather, Gallant, Roy A., Garden City
- Weather Made Clear, Holmes, David C., Sterling
- Everyday Weather and How It Works, Schneider, H., McGraw-Hill
- Eric Sloane's Weather Book, Sloane, Eric, Duell
- All About the Weather, Tannehill, I. R., Random House
- The Hurricane Hunters, Tannehill, Ivan, Dodd
- The Wonders of the Atmosphere, Wolfe, Louis, Putnam
- Lightning and Thunder, Zim, Herbert S., Morrow
- Weathercasting, Laird, Charles & Ruth, Prentice
- Treasure in the Rock, Bush, Helen, Longmans Canada Ltd.
- Rocks and Their Stories, Fenton, C. L. & Fenton, M. A., Doubleday
- Collecting Rocks, Minerals, Gems, and Fossils, MacFall, R. Hawthorn
- How to Know Minerals and Rocks, Pearl, R. M., Signet
- Wonders of Rocks and Minerals, Pearl, Richard M., Dodd
- The Story of Rocks, Shuttlesworth, Dorothy, Doubleday
- Rocks and Minerals, Zim, H. S., & Shaffer, Paul R., Golden Press
- Field Book of Common Rocks and Minerals; Loomis, F. B., Rev. Ed., Putnam

NOTE

This list of books is merely a suggested list and by no means is complete, or completely up-to-date.

REFERENCE BOOKS FOR EARTH SCIENCE

- Time, Space and Matter, #7 Teachers' Folio
- The Earth, National Science Teachers' Association
- A Sourcebook for the Physical Sciences, Brandwein, et al.
- Modern Earth Science, Ramsey et al, 1968
- Principles of Science, Heimler - Neal (Book 1)
- Principles of Science, Heimler - Neal (Book 2)
- Investigating the Earth (E.S.C.P.)
- Modern Earth Science, Ramsey et al, 1965
- Exploring Earth Science
- Earth Science, Cambridge Work-a-Text
- Earth Science, Namowitz & Stone
- Science Activities II
- Science Activities I
- The Earth Space Science, Laidlow Series, Hibbs, et al
- Focus on Earth Science, Bishop, Lewis et al
- Geology and Earth Science Sourcebook, Holt, Rinehart and Winston
- Earth Science Lab Approach
- Foundations of Space Science, Holt, Rinehart & Winston
- Pathways in Science, Globe
- Resource Book, S.R.A.
- Earth Science, Van Nostrand
- Science World
- Weather, Golden Press
- Rocks and Minerals, Golden Press
- Stars, Golden Press
- Manual of Lecture Demonstrations, Laboratory Equipment, and Observation Equipment For Teaching Elementary Meterology in Schools; Nangerger; UNESCO

FILMS, FILMSTRIPS AND KITS

Available for Earth Science from I.M.C.

ASTRONOMY

- F 658	Eclipses of the Sun and Moon
- F 196	Universe
- F 850	Day and Night
- F 765	Sky
- F 919	Moon Adventures in Space
- F 70	Earth Satellites; Explorers of Outer Space
- F 766	Space Probes - Exploring Our Solar System
- F 209	What is Space?
- F 695	History and Development of Rockets
- F 176	Rockets; How They Work
- F 957	Sun's Family
- FS 427	Exploring the Moon
- FS 406	The Astronomer At Work
- FS 404	New Discoveries About Planet Earth
- FS 423	Space Rockets

KITS

- K 61	Target Moon

Department of Extension Astronomy Films

- A 5543-5	Exploring By Satellite
- A 4230-5	About Time
- A 5480-2	The Flaming Sky
- A 5890-1	Charting the Universe

(b) WEATHER (films)

- F 820	Air All Around Us
- F 969	What Makes Rain
- F 116	How Weather Helps Us
- F 880	How Weather is Forecast
- F 161	Origins of Weather
- F 599	Inconstant Air
- F 628	Atmosphere and Its Circulation

WEATHER (filmstrips)

- FS 408	Meteorological Instruments

Department of Extension Weather Films

- A 5740-2	First Mile Up (Pollution)
- A 6886-7	Above the Horizon (Weather)
- A 3748-9	Meteorology Fog
- A 3741-3	Ice Formation (Meteorology)
- A 3744-7	Meteorology, Temperature, Wind, Pressure
- A 551	The Weather
- A 3732-40	Synoptic Meteorology
- A 4332-7	Unchained Goddess

(c) GEOLOGY (films)

- F 68	Earth in Change - Earth's Crust
- F 861	Face of the Earth
- F 721	Birth of the Soil
- F 208	What is Soil
- F 787	Volcanoes
- F 965	Water Cycle
- F 731	Message from A Dinosaur
- F 917	Minerals and Rocks
- F 179	The Sun
- F 374	Rocks that Form on Earth's Surface
- F 630	Animals of Prehistoric America
- F 680	Geological Work of Ice

GEOLOGY (filmstrips)

- FS 429	Our Earth is Changing
- FS 432	The Soil
- FS 431	Story of the Earth We Find in the Rocks
- FS 409	Life Cycle of Rivers
- FS 428	How We Think Our Earth Came To Be
- FS 430	How Rocks are Formed

GEOLOGY

Kits from I.M.C.

- K 103	Collecting and Interpreting Fossils
- K 101	Fossils and Organic Change
- K 104	Fossils and Prehistoric Environments
- K 105	Fossils and Relative Ages of Rocks
- K 102	How Fossils are Formed
- K 73	Glaciation
- K 96	How a Glacier Shapes its Valley
- K 95	Investigating a Glacier
- K 97	Reconstructing a Glacier
- K 98	Some Side Effects of the Ice Age
- K 176	Coal
- K 177	Comparing Rocks
- K 180	Metamorphic Rocks
- K 185	Recognizing Rock Making Minerals
- K 186	Rocks and the Landscapes
- K 187	Shale, Sandstone and Conglomerate
- K 188	Volcanic Rocks

Department of Extension Geology Films

- A 328	Mountain Building
- A 6373-4	The Stream
- A 6688-90	The Hidden Earth
- A 3761	Limestone Cover
- A 6721-3	Crystals
- A 6455-6	Crystals and their Structures
- A 4590-1	Dinosaur Age
- A 5613	Dinosaur Hunting Today
- A 326	Work of Rivers
- A 1127	Volcanoes in Action
- A 1296	Buta Caves

TEACHER'S NOTES

Investigation 1-1

Considerable time should be spent on weighing and the relationships between weights and volumes before the actual concept of density in introduced. A student will be able to calculate and understand the study of water density only when he understands weights and volumes clearly. The density of water becomes much clearer when compared with other substances in following lessons.

This lesson allows for a considerable amount of laboratory techniques and procedures to be stressed, especially those of weighing and measuring volumes.

STUDENT'S NOTES

Investigation No. 1-1

PREPARATION

1. Problem
   To study the density of water.

2. Background
   Before we can study the density of water, we must have a thorough understanding of the term density. Density is the weight of an object in relation to its volume.

3. Prediction
   What will the density of water be:

   (i) .... lb. per galloon
   (ii) .... gm. per liter
   (iii) .... gm. per milliliter

5. Design
   (a) Water can be weighed by weighing an empty container, pour a known amount of water into it, and then weight it again.

EXPERIMENTATION

6. Procedure
   (a) Weigh water and express the density as grams per milliliter, grams per liter, and pounds per galloon.

DATA

8. Organization of Data

(a) Weight of container and water	....
(b) Weight of container	....
(c) Weight of water	....

10. Mathematical Treatment
    (a) Once the weighing is finished the density of water can now be expressed as a weight per volume.

    (i) Density = ... gm. per millilieter
    = ... gm. per liter
    = ... lb. per galloon

    Possible sources of error:

CONCEPTS

11. Operational Definition
    Explain what is meant by the density of water and show how it is expressed.

OPEN-ENDEDNESS

16. New Problems
    Once the procedure for finding the density of water is understood design an investigation to calculate the density of warm water, cold water, glycerine and other liquids.

STUDENT'S NOTES

Investigation No. 1-2

PREPARATION

1. Problem
   To compare the density of water with other liquids.

5. Design
   The density of water can be compared with another liquid, for example, glycerine, by placing equal volumes of each in a test tube.

EXPERIMENTATION

6. Procedures
   Pour equal volumes of water and glycerine into a test tube and shake. Then let the mixture settle. Use other liquids also.

7. Observations
   (b) Observe which liquid is sitting on top and which is on the bottom.
   Diagram.

CONCEPTS

11. Inference

.... is more dense or denser than ....

OPEN-ENDEDNESS

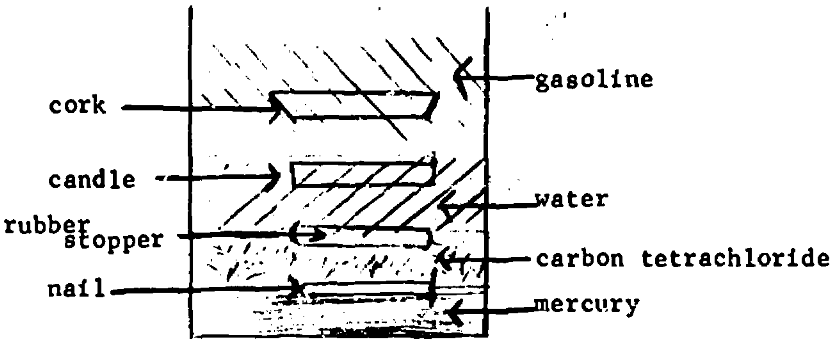
16. New Problems
    Explain a relationship between the density of warm and cold water with convection currents.

17. Application
    By knowing the densities of different substances many questions can be answered.
    (i) Would oil stay on top or go to the bottom of a lake?
    (ii) Does warm water lie on top or below cold water?

TEACHER'S NOTES

Investigation 1-2

Density is quite a difficult concept for a lot of eighth graders. However, by dropping different solids into four different liquids the concept becomes much easier. (see diagram)



This is best done by a demonstration, since mercury and gasoline are used.
Additional investigations can arise by observing the rubber stopper expanding and the candle dissolving.

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
6. Procedure
7. Observations

PROCESSING OF DATA
8. Organizing Data
9. Graphing
10 Mathematical Treatment

CONCEPTUALIZING DATA
11. Operational Definitions
12. Inferences
13. Mathematical Relationships
14. Mental Models

OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 1-3

An investigation of this type can be very messy and a waste of time if students are not aware of the problems which may occur when performing it. Students will do a better job if they are aware of these difficulties and are trying to improve upon their procedures.
A preliminary discussion should be held to emphasize that water does have a pressure and relate this to its weight. A discussion concerning swimming pools introduces this lesson very well.

STUDENT'S NOTES

Investigation 1-3

PREPARATION

1. Problem
   To show that the pressure of water increases with depth.

2. Prediction
   The water pressure is greatest at:

5. Design
   Punch three holes, one below the other in a large tin can. The uppermost hole should be about 1/3 of the way down, and the lowest hole near the bottom. Fill the can from a faucet and let enough water run into the can to keep it filled.

EXPERIMENTATION

6. Procedure
   Allow the water to run so that you can notice the curvature of the streams that come out of each of the holes.

7. Observation
   Which stream indicates the greatest pressure.

CONCEPTS

12. Inference
    Water pressure increases as the depth increases.

OPEN-ENDEDNESS

16. New Problems
    If a concrete dam were to be built should it be built thicker at any particular point?

TEACHER'S NOTES

Investigation 1-4 & 1-5

Preliminary discussions about common experiences at swimming pools will introduce the investigations about buoyancy.

When the students have noticed the difference between the weight of a body in water and in air they should set up an operational definition for buoyancy. Now the students can set up a simple apparatus to check upon the displacement of the water. This should lead to the discovery of Archimedes' Principle.

Archimedes' Principle can lead to many interesting topics such as the floating of ships, the operations of submarines, and underwater studies.

Related investigations similar to the following can provide interesting discussions.

1. Why is it easier to float in salt water than in fresh water?

   Put an egg into a tall liter beaker and then pour water into the beaker until it is about one-third full. The egg remains at the bottom of the beaker. Make a saturated salt solution in another beaker. Put the egg into this solution and notice that it floats. Why does it sink in fresh water and float in a concentrated solution of salt?

2. To make a diver

   Almost fill a wide-mouthed glass jar with water. Half fill a small test tube, about 2" long, with water. (A vial can be used instead.) Close the tube with the finger, invert the tube, place the open end under water and remove the finger. The tube should float only about one-quarter inch above water. If more than this is above water, take the tube out, pour a little more water in the tube, and then float it again. Repeat the adjustments until the tube floats with only a little of it above water. Stretch a piece of sheet rubber over the mouth of the jar (a piece of an old inner tube will do) and hold it in place with a rubber band (or tie it in place with thread).

   Now press on the stretched rubber with the finger and the diver sinks to the bottom of the jar. Release the pressure and the diver rises to the surface. The diver can be made to rise and sink indefinitely. How can you explain it?

STUDENT'S NOTES

Investigation 1-4

PREPARATION

1. Problem
   Would the weight of a body in air weigh the same amount in water?

3. Prediction
   Will a body weigh the same in water and air or will the body weigh more in water?

5. Design
   Attach a brick (or similar object) to a spring balance so that it may be lowered into a beaker of water.

EXPERIMENTATION

6. Procedure
   Did you notice the readings change at all? If they did change was there any change after the object was completely submerged?

DATA

8. Organizing of Data
   Reading in air ____________________

   Reading 1/3 in the water ____________________

   Reading 1/2 in the water ____________________

   Reading just submerged ____________________

   Reading well submerged ____________________

CONCEPTS

12. Inference
    The upward and downward forces affecting the body are not the same. The upward force is greater than the downward force in the water. This difference we call buoyancy (or buoyant force).

11. Operational Definition
    Buoyancy is

OPEN-ENDEDNESS

16. New Problems
    Would there be some principle which would apply consistently for buoyancy.

STUDENT'S NOTES

Investigation 1-5

PREPARATION

1. Problem

To illustrate a principle related to all floating bodies.

2. Background

There is an apparent weight loss of objects when immersed in water. This is due to a buoyant force which water exerts upon any object immersed in it. When a body is immersed in water, the side pressures counteract each other. However, the upward pressure exerted on an object is greater than the downward pressure on the object. This difference in upward and downward forces is called buoyancy.

5. Design

We can observe how an object floats by placing it in a container of water. We can check on how much water it displaces by collecting the overflow in an overflow beaker.

EXPERIMENTATION

6. Procedure

A suitable floating object is a small can half-filled with water. Weigh the can and water. Gently lower it into an overflow bucket, filled with water, until the can floats. Collect the displaced water in a beaker and weigh it.

DATA

8. Organization of Data

Weight of small can and water which is being submerged ______________

Weight of displaced water ______________

10. Mathematical Treatment

Compare carefully the weight of the lowered object with the weight of the displaced water.

CONCEPTS

12. Inference

The collected data should certainly support the statement that "a floating body displaces its own weight of water." In other words, this principle known as Archimedes' Principle, applies both to floating and sumberged bodies. A more general statement of Archimedes' principle is "any object wholly or partly immersed in a liquid is buoyed up by a force equal to the weight of the liquid displaced."

OPEN-ENDEDNESS

16. New Problems
    - (a) Do research on the floating of ships. Sumbarines can be raised or lowered in the water. How do they do this?
    - (b) Why is it easier to float in salt water than in fresh water?
    - (c) How could we make a diver rise and sink using simple apparatus?

TEACHER'S NOTES

Investigation 1-6

PREPARATION

1. Problem

This problem relates very closely to the phenomenon of land and sea breezes. Normally, it is done as a grade nine experiment in Heat and Temperature. A quantitative approach is not necessary.

6. Procedure

As written in student notes, the experiment is very difficult because of the large number of simultaneous readings.
Have each group of students do three or four materials only, and record data on the blackboard.
If all groups can attain the same final temperature, a graph for all six substances can be drawn.
Avoid open flames by using hot tap water
-- usual about 60 - 65°C.

- for better results, beakers may be replaced by plastic or styrofoam containers that are better calorimeters.

EXPERIMENTATION

7. Observations

The temperature rise should be:

Most   Least

STUDENT'S NOTES

Investigation 1-6

PREPARATION

1. Problem

   Investigation of heat capacity.

2. Background Information

   Due to different molecule sizes and intermolecular forces, different substances can hold different amounts of heat.

3. Prediction

   If we use equal masses of various materials and heat them to equal temperatures the amount of heat they hold should vary.

EXPERIMENTATION

6. Procedure

   (1) Place 20 gm. of each copper, alcohol, water, soil, sand and kerosene into each of 6 test tubes. Record temperature of each.

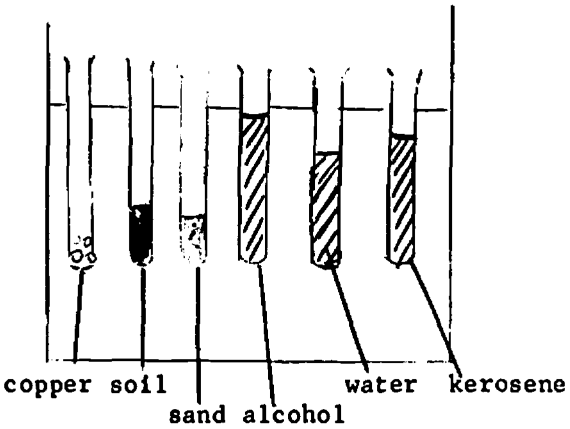
   (2) Heat all tubes in a common water bath (below boiling point of alcohol) until all reach the same temperature - Record temperatures every 30 seconds.

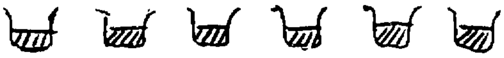
   CAUTION - Keep alcohol away from open flame.

   (3) While waiting, place 20 cc. of water in each of 6-100 ml. beakers. Keep water cool or at the same temperature in all beakers. Record temperatures.

   (4) When all substances have reached the same final temperature, quickly pour each into the 6 beakers.

   (5) Observe temperature change in the water.





STUDENT'S NOTES

Investigation 1-6 (cont'd)

DATA

7 & 8 Observations and Organization

Make a chart of temperature changes as you warm the substances

Time	Substances					
	Copper	Sand	Soil	Alcohol	Water	Kerosene
0						
30						
60						
90						
120						
150						
180						
210						
240						
270						
300						
330						
360						
390						
420						

Record temperature changes in the water

1. copper -
2. sand -
3. soil -
4. alcohol -
5. water -
6. kerosene -

STUDENT'S NOTES

Investigation 1-6 (cont'd)

9. Graphing
   Draw graphs of the change in temperature when substances are in water bath.

CONCEPTUALIZATION OF DATA

11. Definitions:
    Heat capacity is:

12. Inferences
    Which substance heats up fastest? Why?

    Which substance heats slowest? Why?

    Which substance has the greatest heat capacity?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
6. Procedure
7. Observations

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9. Graphing
0 Mathematical Treatment

CONCEPTUALIZING DATA
1. Operational Definitions
2. Inferences
3. Mathematical Relationships
4. Mental Models

OPEN-ENDEDNESS

5. Further Evidence
6. New Problems
7. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 2-1

Suggestions to Teachers

(1) Break students up into groups and have two or three groups do each of the problems, exchange information and discuss results in a post-lab.

(2) Alternate Design 3 is to repeat Design 1 with the addition of blowing on the finger.

PREPARATION
1. Problem

There are a number of variables which could be measured in investigations on evaporation, thus the problem is broken down to look at the following variables:
(1) Evaporation is accompanied by cooling
(2) Temperature effects rate of evaporation
(3) Wind effects rate of evaporation
(4) Different liquids evaporate at different rates

5. Design

Various liquids can be used to speed up the collection of data, such as hexane, acetone and ether.

OPEN-ENDEDNESS
16. New Problems

Many household appliances use the principle of evaporation to cool things, students could look into the different coolants used.

STUDENT'S NOTES

Investigation 2-1

PREPARATION

1. Problem
   What are some of the factors effecting evaporation?

2. Background Information
   Read and make notes from Science Activities, Book 1, P. 269 and Science Activities, Book 2, P. 310. List at least 4 sources of water vapor in the atmosphere.

   Sub-Problem (1)
   What happens to the temperature of the air surrounding a body of water during evaporation?

DESIGN FOR COLLECTION OF DATA

Design (1)

- (a) Dip finger in water and hold it in the air.
- (b) Dip finger in alcohol and hold it in the air.
- (c) Place thermometer in beaker of water and second thermometer in the air above the water.
- (d) Record temperature of surrounding air
- (e) Repeat (c) and (d) with alcohol instead of water.

Sub-Problem (2)
Does temperature have an effect on the amount of evaporation?

Design (2)

- (a) Put equal quantities of water in pie plates and mark levels of water.
- (b) Place one pie plate in the refrigerator and the other in a draught-free location in the room.
- (c) Record the temperature of the air above both locations.

Design (3)

- (a) Put equal quantities of water in pie plates and mark levels of water.
- (b) Place one in a draught-free location.
- (c) Fan the other pie plate vigorously.
- (d) Record the temperature of the air above both locations.

Sub-Problem (3)
Does fanning a body of water affect the amount of evaporation.

INTERPRETATION OF DATA

- (1) Does evaporation produce a cooling effect?
- (2) Which evaporates fastest, water or alcohol?
- (3) List all variables affecting the rate of evaporation.

OPERATIONAL DEFINITION OF EVAPORATION

New Problem: (1) Why does alcohol evaporate faster than water?

(2) How does an air conditioner work?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
6. Procedure
7. Observations

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8. Organizing Data
9. Graphing
0 Mathematical Treatment

CONCEPTUALIZING DATA
1. Operational Definitions
2. Inferences
3. Mathematical Relationships
4. Mental Models

OPEN-ENDEDNESS

5. Further Evidence
6. New Problems
7. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 3-1

Concepts
- (a) Water vapor (in the atmosphere) is an invisible gas.
- (b) Water vapor needs to be cooled into a liquid to be observed.
- (c) Water vapor requires a surface to condense upon.

Suggestions to Teachers

Hypothesis
- (a) Ask students how they know there is water vapor (moisture) in the air. CLOUDS, PRECIPITATION, FROST and DEW are possible answers.

- (b) Have students take care that the outside of the apparatus is free from moisture before start of experiment.

Possible Problem Arising from Interpretation 2

Students might suggest that the water from the inside of the container may have evaporated and then condensed on the outside of the container.

Suggested Way to Overcome this Problem

Have students repeat the experiment with a container with a tight-fitting lid.

Alternate Design

You can substitute dry ice for the ice water and you will produce FROST.

STUDENT'S NOTES

Investigation 3-1

PREPARATION

1. Problem

Is there water vapor in the air?

4. Hypothesis

Give as many reasons as you can to support the statement that there is water vapor in the air.

5. Design

(1) Place ice and water in a shiny tin being careful not to get any moisture on the outside of the tin. (If snow is available, use instead of ice.)

Materials

shiny tin, water and ice

EXPERIMENTATION

7. Observations

Record all observations of the outside of the tin.

INTERPRETATION OF DATA

(1) What formed on the outside of the tin?

(2) Where did the moisture come from?

(3) Why could we not see it before?

(4) What change in temperature of the air was required to see the moisture?

OPEN-ENDEDNESS

15. Further Evidence

What is the name for this type of moisture when formed in nature?

TEACHER'S NOTES

Investigation 3-2

PREPARATION

1. Problem
   The problem is to find a chemical method of determining very small amounts of water vapor.

5. Design
   Make sure that the cobalt chloride papers are BLUE, if they are purple or red, you can regenerate the papers by heating carefully in an open container.

4. Hypothesis
   Blue cobalt chloride papers turn RED upon absorption of water vapor.

Note:

The design sets out a controlled experiment, i.e., dry air will not turn the cobalt chloride paper RED.

STUDENT'S NOTES

Investigation 3-2

PREPARATION

1. Problem
   To test for the presence of water vapour in a sample of air.

2. Background Information
   Read and summarize p. 25 and p. 422 of Exploring Earth Science.

4. Hypothesis
   What do you expect to happen to a sample of cobalt chloride if placed in a moist jar?

DESIGN FOR COLLECTION OF DATA

(1) Heat an open flask with a bunsen burner (alcohol burner) for at least ten minutes.
(2) Place a freshly prepared strip of cobalt chloride paper in the flask and seal with a stopper.
(3) Blow into another flask two or three times.
(4) Place a freshly prepared strip of cobalt chloride paper in the flask and seal with a stopper. Observe.
(5) Place above jar in a hot water bath and observe.
(6) Place above jar in a cold water bath and observe.

INTERPRETATION OF DATA

(1) Why did you heat jar #1? Is jar #1 a control? Why?

(2) What is a positive test for moisture in a sample of air?

(3) Explain the differences in observations made in 5 and 6 of Design.

(4) In the case of saturated air the cobalt chloride strip acts the same way as the dust particles in cloud formation. What is the name for the name for the cobalt chloride strip and the dust particles?

(5) What would be the relative humidity of completely dry air and what color would the cobalt chloride strip be?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
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OPEN-ENDEDNESS

15. Further Evidence
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TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 3-3

PREPARATION

1. Problem

The amount of moisture a sample of air can hold depends upon the temperature of the air. The higher the temperature of the air the greater amount of moisture it can hold.

5. Suggested Design

The following design could be used to gather the data required to produce the saturation curve as shown in Exploring Earth Science, P. 26-27.

Set up a number of containers and place an equal quantity of water in them.
Seal the containers and place in locations where the temperatures vary from 50°F to 100°F.
Record the new quantity or level of water in the container after the containers reached the desired temp.
Subtract the final quantity of water from the initial quantity of water. This gives the quantity of water in the air and knowing the volume of the container, you can calculate the saturation curve.

PROCESSING OF DATA

10. Mathematical Treatment

$$\text{Relative Humidity (at a specified temperature)} = \frac{\text{amount of water the air is holding}}{\text{amount of water the air can hold}} \times 100\%$$

STUDENT'S NOTES

Investigation 3-3

PREPARATION

1. Problem
   What effect does the temperature have on the amount of moisture an air sample can hold?

2. Background Information
   Saturation is defined as the maximum amount that something can hold. Air at a certain temperture can only hold a certain maximum amount of water. At that temperature of the air, it is said that the air is saturated. The greater the temperature of the air, the more water it can hold.

   The amount of water vapor in the air can be determined quite easily by taking a known volume of dry air at a specific temperature and let water evaporate into it. After evaporation, the difference between initial and final amount of water in the container is the amount of water (gm. or oz.) that the volume of air can hold at the given temp. If this process is repeated many times and the dsta plotted on a graph, it is called "saturation curve".

   Saturation curves can be used to find

   Relative Humidities where $RH = 100 \times \frac{\text{amount of water holding}}{\text{amount of water at ssturation}}$

   e.g., if 1,000 ft^3 of air at 56°F can hold 12 ounces of water but the air is only holding 6 ounces then

   $$\text{Relative Humidity} = \frac{\text{unit of water holding}}{\text{unit of water saturation}} \times 100\%$$

   $$= \frac{6}{12} \times 100\% = 50\%$$

5. Design
   You will record your own design to obtain a saturation curve and also list materials required.

PROCESSING OF DATA

8. Organization of Data
   Copy saturation curve from p. 26, Exploring Earth Science, on graph paper provided.

INTERPRETATION OF DATA

1. Air at 10°F will hold (more, less) water vapor than air at 20° F. Volume is 1000 ft^3.
2. How many gms. of water vapor are there in 1000 ft^3 of air at 80°F?
3. How many gms of water vapor are there in 1000 ft^3 of air at 96°F?

4. 1000 ft^3 of air is saturation with 12 oz. of water vapor. What is the temperature of the air?

5. 2000 ft^3 of air at 60°F will hold a maximum of how many oz. of water?

6. What is the R.H. of saturated air?

7. What is the R.H. of air if it holds 4 oz. of water when it could hold 12 oz. of water at the same temperature.

8. 1000 ft^3 of air at 80°F holds 8 oz of water. What is R.H.?

9. 1000 ft^3 of air at 44°F contains 9 oz. of water. What is the R.H.?

10. R.H. of air is 50% and the air holds 8.5 oz. of water, what is the temperature of the air?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
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TECHNIQUES

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AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 3-4

PREPARATION
1. Problem
   The purpose of this investigation is to show that any body of air contains a large quantity of water vapor which we cannot see.

PROCESSING OF DATA
10. Mathematical Treatment
   (1) Length, width and height of room must be measured in feet.
   (2) Volume of room (rectangular prism) is L x W x H ft^3.
   (3) Find the amount of moisture in gms/1000 ft^3 because you can relate to mls. of water (1 gm of H_2) = 1 ml. H_2O).
   * You can show students the equivalent amount of liquid water if all the water vapor in the room were condensed and collected in a container.
   (4) The amount of moisture given by the graph is the amount per 1000 ft^3 assuming saturated air (100%RH) at the given temperature. To correct this use R.H. of room as a decimal (i.e. 82% = .82)

Calculation

Total weight of water vapor in the room (in grams),

$$= \frac{\text{Vol of Room in ft}^3}{1000} \times \underset{\nearrow\ \text{from saturation curve}}{\text{amount of moisture /1000 ft}^3} \times \underset{\nearrow\ \text{from hygrometer}}{\text{RH}}$$

STUDENT'S NOTES

Investigation 3-4

PREPARATION

1. Problem
   How many gms. of moisture (water vapor) are there in the science room?

2. Background Information
   Read and summarize p. 26-27 of Exploring Earth Science and draw the saturation curve on a piece of graph paper.

DESIGN FOR COLLECTION OF DATA

(1) Measure the length, width and height .
(2) Using a hygrometer find Tdry and Twet of room in feet.

MATERIALS

yardstick, hygrometer and graph paper

6. Procedure
   Record any changes or addition to Design.

7. Observations and Treatment of Data
   (1) Calculate volume of room volume = L x W x H ft ^{3}
   (2) Calculate Relative Humidity
   (3) From graph, find amount of moisture per 1,000 ft^3 at room temperature.

INTERPRETATION OF DATA

(1) Calculate the total amount of water vapor in the science room.
(2) If the temperature was lowered to Dew Point Temp., what would happen and how much moisture would be collected?

NEW PROBLEMS

(1) If a room has a volume of 4,000 ft.^{3} (cubic feet) and TDry = 50°F, TWet = 46°F, what is the total amount of moisture (water vapor) in the room.
(2) Is an equal amount (volume) of moist and dry air the same weight? How would you show the answer to the above question experimentally, assuming that the moist and dry air have the same temperature

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
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5. Experimental Design

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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

: Investigation 3-5

CONCEPTS
- (a) Relative humidity varies from day to day.
- (b) Relative humidity varies during the day.
- (c) Relative humidity is a measure of the amount of moisture in the air.
- (d) Air can hold a great deal of moisture depending upon its temperature.

Suggestions to Teachers

Ask questions about why it would be important to know the amount of moisture in the air - re meteorologists, weather reports.

2. Background Information
Research how the following instruments work:
- sling pyschometer
- hair hygrometer
- wet and dry bulb hygrometer

Calculations for a wet and dry bulb hygrometer

You require	Temp. Dry bulb Tw	eg. 76^{o}F.
	Temp. Wet bulb Tw	eg. 72^{o}F.
	Difference in Temp. ΔT	eg. 4^{o}F.

T Dry 1 2 3 4 5 6 7 8 9 10....

. . Relative Humidity is 82%

76 82

NOTE: Wet and Dry bulb Hygrometer ot work for temperatures below 32^{o}F.

Answers to Exercise in Background tion are

(a) 12% (b) 56% (c) 91% 100%

STUDENT'S NOTES

Investigation 3-5

PREPARATION

1. Problem
   (1) To compare the Relative Humidity and Dew Point Temperature at different times of a day.
   (2) To compare the Relative Humidity and Dew Point Temperature for a school week (readings to be taken at same time each day).

2. Background Information

   If we recall that evaporation requires heat and the fact that when a body of air is holding as much moisture as possible, it is called saturated air. The sling pyschrometer (hygrometer) works on the principle that one of the two thermometers has a wet cotton on it; the two thermometers are swung in the body of air to be measured; the wet bulb moisture is thus forced into the body of air to be measured by evaporation causing the temperature to drop until the air surrounding the thermometer is saturated, this is Twet; the other thermometer measures the air temperature, this is Tdry or Tunsaturated.

EXERCISE

Calculate the following Relative Humidities

(a) Tdry = 64°F Twet = 44°F
(b) Tdry = 50°F Twet = 43°F
(c) Tdry = 78°F Twet = 76°F
(d) Tdry = 40°F Twet = 40°F

DESIGN FOR COLLECTION OF DATA

(1) Wet the cotton surrounding lower thermometer.
(2) Swing for one minute and record temperature of both thermometers.
(3) Refer to problems.

MATERIALS

Sling physchrometer, water and charts

7. Observations & Organization of Data

Record data in a similar chart as below.

Date	Time	Tdry	Twet	Δ T	RH	Td.p.

STUDENT'S NOTES

Investigation 3-5 (cont'd)

INTERPRETATION OF DATA

(1) Does the amount of moisture in the air change during the day? Why?

(2) Does the amount of moisture in the air change from day to day? Why?

OPERATIONAL DEFINITION

Write a workable definition of Relative Humidity.

OPEN-ENDEDNESS

16. New Problems

(1) What would be the Relative Humidity during a heavy rainstorm?

(2) On a summer's day, where does the moisture come from to form the thunderstorm clouds?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 3-6

PREPARATION

1. Problem

   Students should come to understand the cyclic process of the earth's water through the atmosphere.

2. Background Information

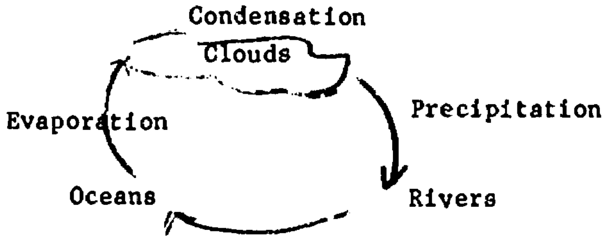
   List the sources of water which enters the atmosphere
   (a) evaporation of fresh and salt water
   (b) transpiration of plants and animals
   (c) industrial sources

   e.g. water by-product of burning hydrocarbons (sugar)

CONCEPT

The world water balance is constant.

World Water Cycle



Investigation 3-6 STUDENT'S NOTES

PREPARATION

1. Problem

How does the perspiration of a hand in a small enclosed space compare to the world's water cycle?

2. Background Information

Read pages 269 - 270, Science Activities, Book I

DESIGN FOR COLLECTION OF DATA

(1) Place one hand into a plastic bag and fasten to wrist with an elastic band.
(2) Leave in plastic bag for 10-15 minutes.
(3) Record observations of both hands each minute.

7. Observations & Organization of Data

Time	Left Hand Observations	R.H. Observations

Interpretation of Data

(1) Is there moisture on both hands? If not on one hand, explain what happened to the moisture.

(2) What can you say about the temperature of both hands?

(3) What is happening to the water vapor content inside of the plastic bag? the R.H. inside of the bag?

(4) Is Dew Point Temperature reached inside the bag? How do you know?

(5) How does this experiment relate to the world's water cycle?

STUDENT'S NOTES

Investigation 3-7

PREPARATION

1. Problem
   What conditions are necessary for the formation of clouds?

2. Background Information
   Exploring Earth Science, pages 30 - 33

DESIGN FOR COLLECTION OF DATA

(1) Pour ½ cup of warm water into a milk bottle, shake, and then pour it out.
(2) Blow into bottle a number of times making sure that the opening is sealed with your mouth.
(3) Release suddenly and observe.
(4) Repeat (1) but this time hold a smoking match over top of bottle and blow smoke into bottle.
(5) Repeat steps (2) and (3) and observe.

EXPERIMENTATION

7. Observations & Organization of Data

	Observations
without smoke	
with smoke	

INTERPRETATION OF DATA

(1) What requirement did you require to produce a cloud?

(2) What are the sources of nuclii in our atmosphere?

(3) What is the name of the process of changing water vapor into liquid water called?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

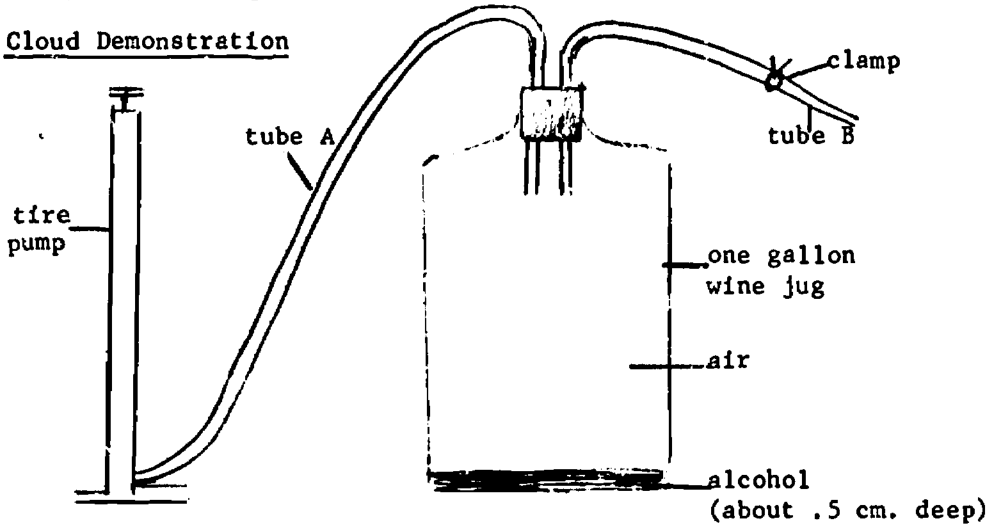
AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 3-7 (a)

Cloud Demonstration



1. Set up apparatus as shown, with clamp on tube B closed.
2. Stopper should be fitting snugly (do the demonstration beforehand to determine how snug).
3. Pump air into the jug until the stopper pops
   - there is a dramatic "pop" with the simultaneous appearance of a dense white cloud in the bottle.
4. The kids usually want this done again, so replace the stopper snugly, open clamp on tube B, and use pump to disperse the cloud.
   Then close clamp and the apparatus is ready.

Problem

The concepts to be developed are:
1. Clouds are formed from water vapor in the atmosphere,
2. moist air must be cooled to saturation before clouds will form, and
3. solid particles in the atmosphere are required for cloud formation

Suggestions for Further Study

Both investigations can be repeated using nuclii produced from salt crystals, soil and other substances to see if they also aid cloud formation.

STUDENT'S NOTES

Investigation 3-7(a)

PREPARATION

1. Problem
   How are fogs produced?

2. Background Information
   Read page 30, Exploring Earth Science

DESIGN FOR COLLECTION OF DATA

(1) Fill milk bottle with hot water and let stand for a few minutes (2 - 3 minutes).
(2) Pour out most of the water leaving ½" in the bottom.
(3) Place an ice cube across the neck of the bottle.

Repeat steps 1 and 2

(4) Place a burning stick into the milk bottle and allow some smoke to enter.
(5) Place an ice cube across the neck of the bottle.

7. Observations & Organization of Data
   Place all observations in the following chart.

with smoke	without smoke

INTERPRETATION OF DATA

(1) What effect had the introduction of smoke particles?

(2) How did the cloud formed differ from the previous experiment?

(3) What is the source of moisture in the air?

(4) Is the air very dry or nearly saturated in the bottle?

(5) What cools the air below the dew point?

(6) What happens to air cooled below its dew point?

OPEN-ENDEDNESS

16. New Problems
    Explain (a) radiation fogs (b) advection fogs

CONCEPTUALIZING DATA

11. Operational Definitions

    of (a) fog and (b) cloud

STUDENT'S NOTES

Investigation 3-8

PREPARATION

1. Problem

What is Dew Point Temperature?

2. Background Information

Refer to film on "Clouds".

4. Hypothesis

To be based on Background Information.

DESIGN FOR COLLECTION OF DATA

(1) Add water to a shiny container and record temperature.
(2) Add ice cubes and record final temperature of ice-water mixture.
(3) After five minutes record temperature of air--some distance from container.
(4) Record temperature of air next to containers.

MATERIALS

shiny container, water, ice and thermometer

EXPERIMENTATION

6. Procedure

Record any changes or additions to Design.

7. Observations

Record all temperatures and also record observation of outside of shiny container.

INTERPRETATION OF DATA

(1) What was the Dew Point Temperature of the room?

(2) Where did the dew come from?

(3) Why did it form on the outside of the container?

(4) Did evaporation from the container cause the dew? Explain.

(5) What process is taking place during dew formation?

CONCEPTUALIZING DATA

11. Operational Definitions

Write in your own words a definition of (a) dew and (b) condensation.

OPEN-ENDEDNESS

16. (1) How does Dew form in nature?
    (2) How does cloud formation compare to dew formation?
    (3) Find the following Dew Point Temperatures.
        (a) Tdry = 75°F Twet = 71°F (c) Tdry = 60°F Twet = 60°F

        (b) Tdry = 40°F Twet = 32°F (d) Tdry = 100°F Twet = 72°F

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 4-1

CONCEPT
1. There are several kinds of precipitation, depending upon temperatures in the air masses at the front.

2. The formation of some kinds of precipitation is not completely known.

NOTE:

A goodly number of students say that cloud formation is precipitation. Therefore, one of the main objectives of investigations 3-7 and 4-1 will be to have the students be able to state the difference between condensation and precipitation.

This is a good lesson to have the students hypothesize because all students have seen, or at least heard of the different types of precipitation. Write down on the board the different types of precipitation, as given by the students. Then tell the students to write down what each is composed of, and how it was formed.

(The misconceptions are remarkable!)

STUDENT'S NOTES

Investigation 4-1

PREPARATION

1. Problem

   What conditions are necessary for the kinds of precipitation to form?

4. Hypothesis

   All of us have seen most of the different kinds of precipitation: rain, snow, hail, and sleet, etc. But how do they form? Before you look up (in texts) the explanation of scientists, write down in your notes, what you think causes each type of precipitation.

RESEARCH

Find, in your texts or library books, the various types of precipitation, and an explanation of how each is formed. Be sure to note if each explanation is fact or theory.

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

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OPEN-ENDEDNESS
15. Further Evidence
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17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 5-1

CONCEPTS

(1) Increase speed of the water and the load capacity will increase.

(2) Some parts of soil will be carried by the water easier than other particles.

This investigation leads to the understanding of the work of rivers.

Investigation 5-1 STUDENT'S NOTES

PREPARATION

1. Problem

Does the load a body of water holds depend upon the speed of the water?

DESIGN FOR COLLECTION OF DATA

Part (a) 1. Add 10 gms. of soil to a beaker of water.
2. Stir and allow to settle for 10 minutes.
3. Record observations.

Part (b) 1. Stir slowly and record observations.

Part (c) 1. Stir vigorously and record observations.

MATERIALS

soil, beaker, stirring rod and water

EXPERIMENTATION

7. Observations and Organization of Data

	Design 1	Design 2	Design 3
Color of Water			
Amount of Sediment on Bottom			

STUDENT'S NOTES

Investigation 5-1 (cont'd)

INTERPRETATION OF DATA

1. In which design is the water moving the fastest?

2. In which design is there the least amount of a sediment on the bottom of the beaker?

3. What causes the color in the water?

4. In which design is the load capacity of the water the greatest?

5. Under what conditions will the load capacity of a body of water increase?

CONCEPTUALIZING DATA

11. Operational Definitions

Define the term LOAD CAPACITY in your own words.

OPEN-ENDEDNESS

17. Applications

In what season will the load capacity in a river be the greatest? By looking at the color of the river during this time, how can you tell that the load capacity is higher?

SCIENTIFIC PROCESSES

PREPARATION

1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION

6. Procedure
7. Observations

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CONCEPTUALIZING DATA

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OPEN-ENDEDNESS

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TECHNIQUES

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TEST ITEMS

TEACHER'S NOTES

Investigation 5-2

Students should be aware of the analogy taking place with the small beaker of water representing a larger body of water. This can be related to the use of a small quantity of potassium permanganate carefully placed in the beaker. This investigation lends itself well to very close observation of change, which in turn can stimulate reports on ocean currents and movement.

STUDENT'S NOTES

Investigation 5-2

PREPARATION

1. Problem

To realize large bodies of water have moving currents in them, to see how these currents move and what affects the movement of water.

3. Prediction

(a) What will affect the movement of water?
(b) What could we call these moving currents?

5. Design

Since large bodies of water cannot be studied in the classroom, set up a beaker of water to represent a body of water. Add a small amount of potassium permanganate in one corner to enable you to notice any changes.

EXPERIMENTATION

6. Procedure

Once your beaker has been set up, gently apply heat to the portion under the potassium permanganate.

7. Observations

What did you notice occur?

CONCEPTS

The movement that you have seen is an example of convection currents. These are similar to those in an ocean.

11. Operational Definition

Convection currents are ....
These currents are affected by ....

OPEN-ENDEDNESS

15. Further Evidence

You could design additional investigations by using pop bottles, hot and cold water, and coloring to notice positions taken by hot and cold water.

17. Application

This gives you a good idea of how currents can be produced in large bodies of water by temperature changes. Could you think of changes which would occur in large bodies of water?

(a) from summer to winter ....
(b) from night to day ....
(c) across areas of different latitudes ....

16. New Problems

This investigation can lead you into a study of ocean currents.

IENTIFIC PROCESSES

EPARATION
- Identifying and Forming Problem
- Background Information
- Prediction
- Hypothesis
- Experimental Design

PERIMENTATION
- Procedure
- Observations

OCESSING OF DATA
- Organizing Data
- Graphing
- Mathematical Treatment

NCEPTUALIZING DATA
- Operational Definitions
- Inferences
- Mathematical Relationships
- Mental Models

EN-ENDEDNESS
- Further Evidence
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- Applications

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ST ITEMS

TEACHER'S NOTES

Investigation 5-3

CONCEPT

Moving water--waves, contain energy for shaping coastlines and forming beaches and special features of coastlines.

2. Background Information
   Picture comparison? Princeton Project #6 "The Surface of the Earth"

5. Design
   Best to get a modified small stream table. For individual investigation pans will work.

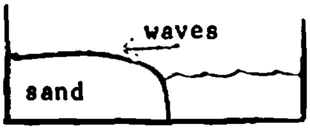
6. Procedure
   (a) Generation of waves uniform
   (b) Tilt of pan
   (c) Water level
   } Important point

7. Observations

   (a) Note nip stage in early phase; formation of wave cut notch, abrasion, platform, and shoreline face terrace; and finally a sloping beach. Careful observation can result in seeing particle sorting and longshore drifting of particles.

   (b) Diagrams

i)



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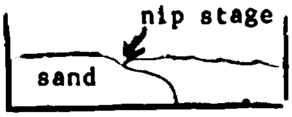

STUDENT'S NOTES

Investigation 5-3

PREPARATION

1. Problem

To investigate how waves and wave energy create new shore lines and beaches.

2. Background Information

Note changes in shore lines and beaches with pictures. Before and after pictures of sea cliffs, shorelines and beaches.

5. Design

Materials and Apparatus

cakepan, waterproof with approx. dimensions 10" x 15" x 3", sand, a spoon or paddle, wooden supports to raise pan or blocks to raise pan, water

EXPERIMENTATION

6. Procedure

(a) Place moist sand in pan to depth of 2½". Make sand cover approximately half the bottom of the pan.
(b) At the edge of the sand construct a steeply sloped beach. Make the shoreline relatively straight.
(c) Gently fill the remainder of the pan with water to a level which is half way up the beach.
(d) Raise the sand end of the pan to a height of ½" above horizontal.
(e) With the spoon generate waves to strike the beach. Keep the movement of waves constant and steady.
(f) With time note the change of the shape of the beach and the coastline.

7. Observation

(a) Make a cross-sectional diagram of the shape of the beach at specific time intervals.
(b) Make diagrams of the changes in the shape in the shape of the shorelines.

CONCEPTUALIZATION OF DATA

11. Interpretation of Data

(1) Explain how wave energy shapes shorelines and beaches.
(2) What are the general shapes and stages in the changes in the shoreline of a relatively straight shoreline?
(3) What is the general shape change in the shoreline of a relatively straight shoreline?

15. Further Evidence

Attempt the investigation on a large scale--a streamtable.

16. New Problems

(a) How does wave speed affect shoreline and beach formation?
(b) Angle at which the waves approach the shoreline and beach?
(c) Water level changes?
(d) Special land formations at a beach?
    i) headlands
    ii) bays
    iii) off shorelines

SCIENTIFIC PROCESSES

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1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
6. Procedure
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15. Further Evidence
16. New Problems
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TEST ITEMS

TEACHER'S NOTES

Investigation 5-4

This type of investigation lets the student visualize what the ocean floor could be like. The largest vessels available (aquariums, etc.) increase the effects produced by the investigation. By letting the students use their imagination further discussion, reports, etc. can be easily obtained about such topics as buried cables, ocean canyons, underwater plant and animal life.

Care should be taken about the cleanliness of the science area when doing experiments of this type. This particular investigation may give better results if the materials are set up during a previous period.

STUDENT'S NOTES

Investigation 5-4

PREPARATION

1. Problem
   To study turbidity currents and their effect.

2. Background Information
   Many deposits of material may suddenly slide along the floors of oceans, seas or lakes. This may be caused by too much weight on steep slopes, earthquakes, earth-folding, etc. Any sliding material creates a very strong current. Such currents are called turbidity currents because the water becomes very turbid or muddy.

5. Design
   Since we cannot see turbidity currents first hand we will try to produce the effect using a large beaker. (a large container like an aquarium would work better, if available)

EXPERIMENTATION

6. Procedure
   Set up a steeply sloped section of soil in the beaker (see diagram). Towards the lower part, lay a toothpick along the top of the soil. Carefully lower some type of lump which will roll down the slope when released.

7. Observation
   When the lump rolls down the slope, notice any disturbance caused. Also keep very close track of any disturbance to the toothpick.

CONCEPTS

12. Inference
    This analogy hopefully enables you to realize how a turbidity current could be set up. For example, the lump that was rolled down in the beaker could resemble material deposited by a river landsliding down the continental slope. The toothpick could represent trans-ocean cables.

OPEN-ENDEDNESS

15. Further Evidence
    Possibly you could design another experiment to further show the production of turbidity currents and their effects.

17. Application
    How do turbidity currents affect trans-ocean cables? How can watching buried cables tell us something about underwater turbidity currents?

SCIENTIFIC PROCESSES

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1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

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TEST ITEMS

TEACHER'S NOTES

Investigation 6-1

CONCEPT

Infiltration (water entering the soil)

Objective

To learn, by investigating, that the fresh water in the ground is replenished; and that several factors affect the rate of entry of water into the ground.

2. Background Information

The word "infiltration" need not be mentioned. A pre-lab for this and following related investigations should be held to determine the variables involved with infiltration. These are: (1) amount of rainfall, (2) amount of porosity in the rock or soil, (3) the amount and/or type of plant cover, and (4) the slope of the land (topography).

5. Experimental Design

The pre-lab could also be used to reach consensus on a class design; or the design could be written out for the students in the amount of detail desired. For example, types of soil and amounts of water used could be stated or left open. The pre-lab could also discuss the variables: in this investigation they are the amount of water poured in versus the amount of water drained out in a given time. The other variables are controlled by using equal amounts of soil, same type of soil, and same slope & cover.

EXPERIMENTATION

6. Procedure

The student should enter amount and type of soil, as well as amounts of water used, if it was decided to leave these open in the design.

CONCEPTUALIZING DATA

12. Inferences

Students should check with other groups to see if similar results were obtained. Or else, a post-lab discussion could determine this.

STUDENT'S NOTES

Investigation 6-1

PREPARATION

2. Background Information

It has been known since the dawn of history, that water occurs below the surface of the ground. Man observed water coming from the ground as springs. Later man learned to dig wells to tap underground reservoirs of water. The questions arise: "Has the water always been underground?" If this is the case, the water we take from the ground is not replaced; or "Is the underground water being replaced about as fast as the water is removed from the ground?" If this is the case, there must be methods by which the water enters the ground.

There are several variables which would affect the entry and/or rate of entry of water into the ground. What are they? How could you design investigations which control the variables (in turn) so that you can find how each one affects water entry, without being affected by any of the others?

1. Problem

How does the amount of rainfall affect the entry of water into the ground.

3. Prediction

Based on past experience, what do you think.

4. Hypothesis

What is your reason for thinking as you do?

Variables

What are the variables in this problem?

5. Experimental Design

Take two equal samples of the same kind of soil, place the samples in separate cans which have a few holes punched in their bottoms. Pour a measured amount of water carefully into one can, and a lesser measured amount into the other can: do this simultaneously. Catch and measure the amounts of water which drain from each soil can in a certain length of time.

EXPERIMENTATION

6. Procedure

Note in your procedure how much soil you used, what type it was (clay, loam, etc.), how much water you used, and what length of time the water drained through the soil.

7. Observations

Record your results in chart form.

CONCEPTUALIZING DATA

12. Inferences

Were there different amounts of water caught after draining through the soil? Explain your answer. Do you think other students got the same kind of results? Check and see with several groups. Can you make a general statement about the amount of rainfall and the amount

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TEACHER'S NOTES

Investigation 6-2

CONCEPT

Infiltration

Note:
The variables are: dependent: amount of water drained
:independent: soil type

Note:

The clay soil must not be in clods: it must be broken down. Clay soil absorbs water: and probably most clays will expand on becoming wet, thus reducing porosity. Because of its absorbing qualities, clay can contain (hold) a lot of water. Compacted and/or saturated clays are impervious to the passage of water.

STUDENT'S NOTES

Investigation 6-2

PREPARATION

1. Problem
   How does the soil type affect the rate of entry into the ground?

Variables
   What are the variables in this problem?

3. Prediction
   Based on your present knowledge or ideas of the different types of soil, what do you think the result will be?

4. Hypothesis
   Why do you think your results will be correct?

5. Experimental Design
   Use sandy soil, clay soil, loam soil, and a mixture of the three. Write down exactly how you would test your hypothesis using water and the soil samples. State how you are going to control the other variables, such as time, so they do not affect your results.

EXPERIMENTATION

6. Procedure
   State amounts of the soils, and water, and time, and any other details not given in the design.

7. Observations
   Record in chart form.

CONCEPTUALIZING DATA

12. Inferences
    Did all of the water drain through the soils? Explain. Did other groups get similar results? Check and see: record a couple of others. Use your results and others to make a generalization.

OPEN-ENDEDNESS

16. New Problems
    Can water enter the ground through rocks as well as soil? Do some research for answers.

SCIENTIFIC PROCESSES

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2. Background Information
3. Prediction
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Investigation 6-3

Note:

The "equipment" for this will take some time to prepare. You are going to need two similar soil types, one of which has plant growth, and the other which has significantly less growth or no growth. There should be equal thicknesses of soil in each trough (or perforated can). (Hence, plant some grass a month ahead of time.)

5. Experimental Design

For this investigation, a pre-lab discussion where the various ideas are brought together for a class design would probably be best. Equal amounts, same type of soil, length of time, type of vegetation (grass best?), and amount of water are the variables to be considered.

STUDENT'S NOTES

Investigation 6-3

PREPARATION

1. Do plant cover differences affect the rate of entry of water into the ground?

Variables

What are the variables in this problem

3. Prediction

4. Hypothesis

5. Experimental Design

EXPERIMENTATION

7. Observations
   Record your results in a table.

CONCEPTUALIZING DATA

12. Inferences
    Explain your results. Take into account the results of other groups.

OPEN-ENDEDNESS

16. New Problems
    Are all types of vegetation equally good at aiding water to enter the ground?
    Do some research for an answer.

TEACHER'S NOTES

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TEST ITEMS

Investigation 6-4

STUDENT'S NOTES

Investigation 6-4

PREPARATION

1. Problem
   Does the steepness of the slope of the ground affect the rate of entry of water into the ground?

Variables
   What are the variables in this problem.

3. Prediction

4. Hypothesis

5. Experimental Design
   Two troughs, soil, water are provided. Design an investigation to determine how steepness affect the amount of water which enters the ground. Be careful: you should be aware of erosion in this study. Plan to eliminate the effect of erosion.

EXPERIMENTATION

6. Procedure
   Enter slope angles, amount of water used, and time interval used in your investigation.

7. Observations
   Record results in chart form.

CONCEPTUALIZING DATA

12. Inferences
    Compare your results with other groups and then write a general statement about the probable effect of slope on entry of water into the ground.

SCIENTIFIC PROCESSES

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Investigation 6-5

CONCEPT

Infiltration, reservoirs, water table

Note:
Possibly one of the important ideas here is under New Problems, where man is using the water from underground storage faster than it can be replaced naturally. This is not an immediately obvious environmental change, but the effects can be long-lasting or permanent. Long-lasting effects are lowering of water table which increase water supply problems. Permanent damage is when some reservoirs are emptied of water, and the overlying weight could crush the porous rock, reducing porosity permanently.

Investigation 6-5

PREPARATION

1. Problem

   Is much water stored underground?

2. Background Information

   You have seen from your investigations that water can enter the ground. But are there important amounts of underground water?

Research

Look in various texts (science, library, social studies) for indications of the importance of underground water. Do farmers depend on it? Do cities? Do certain industries? Make notes about your findings.

EXPERIMENTATION

16. New Problems

    What are the results if water is taken out of underground storage faster than it flows in? Would the reservoir rock collapse, causing the land to sink a bit?

SCIENTIFIC PROCESSES

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Investigation 6-6

CONCEPT

Capillarity.

PREPARATION

1. Objectives
   To learn about capillarity by investigation.
   To learn about capillarity in the water cycle, and in the life cycle.

2. Background Information
   If desired, background information can be given directly, and the investigation with the capillarity tubes can be part of the investigation.

3. Prediction
   The background information should provide students with the experience to make a guess.

4. Hypothesis
   There may be negative predictions because there are no straight line tube-like channels in soil.

OPEN-ENDEDNESS

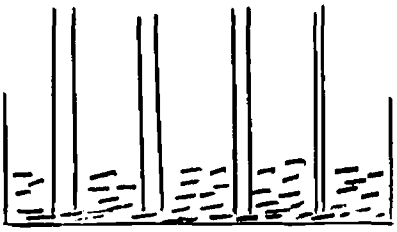
16. New Problems
    In dry times, the roots of plants depend on capillary action for water. Water freezing in a capillary crack will wedge it further apart. This is an example of mechanical weathering: the result is to reduce the height of the capillary column by increasing the diameter.

Investigation 6-6 STUDENT'S NOTES

PREPARATION

2. Background Information

Cut lengths of capillarity tubing 15 cm. long. Note the different diameters. Stand upright in water as shown in the sketch. What is the level of water in each of the tubes? Is there some connection between the height of water in the tube and the diameter of the tube? Explain. Is this simple experiment an example of capillarity? What is capillarity?



1. Problem

Would capillarity exist in soil?

3. Prediction

4. Hypothesis

5. Experimental Design

Place three dry soil types in each of three transparent cylinders having cloth bottoms. Place the cylinders in a pan of water. Measure the height of wetting of each sample at the end of given times.

EXPERIMENTATION

7. Observations

Record in a table form.

CONCEPTUALIZING DATA

12. Inferences

Check with other groups and make a general "rule".

OPEN-ENDEDNESS

16. New Problems

How do plants depend on capillarity? What would happen if water in a capillary crack in rock froze?

SCIENTIFIC PROCESSES

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TEST ITEMS

TEACHER'S NOTES

Investigation 7-1

CONCEPT
Water is the prime agent in various earth processes.

PREPARATION
1. Problem
Are any gases dissolved in Edmonton's tap water?

Sub-Concepts
- various gases are dissolved in water
- oxygen, dissolved in water, is an effective weathering process
- water pollution, natural or man-made, has become serious.

Time Allotment
Start one day, set aside, and finish the next day.

Pre-Lab

Tell the students they will be starting two experiments (problems 1 and 2) on the same day.

6. Procedure
Have the students begin this experiment, set their beakers aside, and begin problem (2).

Research

Some research will be necessary for the students to find the relationship between solubility of air in water and the temperature of water.
Also, enrichment research may be done on natural water pollution in bodies of water where circulation is poor or lacking (production of hydrogen sulphide gas and methane gas).

STUDENT'S NOTES

Investigation 7-1

2. Background Information

Is the water you get from a tap chemically pure? Edmonton has a water purification plant; does it remove everything from the water? Is anything added to the water?
The purification plant is concerned with making water fit to drink. This involves the removal of solid materials, the destruction and/or removal of harmful life, and the addition of proven medical ingredients (our water is chlorinated and fluoridated).

1. Problems

What kinds of matter might be dissolved in water?

Are any gases dissolved in Edmonton's tap water?

3. Prediction

Air is probably dissolved because water treatment often involves aeration.

4. Hypothesis

If air is dissolved in tap water, then the air may come out of solution by allowing the water to warm to room temperature.

EXPERIMENTATION

6. Procedure

Fill a small beaker about 2/3 full of water from a tap. Allow to stand undisturbed until next day.

7. Observations

Make careful observations of the water (appearance and temperature) after pouring, at the end of the period (or school day) and after one day. Record your observations.

CONCEPTUALIZING DATA

12. Inferences

(a) Do you think there were more bubbles formed than you see? Explain.
(b) Give a possible explanation of the air coming out of solution.

OPEN-ENDEDNESS

16. New Problems

(a) How does aeration take place in nature?
(b) How might aeration help in cleaning up polluted water?
(c) Are there any other gases dissolved in water?
(d) Does the air that is dissolved in water have any importance in the rock cycle or water cycle?
(Hint: oxidation is an important chemical process)

TEACHER'S NOTES

SCIENTIFIC PROCESSES

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TEST ITEMS

Investigation 7-2

CONCEPT:
Gases may dissolve in a liquid.

Objective
To show that carbon dioxide gas dissolved in water produces an acid.

4. Hypothesis
It is suggested that the hypothesis be written out because the hypothesis contains a suggestion as to how to go about testing to see if CO_2 affects water.

Experimental Design
It may be desirable to have the students produce CO_2 chemically rather blow (exhale) into water.

16. New Problems
(a) rain may be rbonated by falling through the air

(b) acids are in in the chemical weathering of rocks.

2. Background Infor
Litmus paper is means of testing whether a liquid is an aci tral, or is a base. If blue litmus paper turn a solution, the solution is an acid. If red aper turns blue, the solution is a base. If bot and red remain unchanged, the solution is neutral.

STUDENT'S NOTES

Investigation 7-2

PREPARATION

1. Problem
   Can carbon dioxide be dissolved in water?

2. Background Information
   Litmus paper is a simple means of testing whether a liquid is an acid, is neutral, or is a base. If blue litmus paper turns red in a solution, the solution is an acid. If red litmus paper turns blue, the solution is a base. If both blue and red remain unchanged, the solution is neutral.

3. Prediction
   yes

4. Hypothesis
   If carbon dioxide dissolves in water, we can blow carbon dioxide into the water, and test the water (before and after blowing) with litmus paper to see if any change took place.

5. Design
   Design an experiment to test to see if carbon dioxide can be dissolved in water.

EXPERIMENTATION

6. Procedure
   Carry out the procedure devised in your design. However, note any changes in procedure. Leave the "carbonated" water overnight and test again.

7. Observations
   Record your observations of the water before and after adding carbon dioxide. Be sure to record the litmus paper tests.

CONCEPTUALIZING DATA

12. Inferences
    (a) What did the carbon dioxide do to the water?
    (b) Did the water lose any of its carbonation by standing overnight.

OPEN-ENDEDNESS

16. New Problems
    (a) How is water most likely to become carbonated in nature?
    (b) What is the importance of carbonic acid in the water cycle and/or the rock cycle?

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
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TEST ITEMS

TEACHER'S NOTES

Investigation 7-3

CONCEPT

Solids dissolve in water.

Objectives

To show the students simple flame tests as a means of checking for some elements: to show that water dissolves certain solids easily; to show that chemical precipitates may show the presence of some dissolved materials.

4. Hypothesis

Two hypotheses are given. This will throw the students. Hence, you are going to have to explain that a problem c have many possible solutions (hypotheses) and that each hypothesis is the basis for a separate experiment (if it is a sensible hypothesis).

OPEN-ENDEDNESS

16. New Problems

If time permits, these are good problems to investigate.

(b) Distillation will remove salt from water (but not every student will think of this.)

STUDENT'S NOTES

Investigation 7-3

PREPARATION

1. Problem
Are there any solids dissolved in water?

3. Prediction
It is well known that salt and sugar can easily dissolve in water.

4. Hypothesis
(a) If water contains salt (halite, NaCl) then we can check for salt by tasting the water. (It is not a good practice to taste unknown solutions. Hence, another hypothesis should be formulated.)

(b) If water contains salt, then we can check the presence by chemical means.

2. Background Information
There are several elements which add a distinctive color to the flame of a Bunsen burner. Common salt contains sodium which gives an orange-yellow color to the hot Bunsen burner flame. Calcium is an element which gives an orange-red color to the flame. The chemical family to which chlorine belongs (the halogens) reacts with silver nitrate to form sudden and plentiful precipitates.

EXPERIMENTATION

6. Procedure
Test a prepared solution for sodium and chlorine by the following steps:
(a) evaporate a small amount of the solution until only several drops remain. Pick up a drop on a very fine wire loop and put into the Bunsen burner flame. Repeat with the rest of the solution. (Note: clean the wire loop by alternately dipping in hydrochloric acid and heating in the Bunsen burner flame. Wire loops must be cleaned immediately.)
(b) to about 5 ml, of the solution, add a small amount of silver nitrate ($AgNO_3$).

7. Observations
Record your observations for both (a) and (b).

CONCEPTUALIZING DATA

12. Inferences
What are your inferences

OPEN-ENDEDNESS

15. Further Evidence
Ask the teacher if it is safe to taste the solution, to test using the distinctive salt taste.

16. New Problems
(a) Does filtering remove the salt from the solution?
(b) What is another method of trying to remove the salt from the water?
(c) What makes water "hard".

17. Applications
(a) Find out how salt is produced commercially.

SCIENTIFIC PROCESSES

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15. Further Evidence
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17. Applications

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REFERENCES

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TEST ITEMS

TEACHER'S NOTES

Investigation 7-4

CONCEPT:

The "hardness" of water is due to dissolved solids.

Time Allotment

If only one period can be spared for this experiment, it may be necessary to heat the water samples on a warm hot plate. (NO BOILING)

Note:
Calcium gives a red color to the Bunsen flame; a clean loop is required.

OPEN-ENDEDNESS

16. New Problems

(a) The "scale" is calcium carbonate, which deposited (precipitated) when it became saturated in the water as the water boiled away. And, also because $CaCO_3$ is less soluble in hot water than in cold water.

(b) The vinegar (acetic acid) dissolves the calcium in the bones; calcium is the "stiffner" in bones.

(c) Acid underground flowing water dissolves and removes the calcium carbonate. Yes.

(d) see a Geology text.

STUDENT'S NOTES

Investigation 7-4

PREPARATION

1. Problem

   What makes water hard?

2. Background Information

   The commercial water supply from Vancouver, B.C., is "soft" water. It is collected in reservoirs from the run-off of rain from the surrounding mountains. The water on the prairies, however, falls on rocks of a different composition from those in Vancouver, and has also travelled a good deal further. Hence, there is much more chance for prairie water to dissolve minerals.

EXPERIMENTATION

6. Procedure

   Evaporate tap water on a watch glass over a period of days (or heat gently). Replenish the water in the watch glass as many times as necessary to build up a solid deposit (on the watch glass) which is large enough to analyse. At the same time, evaporate an equal amount of distilled water.

   Take a small amount on the wire loop and put it into the hot Bunsen burner flame.

   Note 1: It may be necessary to moisten the substance with water or hydrochloric acid so that it will remain on the loop.

   Note 2: Make sure your wire loop is clean: put it in the flame with nothing on it. If the loop is clean, there will be no change in the flame color.

   Test a bit of the substance with 10% hydrochloric acid.

7. Observations

   Record your observations of the flame test and the reaction with the acid.

CONCEPTUALIZING DATA

12. Inferences

    What is the substance which you collected?

OPEN-ENDEDNESS

16. New Problems
    - (a) What substance is the "scale" in tea kettles? How did it get deposited in the tea kettle?
    - (b) Chicken bones become "rubbery" when soaked in vinegar for some hours. What chemical change did the vinegar produce in the same bones?
    - (c) How do caves form? Are they usually in the same kind of rock?
    - (d) How do stalactites and stalamites form?

SCIENTIFIC PROCESSES

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5. Experimental Design

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15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

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TEST ITEMS

TEACHER'S NOTES

Investigation 7-5

CONCEPTS

Solutions and Suspensions

(a) Definition of solution
(b) Definition of suspension

A good reference source for this section is Physical Science, a Laboratory Approach re - Tyndall Effect.

Starch mixture is actually a dispersion but when students are classifying the mixture they will call it a suspension.

Precautions

(1) Do not add too much copper sulphate or you will have a suspension.

(2) When heating the glass slide be careful not to put into flame directly.

OPEN-ENDEDNESS

16. New Problems

Students should be aware that the river water is both a solution of dissolved minerals and a suspension of small particles.

STUDENT'S NOTES

Investigation 7-5

PREPARATION

1. Problem

What are the characteristics of solutions and suspensions?

2. Background Information

Research the literature available and give a brief description of the following terms: mixture, solution, solute, solvent, evaporation, filtering, suspensions and Tyndall Effect.

4. Hypothesis

In a solution individual particles of one kind of matter will be separated by particles of the other kind. (Question: What are the names given to the two kinds of matter in a solution?)

DESIGN FOR COLLECTION OF DATA

(1) Place small quantities of salt, starch, copper sulphate or potassium permanganate and soil in 200 mls. of water.
(2) Examine for transmittance of light with a flashlight.
(3) Filter solutions and examine for particles (use microscope if necessary).
(4) Examine filtrate under microscope, then heat to dryness using an alcohol burner. DO NOT put slide in flame.

Materials

salt, starch, copper sulphate or potassium permanganate, soil, 4-250 mls. beakers, funnel, 4 filter papers, 4 test tubes, microscope, and bunsen burner.

PROCESSING OF DATA

8. Organizing Data

	salt	starch	copper sulphate or potassium permanganate	soil
color				
appearance of particles				
does mixture transmit light				
does beam show in mixtures				
is solid removed by filtering				
is solid recovered by heating				
probable classification				

STUDENT'S NOTES

Investigation 7-5 (cont'd)

INTERPRETATION OF DATA

(1) Which solutions transmitted light and which did not (i.e., which illustrated the Tyndall Effect and which did not?)

(2) Were all your mixtures solutions? Explain and identify.

(3) Which mixtures were suspensions?

(4) Explain the differences between solutions and suspensions.

(5) Explain why the light is affected by the various types of mixtures.

(6) Looking back at your abrasion investigation, what could you say about the mixture formed after shaking?

OPEN-ENDEDNESS

16. New Problems

(1) If you were given two (2) unmarked containers, one with water in it and the other with salt in it, how would you proceed to identify the salt solution? (You are not allowed to taste it.)

(2) In a river, explain why, during a flood, the following statement can be true, "The waters of a river are made up of solutions and suspensions."

(3) How can you keep large particles suspended in a mixture?

CONCEPTUALIZING DATA

11. Operational Definition

Write out workable definitions in your own words of solution, suspensions.

SCIENTIFIC PROCESSES

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2. Background Information
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15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 8-1

CONCEPT

Living things contain water.

Objectives

To show that a large part of animals is water; and that water makes up a significant part of plants, and are therefore part of the water cycle.

Preparation

The students should realize, or be led to realize that four things need to be done if quantitative results are required:

(a) weigh samples before start of investigation
(b) heat gently to drive off only water
(c) collect condensate, and test to see if it is water
(d) weigh remains after thorough heating.

If class consensus is desired, a pre-lab discussion could develop the experimental design.

Note:

Use alcohol lamps (or low Bunsen flame) so the students won't drive off grease in the animal sample.

Note:

If several groups collect condensate and pool it, there may be enough to show it has the boiling point of water (and probably is water).

STUDENT'S NOTES

Investigation 8-1

PREPARATION

1. Problem
   Do plants and animals contain water?

2. Background Information
   You know that plants and animals must "drink" water. But does any of this water become part of living tissue?

3. Prediction
   Based on your past experience, do you think living tissue contains water?

4. Hypothesis
   There are several "ideas" (hypotheses) that could be tested.
   For example, you could say that if you covered a plant with a plastic bag, and the bag collected moisture on the inside, this would prove that the plant contained water. But possibly the water just passed through the plant, from roots to leaves, without ever becoming part of the plant.
   Make a hypothesis that you can test to show that water is part of plant material.
   Make a hypothesis that you can test to show that water is part of animal material.

5. Experimental Design
   Design an experiment for each guess (hypothesis). Are you liable to get other liquids as well as water? If so, how can you control your experiment so you get only water? State how you are going to check to see that the liquid is water? Be sure you include how you would determine how much water is in your plant and animal samples.

EXPERIMENTATION

6. Procedure
   Record any change in your design.

7. Observations
   Record in your notes complete observations.

CONCEPTUALIZING DATA

12. Inferences
    Record your inferences in your notes. What generalization appears from your results? Do you think there is water in the wood of a tree, a bone, a seed?

OPEN-ENDEDNESS

16. New Problems
    Do all plants contain the same amounts (or percentage) of moisture? Do all animals contain the same amount of moisture?

RESEARCH

Plants may use water, but they are helpful in conserving water in the ground. Read and report on this.

SCIENTIFIC PROCESSES

PREPARATION

1. Identifying and Forming Problem
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17. Applications

TECHNIQUES

REFERENCES

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TEST ITEMS

TEACHER'S NOTES

Investigation 9-1

CONCEPT

Some kinds of crystals contain water of crystallization.

2. **Information**

If a substance has both hydrated and dehydrated forms, it is usually referred to as "X" in the hydrated form and "dehydrated X" in the dehydrated form, however, this is not always the case.

e.g. Hydrated Form	Dehydrated Form
copper sulphate	dehydrated copper sulphat
gypsum	plaster of paris

6. **Procedure**

(a) If the test tube is not held horizontal, the water driven off will run back down onto the copper sulphate crystal.

(b) There should be enough dehydrated copper sulphate to cover the bulb of the thermometer.

7. **Observations**

(a) Water droplets form along the walls of the test tube. Blue copper sulphate crystals turn into nearly white, amorphous (noncrystalline) dehydrated copper sulphate.

(b) The white dehydrated copper sulphate turns blue. The new material is not crystalline.

(c) The sample of dehydrated copper sulphate should weigh less than hydrated copper sulphate.

(d) There should be an increase in temperature.

10. **Mathematical Treatment**

Wt. H_2O = Wt. Copper Sulphate - Wt. Dehydrated Copper Sul.

$$\% H_2O = \frac{\text{Wt. } H_2O}{\text{Wt. Copper Sulphate}} \times 100$$

Calculated percentage can be compared to theoretical values.

Mol. Wt. $Cu\ SO_4 \cdot 5H_2O$ is:

1 Cu = 63.5
1 S = 32
4 O = 64
10 H = 10
5 O = 80
249.5

$$\%H_2O = \frac{90}{249.5} \times 100 = 36$$

Investigation 9-1 STUDENT'S NOTES

PREPARATION

1. Problem

To investigate water of crystallization.

2. Background Information

Some crystals contain water united with the molecules of which they are made? A dehydrated crystal is one that has lost its water of crystallization. If it takes up water again, it becomes hydrated.

5. Design

Materials and Apparatus

- stand
- single clamp
- test tube
- thermometer
- alcohol lamp
- balance
- copper sulphate crystals
- dropper

EXPERIMENTATION

6. Procedure

(a) Place a crystal of copper sulphate in a test tube and clamp the test tube so it is horizontal. Heat the crystal gently until no more water is given off.

(b) Add a drop of water to the dehydrated copper sulphate.

(c) Crush some copper sulphate to a powder and weigh out a small sample. Put the powder in a test tube and drive off the water of crystallization (stir occassionally to break any lumps). After the copper sulphate is dehydrated, re-weigh the sample.

(d) Place the dehydrated copper sulphate in a test tube containing a thermometer. Add a drop of water and check to see if there is a temperature change.

7. Observations

PROCESSING OF DATA

10. Mathematical Treatment

Using the values obtained from 6(c), calculate the percentage of water in copper sulphate.

SCIENTIFIC PROCESSES

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15. Further Evidence
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17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 9-1 (cont'd)

12. Interpretation of Data

i) Changes include color, crystallinity, weight, amount of water, and temperature.

ii) When water is added to dehydrated copper sulphate, energy is released as copper sulphate forms. This energy was stored previously when the dehydrated copper sulphate was formed (by heating). Some of the heat energy was stored in the dehydrated copper sulphate.

15. Further Evidence

alum, $KA1\ (SO_4)_2\ .12H_2O$

washing soda, Na_2CO_3

table salt, $NaCl$

Epsom salt, $MgSO_4.7H_2O$

borax, $Na_2B_4O_7$

16. New Problems

$C_6H_{12}O_6 \rightarrow 6C + 6H_2O$

Water is produced by a chemical change. When water is added to the carbon residue it does not form sugar again.

17. Application

The water given off is due to a chemical reaction (dehydration of gypsum) rather than by evaporation.

Investigation 9-1 (cont'd)

12. Interpretation of Data

i) What are some of the changes caused by the processes of hydration?

ii) Explain the temperature change during 6 (d)

OPEN-ENDEDNESS

15. Further Evidence

Test other crystalline chemicals for water of crystallization (e.g., alum, washing soda, table salt, epsom salt, and borax)

16. New Problems

Water is given off when sugar is heated but this is not water of crystallization. Why?

17. Application

Plaster of Paris is dehydrated gypsum. One of its uses is for casts on broken arms or legs. When people talk about a new cast that is hardening, they often say it is "drying". Why is this incorrect?

SCIENTIFIC PROCESSES

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TECHNIQUES

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TEST ITEMS

TEACHER'S NOTES

Investigation 10-1

References: Princeton Project (McGraw-Hill) Book 4

5. Design

If a larger system such as block-ice and battery jar are available, these would be better as they last longer.

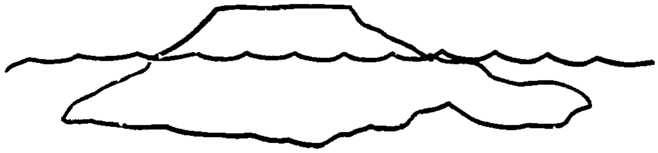
6. Procedure

Caution students that this is to represent an iceberg; but encourage them to move the cube to the center of the glass if they do not do it on their own. Students should consider measurements of size, water height, time, etc.

7. Observations

1. Water rises when ice cube is added
2. Water temperature drops
3. Ice cube grows smaller
4. Glass fogs up
5. There are cracks in the ice cube
6. Ice cube is not clear - turns white
7. About 9/10 of the cube is below the surface
8. Ice cube floats
9. When sunk, ice cube returns to surface
10. Ice cube always goes to the side of the glass
11. Cube floats horizontally
12. Cube edges gradually round off
13. Ice travels with moving water

12. Inferences
1. Icebergs are floating blocks of ice
2. About 90% of an iceberg is below the surface.
3. Ice extends out beyond the visible 10%.



4. Icebergs follow ocean currents.

16. New Problems
- How does ice float in sea water?
- How are icebergs formed?
- How are icebergs transported?

17. Application
See Inference #3

Investigation 10-1

PREPARATION

1. Problem

   Investigation of Icebergs.

5. Design

   To fully investigate icebergs in the classroom is impossible. However, it is possible to investigate a smaller system which is similar to the iceberg. This small system consists of:

   1. a clear transparent container
   2. water
   3. ice cube

   Definition

   Macrocosm - large system. In this case, the macrocosm is the iceberg--ocean system.

   Microcosm - small system. In this case, the ice cube--water system. A microcosm therefore is a miniature representation of some macrocosm.

EXPERIMENTATION

6. Procedure

   Set up the container with water and ice. (fill glass about 2/3 full) Make as many scientific observations of the system as you can. You may manipulate the ice cube at any time but keep in mind you are simulating an iceberg.

7. Observation

CONCEPTUALIZATION OF DATA

12. Inferences

OPEN-ENDEDNESS

16. New Problems

    List several other investigations that may arise from this investigation.

17. Application

    Account for the sinking of the Titanic.

SCIENTIFIC PROCESSES

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TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

TEACHER'S NOTES

Investigation 10-2

1. Problem

Some materials that could be used are salt, sugar, $KClO_3$, $CuSO_4$, $CuCl_2$, Alcohol

2. Background Information

Discuss the reasons that the type of refrigerator or temperature of freezer are not influencing factors.

6. Procedure

If class results are to be compared, some method should be derived to reduce variables. Baby food tins or soup tins (10 oz.) may be used.

Use of colored glass containers should be discouraged.

7. Observation

- Water appears at different temperatures

8. Organizing Data

A more complicated table may be devised to record data for several different salts.

tsp	NaCl	Temp	$CuSO_4$	Temp	Sugar	Temp	Alcohol	T
0								
½								
1½								
2								
2½								

STUDENT'S NOTES

Investigation 10-2

PREPARATION

1. Problem
   Do dissolved materials affect the freezing point of water.

2. Background Information
   Every substance can exist in three physical states--solid, liquid, and gas. Each substance has a certain temperature at which it changes states, from solid to liquid. At this temperature the substance will also change back to a liquid, if heat is added.

3. Hypothesis
   Since pure water and salt water are two different substances, the freezing point will probably be different.

EXPERIMENTATION

6. Procedure
   In equal amounts of water, dissolve the following amounts of salt:

   0 tsp.
   ½ tsp.
   1 tsp.
   1½ tsp.
   2 tsp.
   2½ tsp.
   3 tsp.

   Freeze each sample in an open container in a deep freeze or refrigerator. Remove from the freezer and allow to thaw. As water appears in each sample, record the water temperature.

7. Observation

SCIENTIFIC PROCESSES

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16. New Problems
17. Applications

TECHNIQUES

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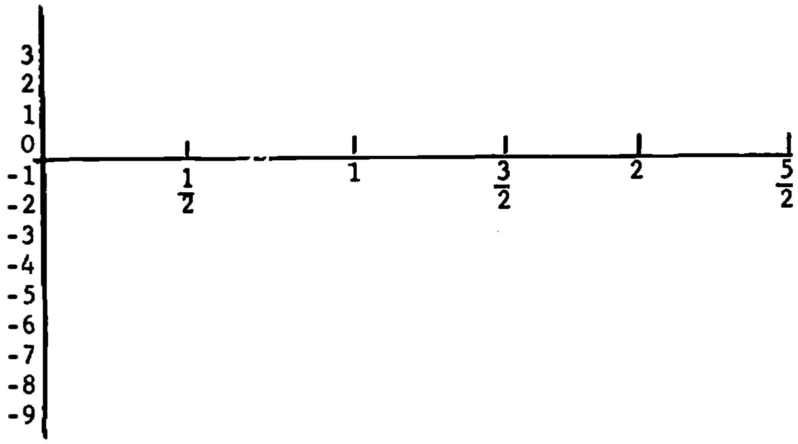
TEST ITEMS

TEACHER'S NOTES

Investigation 10-2 (cont'd)



N.B.: Usually grade eight students have not studied graphs in 4 quadrants at this point.

12. Inferences

- Dissolved materials effect the freezing point of water.

STUDENT'S NOTES

Investigation 10-2 (cont'd)

Processing of Data

8. Organization of Data
   Make a chart of your temperature readings.

Teaspoons of Salt	Temperature
0	
½	
1	
1½	
2	
2½	
3	

9. Graphing
   Draw a graph of Teaspoons of Salt vs. Freezing Temperature

CONCEPTUALIZATION OF DATA

12. Inferences

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

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TEST ITEMS

TEACHER'S NOTES

Investigation 10-3

1. Problem

Caution students that there are two problems, or break the work into two experiments.

6. Procedure

(a) Generally this is a home assignment.

(b) The ice may be replaced with a large C-clamp. Pipe and doweling should be cooled before experiment.

7. Observations

(a) Ice bends but does not melt.

(b) Ice flows (solid) out of the hole in the pipe.

CONCEPTUALIZATION OF DATA

12. Inferences

(a) Ice can easily be bent by its own weight or pressure upon it.

(b) Under pressure, ice may be made to "flow".

OPEN-ENDEDNESS

Application

This experiment should help students account for glacier movement.

STUDENT'S NOTES

Investigation 10-3

PREPARATION

1. Problem
   To show that ice is not a rigid substance.

6. Procedure
   (a) Place a bar of ice 45 x 5 x 2.5 cm. in a freezer. Support the ends and place a weight on the middle. Observe each day for one week.
   (b) Fill a one inch pipe (about 4" long) with crushed ice after drilling a small hole in the middle of the pipe. Plug each end with a short (2") piece of doweling and apply pressure to the ice using a vice.

7. Observations

   (a)

   (b)

STUDENT'S NOTES

Investigation 10-3 (cont'd)

CONCEPTUALIZATION OF DATA

12. Inferences

(a)

(b)

OPEN-ENDEDNESS

17. Application

SCIENTIFIC PROCESSES

Investigation 10-4

PREPARATION
1. Identifying and Forming Problem
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3. Prediction
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OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

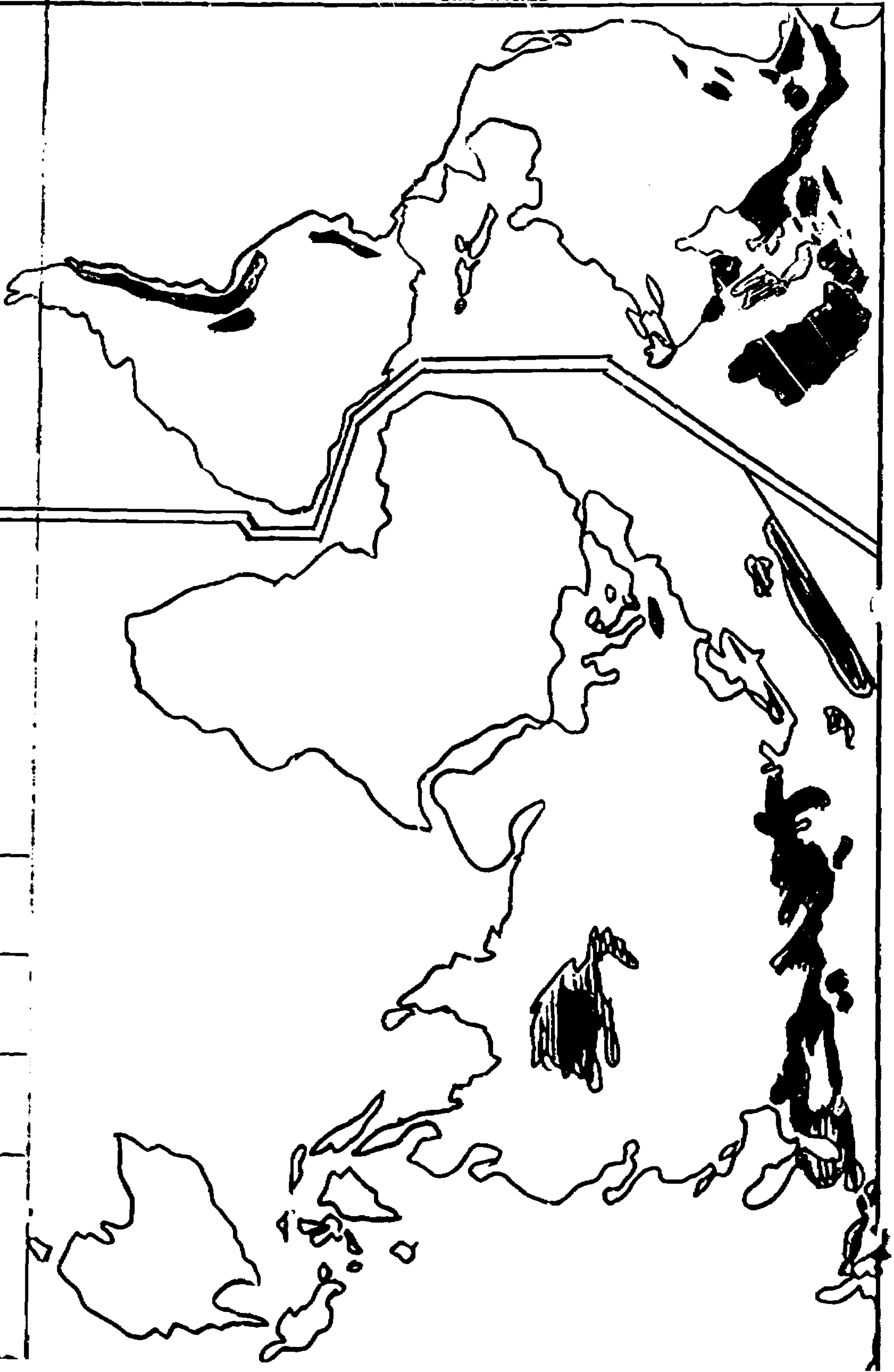
TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

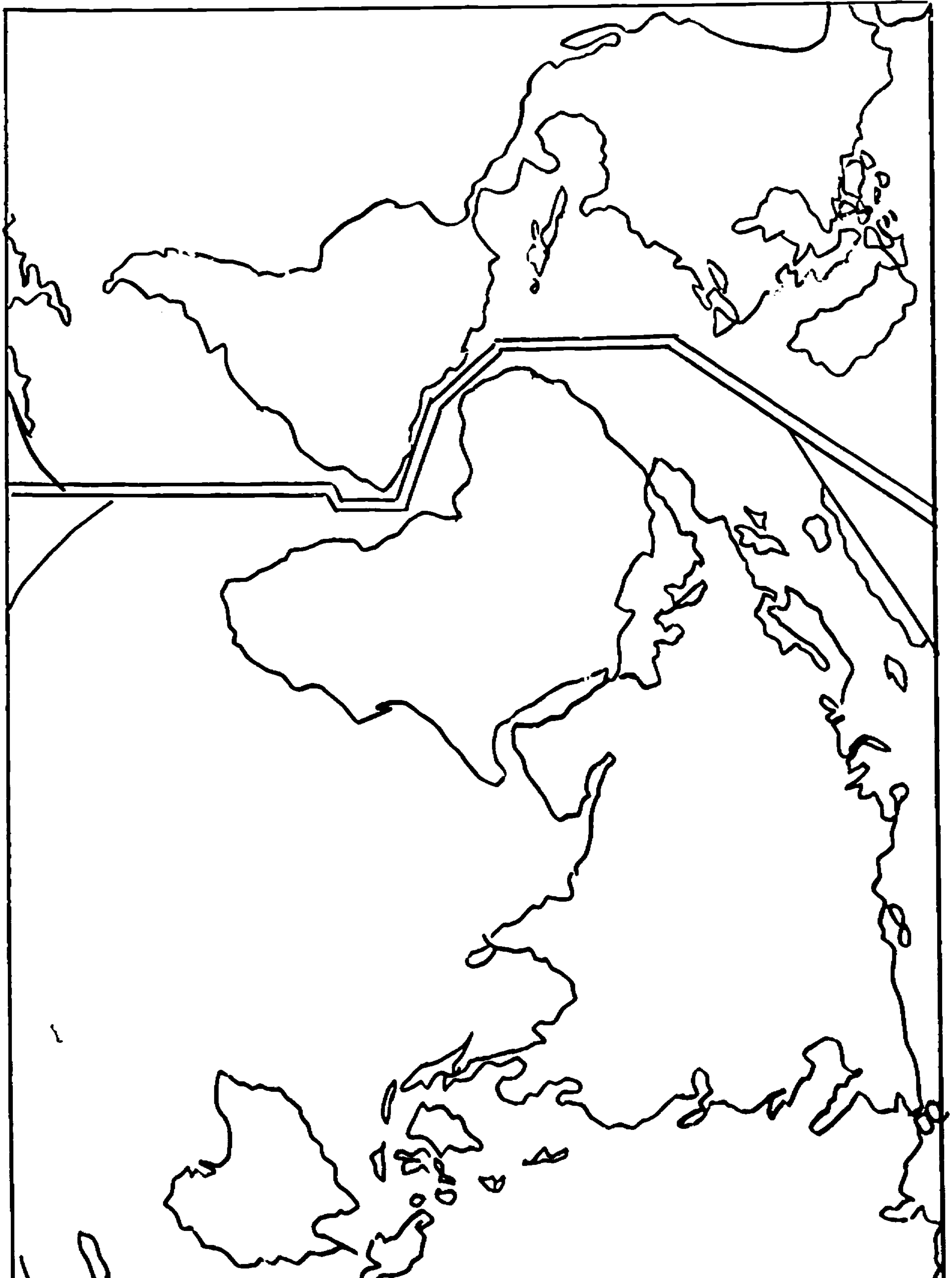
TEST ITEMS

MAP OF GLACIAL REGIONS OF THE WORLD



STUDENT'S NOTES

Investigation 10-4



SCIENTIFIC PROCESSES

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OPEN-ENDEDNESS

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17. Applications

TECHNIQUES

REFERENCES

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TEST ITEMS

TEACHER'S NOTES

Investigation 10-5

1. Problem
   - To show water increases in volume (9%) when it freezes.
   - To illustrate how freezing water can be a major factor in weathering.

7. Observations

   - The bottle breaks.

8. Inferences

   - Because water increases in volume as it freezes, the bottle is subjected to great internal pressures and breaks.

OPEN-ENDEDNESS

- Water seeping into cracks in rocks or between rocks freezes, expands and breaks into smaller fragments.

STUDENT'S NOTES

Investigation 10-5

PREPARATION

1. Problem
   What happens to water when it freezes?
   (to be done at home)

6. Procedure
   Fill a small bottle with water. Seal lid tightly. Place this in a plastic bag and set in a freezer. Observe next day.

7. Observations

12. Inferences

OPEN-ENDEDNESS

How can this idea be utilized in nature?

TEACHER'S NOTES

SCIENTIFIC PROCESSES

PREPARATION
1. Identifying and Forming Problem
2. Background Information
3. Prediction
4. Hypothesis
5. Experimental Design

EXPERIMENTATION
6. Procedure
7. Observations

PROCESSING OF DATA
8. Organizing Data
9. Graphing
10 Mathematical Treatment

CONCEPTUALIZING DATA
11. Operational Definitions
12. Inferences
13. Mathematical Relationships
14. Mental Models

OPEN-ENDEDNESS

15. Further Evidence
16. New Problems
17. Applications

TECHNIQUES

REFERENCES

AUDIO-VISUAL AIDS

TEST ITEMS

Investigation 10-6

Inference

- The time required for water to freeze is directly related to its mass but not to its volume.

- The hotter water was lighter and thus cooled faster and froze more quickly.

OPEN-ENDEDNESS

STUDENT'S NOTES

Investigation 10-6

PREPARATION

1. Problem

To investigate the relationship between initial temperature of water and time required for freezing.

4. Hypothesis

EXPERIMENTATION

6. Procedure

(1) Place 300 ml of hot water (-70°C) in an icecube tray. Place 300 ml of cold water (-10°C) in another tray. Place both in freezer at the same time. Observe every hour until both are frozen.

(2) Repeat using 300 grams of each instead of 300 ml. Observe.

7. Observations

CONCEPTUALIZATION OF DATA

12. Inference