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AUTHOR Chave, E. H.; And Others
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ABSTRACT

The Hawaii Marine Science Studies (HMSS) Project has developed over twenty instructional units, which include student laboratory and field investigations, teacher guides and supplementary reference materials. HMSS units can be taught as a one or two semester course in high school marine science, or selected portions can be combined as marine science modules for use in other secondary courses. Design of HMSS materials is based on the premise that study of the oceans provides opportunity for students of all abilities to actively engage in multidisciplinary scientific inquiry while learning basic concepts of science. HMSS units are organized around the three themes. Two of the themes, the Fluid Earth and the Living Ocean, together represent the traditional areas of oceanography. The third theme, Technology and the Ocean, provides a natural science background for the study of socio-technical issues. Instructional units included under each theme are listed in this booklet along with sample instructional materials. (Author/BB)

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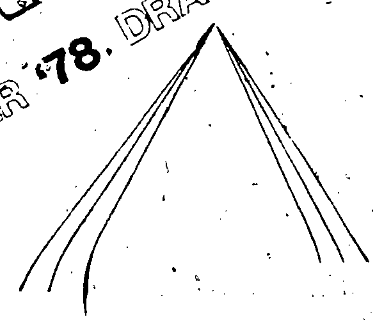
SAMPLER

HAWAII MARINE SCIENCE STUDIES PROGRAM

HMSS



SUMMER '78 DRAFT EDITION

HMSS Staff

Project Directors

Francis M. Potter [illegible] Director
E. Barbara Klemm [illegible] Associate Director

Principal Authors

E.H. Chave
Keith E. Chave
E. Barbara Klemm
Francis M. Pottenger
S. Arthur Reed
Raymond K. Rounds
Thomas Speitel

Contributors

Athline Clark
Ann Halsted
Will Kyselka
Ed Laws
Barbara Lee
Carol McCord
Barbara Z. Siege[illegible]
Anne Virnig
Dorothy Wendt

Support Staff

Pete Guido
Carol McCord
Jeanne Miyakaw[illegible]
Jean Millholan[illegible]
Anne Virnig

Curricu[illegible] [illegible] Group
Universit[illegible] [illegible] Summer 197[illegible]
[illegible]

F[illegible]ding has b[illegible] [illegible] through [illegible] Uni[illegible] of Hawa[illegible] [illegible]ulum Research [illegible] Group [illegible] Sea G[illegible] Project [illegible] Marine Scie[illegible] [illegible]ject [illegible] and [illegible]ough [illegible] [illegible]al Science [illegible]ation (NSF), t[illegible] [illegible]/PCTD [illegible] [illegible]dies Teacher [illegible]ing Institute [illegible] welcomed at the [illegible] [illegible]ect Office University Laborat[illegible] University Avenue Hon[illegible]lu, Hawai[illegible] 968[illegible]2. [illegible]one: (808) 948-6[illegible] [illegible]3.

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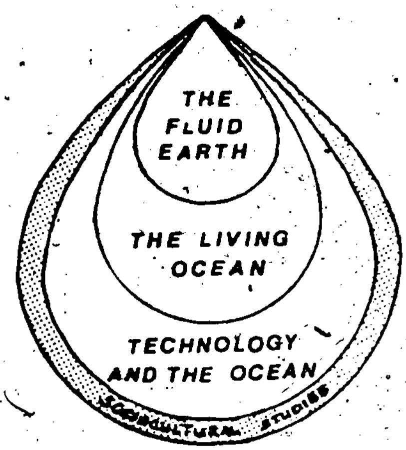
Figure 1. Logo Showing Themes of the HMSS Program.



1. OVERVIEW

The Hawaii Marine Science Studies (HMSS) Project has developed over twenty instructional units, which include student laboratory and field investigations, teacher guides and supplementary reference materials. HMSS units can be taught as a one or two semester course in high school marine science, or selected portions can be combined as marine science modules for use in other secondary courses.

Design of HMSS materials is based on the premise that study of the oceans provides opportunity for students of all abilities to actively engage in multidisciplinary scientific inquiry while learning basic concepts of science.

HMSS units are organized around the three themes described below. Two of the themes, the Fluid Earth and the Living Ocean, together represent the traditional areas of oceanography. The theme Technology and the Ocean provides a natural science background for the study of socio-technical issues. Instructional units included under each theme are listed on the next page.

1. FLUID EARTH units examine properties of water, shoreline dynamics, the nature of the world of water and its interactions with the atmosphere and the lithosphere. Fluid Earth units and/or topics can be combined to form modules for earth science, physical science, chemistry, general science, environmental or other courses.

2. LIVING OCEAN units involve an ecological view of biology, examining interactions among plants, animals and the physical and chemical environment. Units and/or topics can be selected for life science, environmental studies, general science or other subjects.

3. TECHNOLOGY AND THE OCEAN units involve the study of human use of the oceans investigating how people employ and transform the marine environment to their own ends. Concepts learned in the first two themes are applied to technical problems. Selected portions may also be used in social studies, industrial arts, agriculture and/or vocational programs.

Outline of HMSS Instructional Unit

The Summer, 19[illegible] Draft Edition of the HMSS programs consists of the twenty units listed below. The three units shown in parentheses will be completed later. A topic from each of the three units designated with an asterisk is included in the HMSS sampler.

Fluid Earth Units

*1. Properties of Water
2. Waves and Beaches
3. Chemistry of Seawater
4. Earth and Ocean Basins

Living Ocean Units

1. Aquaria
2. Field Trip I
3. Classification
4. Algae
5. Cnidaria
*6. Mollusca
7. Echinodermata
8. Sponges and Tunicates
9. Marine Worms
10. Crustacea
11. Field Trip I
12. Fishes, Reptiles and Mammals

Technology Units

*1. Transportation
(2. Aquaculture)
(3. Ocean Resources)
(4. Ocean Energy)

2. DESIGN CONSIDERATIONS

Pedagogical Considerations

Marine science classes in secondary schools draw students with very diverse academic backgrounds, ranging from those who have had no previous science to those who have had as much as three high school years in other science classes. Marine science programs also draw students with a wide ability range, including those with minimal reading and mathematics skills, those who may be less self-motivated or interested in school and those who are excellent scholars with college entrance expectations.

To satisfy the wide range of needs of these diverse student characteristics, the HMSS program is designed around a core of materials that are common for all students. These core materials lay out the logic of the program in terms of concepts and common classroom encounters. Through the teacher guides, suggestions are made for facilitating use of the core of materials. Supplementary references and suggested additional activities are given for students with limited backgrounds. Suggestions for further investigations and listings of recommended references are provided for advanced study for those students with special preparation or desire that ... and motivates them to study beyond the core.

Sequentiality and Modular Design

Marine science units are used in secondary schools in a variety of ways. In many schools, marine modules are included in established courses in biology, earth science, physical sciences or environmental education. In other schools, marine science courses are offered as one-semester or one-year programs. These may have a variety of course titles including marine science, science of the sea, oceanography, ...nology, marine environmental studies and so on.

Consequently, HMSS instructional materials are designed to be modular in nature. The 1978 edition of the HMSS instructional materials comprises the twenty units listed in the outline on page two of the ... Smaller units may be used independently for instructional sequences, or they may be combined to form a one-semester or one year course in marine science. By selectively combining units and/or topics, modules may be formed that are suitable for insertion into other secondary courses. Each unit examines several related topics in marine science through a series of problems or activities. Each topic begins with background information that provides a logic for study, reviews basic science concepts and introduces new vocabulary.

HMSS units have been classroom tested as both independent modules and as combined units forming one-semester and one-year programs. Efforts are now underway to augment the teacher guides with additional information to aid in selecting units, and in planning for the teaching of concepts which logically precede and support unit studies. Suggestions will be made for ways to combine units for various scheduling purposes.

Relationship to Other Programs

Additional secondary instructional materials specifically complementary to the HMSS program are available in the areas of marine social studies. Coastal Problems and Resource Management is a one-semester course designed to enhance the student's appreciation of the political, social, and economic problems that often occur in coastal areas. The course consists of the following five units: Introducing Coastal Regions, Coastal Problems, Politics and Management of the Coastal Region, Management Problems, and Politics and Priorities: Managing Our Coastal Future. Both Hawaiian and continental United States case studies are included. For further information, contact the Coastal Problems and Resource Management Project Office, University Laboratory School, 1776 University Avenue, Honolulu, Hawaii 96822; Phone (808) 948-7910.

3. PROJECT MATERIALS DESCRIPTION

Student Materials (S-pages)

In the student instructional materials, each topic begins with background information, a recapping of basic concepts and the introduction of new vocabulary. Suggested procedures are given to guide investigators. Summary questions call for interpretation and analysis of observations. For students interested in pursuing further studies, there are suggestions for further investigations and a selected bibliography.

Supplementary Reference Materials (R-pages)

As an aid for students, supplementary reference materials are provided. To minimize the volume of required reading appearing on the student pages, detailed descriptions of the use or construction of equipment and extended directions for experimental techniques are provided in supplementary resource booklets for [illegible] needed. Other supplemental references are designed to enrich topics and provide additional background information. These may be used as student readings or as teacher lecture-type presentations. For the Fluid Earth theme, a series of programmatic readings are also provided to allow for review of fundamental concepts.

Teacher's Guide (T-pa[illegible]

For the teacher, the rationale for each unit is given along with suggestions for presenting topics to students with varying abilities and/or prior science backgrounds. Included for each topic are teaching suggestions, advice on classroom and laboratory procedures, and discussion of the corresponding student activities. Supplemental information along with tables and diagrams is also included for the teacher to use as visual aids [illegible] presenting concepts and guiding inquiry. Student evaluations are [illegible]ed in the teacher's guides to help students and teachers in assessing progress.

Equipment and Supplies

The HMSS laboratory uses standard catalog supplies or equipment readily constructed by students and teachers. It is assumed that minimal laboratory facilities are available including running water and lab bench spaces for students. Care has been taken to ensure that the program can work under budgetary constraints.

Studies of living organisms, whenever possible, use readily available plants and animals common to the local aquatic environment. Activities are designed to foster a responsible concern for organsims' and their habitats through sound conservation practices.

4. TEACHER TRAINING AND SUPPORT

HMSS Teacher Training Workshops

HMSS materials are disseminated through teacher workshops designed to prepare teachers for using the program. Throughout the workshop, teachers investigate problems and engage in activities using the laboratory and field procedures suggested in HMSS student materials. Discussions clarify science concepts and focus on teaching strategies, classroom organization and management, and methods for adapting materials to varying student needs

There are [illegible] [illegible]tes for participating in the HMSS workshop other than being [illegible] of science interested in the marine environment. Experience [illegible] shown that most teachers in HMSS workshops are well prepared in one or more areas of science but usually not in all areas of marine science and technology. Teachers are encouraged to share knowledge and experience to enrich the workshop experience.

Special efforts are made during the workshop to familiarize teachers with local marine field study sites and with local marine plants and animals. Discussions of field trip planning include consideration for student safety as well as strategies for optimizing student learning. Recognizing that field trips are not always possible, alternatives, including demonstrations and simulations are explored. Because of the emerging nature of marine science, care is taken to aquaint teachers with ways to keep up to date with developments in marine science and technology.

HMSS Teacher Training Workshops may be of varying lengths depending on needs and interests of teachers. Most of the student activities in the HMSS materials can be included in an intense eight-hour per day two-week workshop. Longer workshops (three to four weeks), and academic year workshops meeting once a week with subsequent follow-up sessions allow for more in-depth exploration of topics of interest and additional opportunities for teachers to participate in ocean front field experiences.

Follow-up Support

Follow-up Sessions provide opportunities for teachers using HMSS instructional materials to get together to share common experiences, successes and problems after the workshop. Typically, these sessions are held after school or on weekends 4 to 6 times during the academic year. Sessions are often held in teachers' classrooms. Occasionally they are planned as trips to field study sites.

5. VALIDATION

Field Testing

The HMSS materials have undergone several writing-testing-revising cycles. They have been tested in the University Laboratory School and in pilot schools throughout Hawaii. A field-tested version will be ready for extended pilot testing in the Summer of 1979. Dissemination thereafter will be through teacher training workshops.

In 1976-77, classroom testing of draft HMSS materials was done at the University Laboratory School with classes of students from grades ten through twelve. Working with students who represented a wide range of abilities and prior experiences in science gave the HMSS staff an immediate opportunity to test the effectiveness of ideas and approaches on diverse groups.

During Spring 1977, classroom teachers reviewed and tested portions of HMSS units. Materials were also reviewed by research specialists to assure their content validity.

Systematic field testing of the HMSS materials in public and private schools of Hawaii was begun in Fall 1977. Pilot teachers were introduced to the first semester of the HMSS materials in the two-week HMSS Pilot Teacher Training Workshop in August 1977. Based on feedback from pilot teachers and their students, HMSS was further revised for the Summer 1978 Draft Edition described in this Sampler. Extensive pilot testing involving more than thirty teachers and their classes is continuing through the 1978-79 school year.

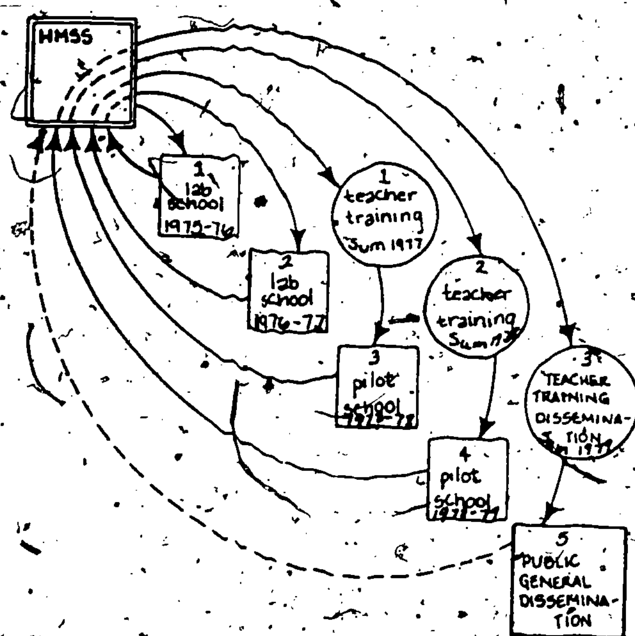


Figure 2. HMSS Write-Test-Revised Cycles.

Steering Committee and Staff

Advising the project is the HMSS Steering Committee, a selected group of teachers and researchers. Teacher members are experienced marine science teachers from local public and private high schools who bring to the committee their experience of the realism of the classroom. Research members include university professors of marine biology, chemistry, geology, and ocean engineering. In its advisory capacity the HMSS Steering Committee meets periodically to discuss the HMSS program. Members are listed on the following pages.

STEERING COMMITTEE: PILOT TEACHERS

1977 HMSS Teacher Workshop

Mr. Charles Burrows	Kamehameha Schools
Mr. Kerry Chesser	Kalaheo High School
Mr. Steve Ching	Pearl City High School
Ms. Sharlene Hamada	Waianae Intermediate School
Mr. Phil Johnson	Kamehameha Schools
Mr. Wayne Kanemoto	Pearl City High School
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Mr. Kent Sanders	Molokai High School
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Ms. Phyllis Wong	Kalani High School
Ms. Kaylene Yee	Campbell High School
Ms. Caroline Young	Ilima Intermediate School

1978 HMSS Teacher Workshop

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Ms. Dorothy M. Wendt	Waipahu High School
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STEERING COMMITTEE: ADVISORS

Dr. E. H. Chave	Curriculum Reserach and Development Group
Dr. Keith E. Chave	Professor of Oceanography
Dr. Doak Cox	Director, Environmental Center
Dr. John P. Craven	Dean, U.H. Marine Programs
Dr. Jack Davidson	Director, U.H. Sea Grant Programs
Sr. Edna Demanche, PhD.	Director, Hawaii Nature Study Project
Dr. John Bardach	East West Center
Mr. Robert Campbell	Professor of Science Education
Mr. Harold L. Goodwin	Goodwin and Goodwin
Mr. John Hawkins	Marine Science Teacher, McKinley High School
Mr. Todd Hendricks	Marine Science Teacher, Kailua High School
Dr. Arthur L. King	Director, Curriculum Research and Development Group
Ms. Barbara Klemm	Curriculum Research and Development Group
Dr. Theodore Lee	Ocean Engineer, Look Laboratory
Mr. Ronald Linsky	Ron Linsky and Associates
Dr. Gordon A. McDonald	Professor of Geology and Geophysics
Mr. John McMahon	Coordinator, U.H. Sea Grant Marine Education
Mr. Sherwood Maynard	Oceanography Department
Mr. Miles Muraoka	Science Curriculum Specialist, Dept. of Education
Ms. Judy Pool	Environmental Curriculum Specialist, Dept. of Education
Dr. Francis M. Pottenger	Curriculum Reserach and Development Group
Dr. S. Arthur Reed	Professor of Zoology
Mr. Raymond Rounds	Marine Specialist, Dept. of Education
Dr. Barbara Z. Siegel	Pacific Biomedical Research Center
Dr. Sanford Siegel	Professor of Botany
Dr. Thomas Speitel	Curriculum Research and Development Group
Dr. Edward D. Stroup	Professor of Oceanography
Dr. Leighton Taylor	Director, Waikiki Aquarium
Ms. Dorothy Wendt	Marine Science Teacher, Waipahu High School
Mr. Alvin Won	Marine Science Teacher, Kaimuki High School

EXCERPTS FROM

the

1978 Draft Edition

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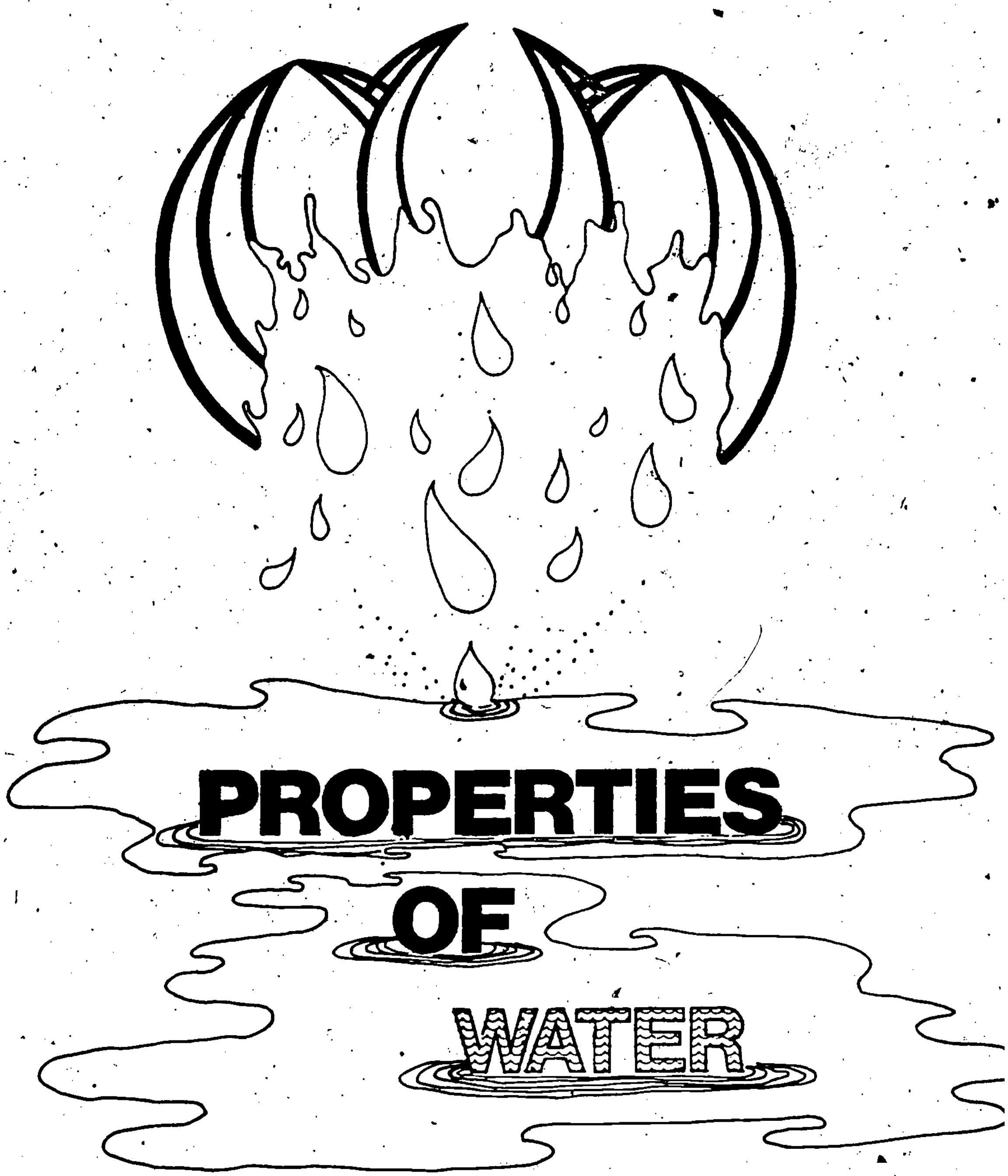
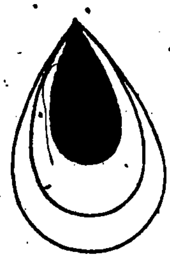

PROPERTIES
OF
WATER



an excerpt from

UNIT 1. PROPERTIES OF WATER

Unit 1. Properties of Water is the first of four units in the theme of The Fluid Earth. Unit 1 is designed to introduce students to the physical properties of water. It covers the basic properties of matter necessary to explain most physical marine phenomena. Included are studies of pressure, density, state change, currents, surface tension, cohesion, and adhesion.

Topic 1. Characteristics of Water provides a general introduction to the physical properties of water. Students are presented with a set of anomalous situations which are to be used as reference observations throughout the remaining unit.

Mass, volume, and density are introduced in an accompanying reading which is not included in this Sampler. Additional information is given in the Draft 1978 Edition of the Teacher Guide on discussions of observations and hypotheses formation for each of the laboratory investigations. An evaluation of student understanding is also included in the complete materials, but not included in the Sampler excerpts.

1. CHARACTERISTICS OF WATER AND OTHER LIQUIDS

Looking at a picture of earth from space, one is struck by the amount of the total surface that is covered by water. In the ocean and lakes we have liquid water, around the poles ice, and in the atmosphere clouds. But what are the characteristics of this substance called water? In a series of laboratory investigations we will attempt to observe and identify some of these properties.

Problem

What are some of the properties of water?

Procedure

1. Go to each of your assigned stations and do the following:
   a. Perform the operations indicated on the procedure card.
   b. Record the observations in your notebook.
2. Put the station back in the same order it was before you used the equipment. When instructed, go to the next station.

Summary Questions

1. What is meant by the phrase, "properties of water"?
2. What properties of water might account for each of your observations?
3. Which observations, if any, might be explained by the same properties?
4. Which of your observations cannot be explained?

1. CHARACTERISTICS OF WATER AND OTHER LIQUIDS

Objectives

To introduce students to

1. A series of situations that will be anomalous to many and will provide insights into characteristic properties of water
2. The idea that the physical properties of liquids vary widely from liquid to liquid.

Anticipated Time: Approximately 1 to 2 class periods.

Class Organization

Time is important. This topic is designed to be completed in 40-80 minutes. There are 10 stations suggested. It will take 4-8 minutes at each station. Other considerations include (a) the problems are straightforward and therefore need not be lingered over, and (b) not all students need to do all observations. Results can be shared during discussion.

Number of Stations depends on the method used for organizing students. Groups of three work well in classes where some students are poor readers. A student who reads well can be assigned the role of organizer. If students work in groups of 3, 10 stations will be needed for 30 students. If students work in pairs, 20 stations will be needed.

Alternatives

The sequence can also be done as a class demonstration. Even here, however, student participation is highly desirable.

Introduction

Student-performed investigation: Introduce the problem without any elaboration. The term properties will be already understood by many students, but for others it will be defined in the context of the observations.

a. Explain that at each station there is a card with instructions. Students are to read the card, perform the operations, and record the data.

b. After students are finished, they are to return the station to the condition it was in initially.

Review of Activities

Use the four Summary Questions found in the student materials to guide discussion.

a. Quickly establish that a property of a substance or a category of substances is an attribute or characteristic quality. For example, properties of water include its lack of color, its transparency, and its boiling point.

b. Having established the general meaning of property, get some consensus as to what was observed and what, if anything, seemed puzzling about each of the situations. With each description, ask what property of water or other liquid might explain the phenomenon observed. Accept terms such as solubility or capillarity if students are unable at this time to label the phenomena they describe. As the students work through Unit I, they will gain a greater understanding of the properties of water.

MATERIALS FOR STUDENT LAB STATIONS
(Instructions are given on pages which follow)

Since this topic calls for the setting up of 10 stations, each station will present a different kind of situation which students are to observe. Note: A list of total materials needed is included in the teacher pages, but omitted from the Sampler.

Station #1
Cohesion & Adhesion & Pressure

1 set	-glass plates with handles
100 ml	-tap water, labelled
100 ml	-salt water, labelled
100 ml	-methyl alcohol or ditto fluid in labelled beaker or bottle
1 ea	-eyedropper
	-toweling
	-instruction card

Station #2
Thermal Densities

1 ea	-common hot water source
50 ml	-dyed ice water, in container
50 ml	-dyed hot water, in container
1 liter	-tap water, labelled
2 ea	-200 ml containers (tall jar
1 ea	-waste bucket
	-toweling
	-instruction card

Station #3
Adhesion and Surface Tension

3 ea -small diameter shell vial
3 ea -large diameter shell vial (3 to 4 cm)
100 ml -methyl alcohol, labelled in beaker or bottle
100 ml -tap water, labelled
100 ml -salt water, labelled
3 ea -eye droppers
-toweling
-instruction card

Station #4
Surface Tension

10 ea -squares of aluminum foil (1 cm x 1 cm)
3 ea -50 ml beakers
1 ea -glass stirring rod
100 ml -tap water, labelled
100 ml -salt water, labelled
100 ml -methyl alcohol, labelled in beaker of bottle
-toweling
-instruction card

Station #5
Solubility

3 ea -graduated cylinder, 10 ml
3 ea -test tubes, 10-15 ml
1 ea -test tube rack
250 g -sodium chloride (table salt
100 ml -tap water, labelled
100 ml -salt water, labelled
100 ml -methyl alcohol, labelled in beaker or bottle
1 ea -used liquid container
-toweling
-waste container or sink
-instruction card

Station #6
Boiling Characteristic of Salt Water vs Fresh Water

1 ea -thermometer (upper limit 110°)
1 ea -heat source (hot plate, preferable to hold two 50 ml beakers)
2 ea -beakers
200 ml -tap water, labelled
200 ml -salt water, labelled
1 ea -waste container or sink
-toweling
-instruction card

Station #7
Buoyancy

1 ea -shell vial, weighted and corked (use sand or BBs for ballast)
3 ea -beakers or tall containers 150 ml (tall)
200 ml -tap water, labelled
200 ml -salt water, labelled
200 ml -methyl alcohol or ditto fluid in beaker or bottle
-toweling
-instruction card

Station #8
Capillarity

1 ea -capillary tube (10 cm or longer)
1 ea -glass tubing, 7mm (10 cm or longer)
1 ea -large bore tubing (10 cm or longer)
3 ea -flat dish (petri dish)
100 ml -tap water, labelled
100 ml -salt water, labelled
100 ml -methyl alcohol
1 ea -styrofoam cup
-tubing holder
-metric ruler
-toweling
-instruction card

Station #9
Expansion of Gases and Non Expansion of Liquids

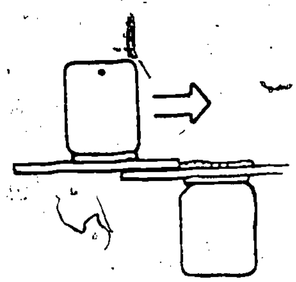
2 ea -Erlenmeyer flasks, 250 ml
2 ea -1-holed #6 rubber stopper to fit flasks
2 ea -glass tubing (20 cm or to bottom of flasks)
2 ea -rubber tubing, 6-8 cm
2 ea -syringes, 30-50 ml
-toweling
-instruction card labelled:
System #1: Air and Water
System #2: Water Only

Station #10
Siphon

2 ea -containers, 200 ml
1 ea -tubing, 25-50 cm
1 ea -metric ruler
500 ml -tap water, labelled
-toweling
-instruction card

DIRECTIONS FOR STUDENT LAB STATIONS

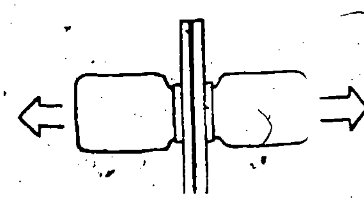
STATION #1



At this station you are testing how hard it is to pull apart two glass plates when there is a liquid between them.

Directions:

1. Pull apart glass plates that have water between them.
   a. Begin with clean, dry plates.
   b. Place 5-10 drops of water on on plate.
   c. Press the second plate against the first plate. Eliminate air bubbles by sliding one plate over the other.
   d. Grasp the jar handles and pull the plates apart.*
   e. Record your observations.



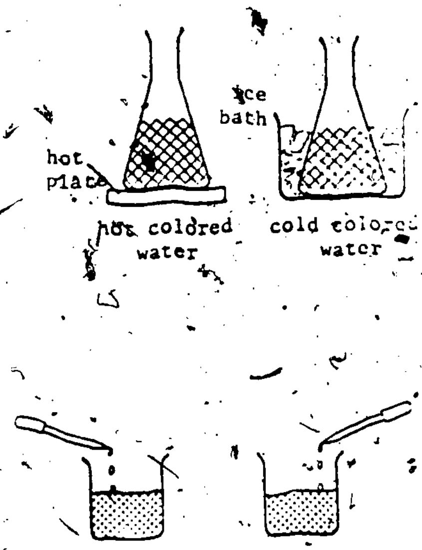
2. Repeat procedure using salt water, then again using alcohol.
3. Suggest a hypothesis to explain your observations. Test if time allows.

When finished, dry off the plates and return the station to its original condition.

*Caution: Pull gently and only in the direction shown by arrows.

STATION #2

At this station you are observing what happens when colored hot or ice-cold water is dropped into water that is at room temperature.



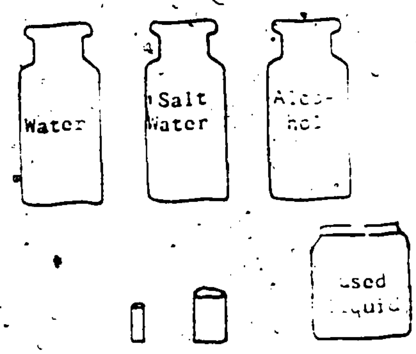
Directions

1. Fill two small clear glass containers 3/4 full of tap water.
2. In one container, place 3-4 drops of hot colored water on the surface of the tap water. Observe and record what happens to the drops.
3. In the other container, place 3-4 drops of colored ice-cold water on the surface of the tap water. Observe and record what happens to the drops.
4. Suggest a hypothesis to explain your observations. Test if time allows. Record results.

When finished, pour water into waste container Return the station to its original condition. Replenish hot or cold water if necessary.

STATION #3

At this station you are observing the appearance of liquids in vials of different sizes.



Directions

1. Observe the appearance of fresh water in the smaller vial.
   a. Fill the smaller vial 1/2 full of water. Sketch what you observe.
   b. Using an eyedropper, fill the same vial to its maximum capacity. Sketch what you observe

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2. Observe the appearance of water in the larger vial.
   a. Fill the larger vial 1/2 full of water. Sketch what you observe.
   b. Using an eyedropper, fill the larger vial to its maximum capacity.

3. Empty both vials. Pour liquid into waste container.

4. Repeat procedures using salt water, then again using alcohol.

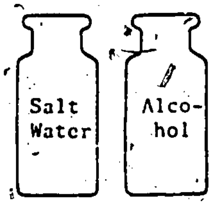
5. Suggest a hypothesis to explain your observations. Test if time allows. Record results.

When finished, return the station to its original condition.

STATION #4

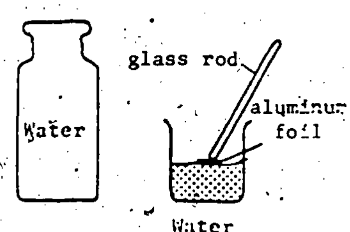
At this station you are observing how readily a small piece of aluminum foil can be made to sink below the surface of liquids.

Directions



1. Obtain a small piece of aluminum foil about 1/2 cm x 1/2 cm. Make it smooth and flat.

2. Observe foil in water.
   a. Fill beaker about 1/2 full of water.
   b. Drop the piece of foil onto the surface of water. Record your observations.
   c. Using the rod, try to sink the foil below the surface. Record the results.
   d. Remove the foil, dry it again. Make the surface smooth and flat.
   e. Empty beaker. Pour liquid into waste container.



3. Using other liquids, repeat procedure #2.

4. Suggest a hypothesis to explain your observations. Test as time allows. Record Results.

When finished, return the station to its original condition. Rinse your beakers well.

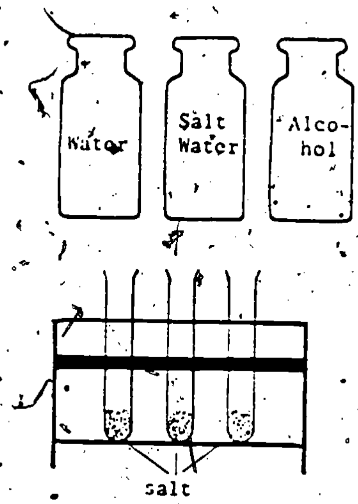
STATION #5

At this station you are testing how readily table salt dissolves in various liquids.

Directions

1. Obtain three test tubes. Place 1 ml salt crystals into each test tube.
2. Into the first test tube, add 10 ml of water. Shake the tube for about 30 seconds, and place tube in the rack.
3. Repeat procedure 2 using salt water, then again using alcohol.
4. Observe how well the salt dissolved in each liquid. Record data.
5. Suggest a hypothesis to explain your observations. Test as time allows.

When finished, empty the test tubes, rinse with tap water, and place tubes upside down in test tube rack to dry. Return the station to its original condition.

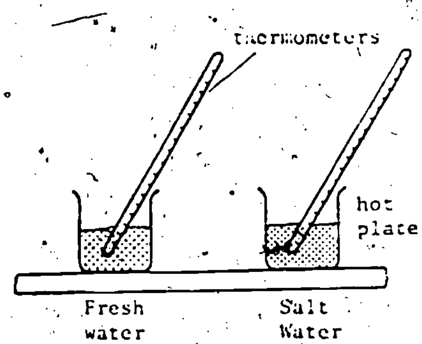


STATION #6

At this station you are observing the difference between fresh water and salt water as they are heated to their boiling points.

Directions:

1. Obtain a hot plate, a thermometer, and two small beakers.
2. Fill one beaker 1/4 full of tap water. Fill the other 1/4 full of salt water.
3. Place both beakers together on the hot plate.
4. Heat, recording temperatures at 30 second intervals until the liquids have boiled for 3 minutes.



5. Suggest a hypothesis to explain your observations. Test if time allows. Record data.

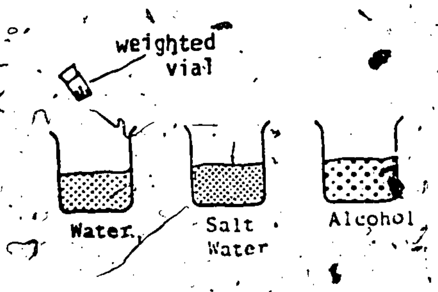
When finished, turn off hot plate, rinse out beakers and return station to its original condition.

STATION #7

At this station you are observing how well a vial floats or sinks in various liquids.

Directions:

1. Obtain 3 glass containers. Fill the first 3/4 full of water, the second 3/4 full of salt water, and the third 3/4 full of alcohol.



2. Try floating the weighted vial in each of the liquids. Record the depth of sinking.

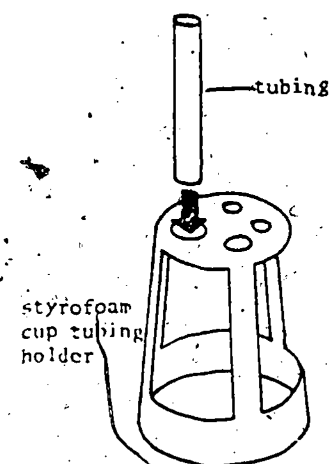
3. Suggest a hypothesis to explain your observations. Test if time allows. Record results.

When finished, pour the liquids back into their containers. Return the station to its original condition.

STATION #8

At this station you are observing how liquids rise in tubes of various sizes.

Directions:



1. Obtain tubes of various sizes, supported vertically in a cup as shown.

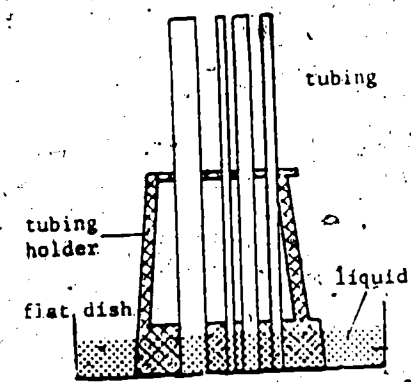
2. Observe how high water rises in the tubes.
   a. Fill a flat dish 1/2 full of tap water.
   b. Place the tubes in the dish of water.

c. Make necessary measurements and record data.
d. Empty the dish.

3. Repeat procedure using salt water and then alcohol.

4. Suggest a hypothesis to explain your observations. Test if time allows. Record results.

When finished, rinse the dish well with tap water. Return the station to its original condition.



STATION #9

At this station you are observing how readily water can be removed from a system that contains water and air as opposed to a system containing only water.

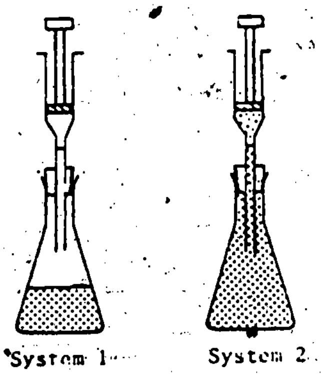
Directions:

1. Hold the barrel of Syringe #1 securely. Pull on the plunger. Record your observations.

2. Hold the barrel of Syringe #2 securely. Pull on the plunger. Record your observations.

3. Suggest a hypothesis to explain your observations. Test as time allows. Record results.

When finished, return the station to its original condition.



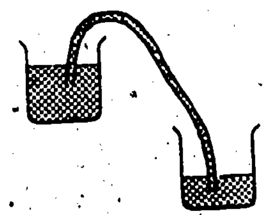
STATION #10

At this station you are observing under what conditions liquids may be siphoned.

Directions:

1. Obtain two containers. Fill one about 3/4 full with water. Leave the other empty.

2. Start the siphon.
   a. Place containers side by side on lab bench.
   b. Fill the connecting tube with water.
   c. Pinch both ends of the tube tightly. Place one end of the tube in the bottom of the container that is empty. Place the other end of the tube in the container with the water.
   d. Release the tubing.
   e. If siphon still does not work, request help from teacher.



3. Raise the container on the left so that the water level is about 2 cm above the one on the right. Observe and record under what conditions the system stops operating.

4. Raise the container on the right so that the water level is about 6 cm above the one on the left. Observe and record under what conditions the system stops operating.

5. Suggest a hypothesis to explain your observation. Test if time allows. Record results.

When finished, return the station to its original condition.


MOLLUSCA
UNIT 6

an excerpt from

UNIT 6. MOLLUSCA

Unit 6. Mollusca is one of ten units examining plants and animals in the theme The Living Ocean.

Unit 6. Mollusca introduces students to the structure and function of marine bivalves, gastropods (snails), and cephalopods (squid and octopus). Included are laboratory activities and investigations using readily available organisms.

Topic 2. Head-Foot Mollusks investigates the distinguishing features of a squid. After students have carried out the lab anatomy procedures, they prepare and taste a recipe using squid.

2. HEAD-FOOT MOLLUSKS

Cephalopods are mollusks. The term cephalopod means head-foot, aptly describing the squid, octopus, cuttlefish and nautilus which belong to this group. A characteristic of cephalopods is the foot, which has become specialized and divided into numerous arms.

Although cephalopods are mollusks, not all cephalopods have complete shells. The nautilus has a well-developed shell. The squid has an internal remnant of a shell, called a pen that looks like a thin sheet of clear plastic. A harder, more brittle plate called a cuttlebone is found in the cuttlefish. The octopus has no shell at all. Its only hard body part is its beak, a mouth part, but this is not a remnant of a shell.

The large eyes of cephalopods are also of interest. The deep-water nautilus has the most primitive eyes. Other cephalopods have well-developed eyes which are remarkably similar to human eyes.

Although most cephalopods are of relatively small size, the giant squid is the largest of all invertebrates, reaching lengths of 15 meters.

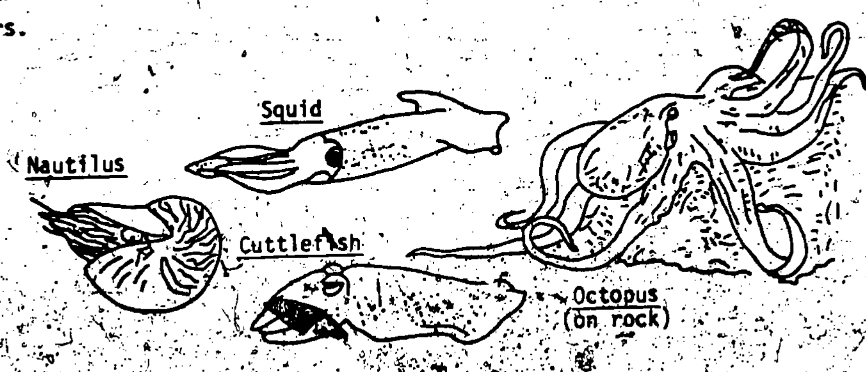


Figure 1. Some Cephalopods

Problem

What are the distinguishing features of cephalopods?

Materials

Per class:
- hot plate or frying pan
- 1 can stewed tomatoes (16 oz)
- basil, oregano and bay leaves
- 15 cm piece Portuguese sausage, sliced (8oz)
- 1 can chili beans (16 oz)
- 1 onion, sliced
- paper plates, plastic forks
- 15 cm square ziplock baggie
- liquid soap

Per team:
- 1 thawed 15 cm squid
- 1 newspaper, 4-5 sheets thick
- several paper towels
- dissecting microscope or hand lens
- 1 razor blade or scalpel
- 3 test tubes with rack
- alcohol or carbon tetra chloride
- salt water
- tap water

Procedure

1. Read over the Summary Questions and keep these in mind as you begin this topic. Refer as needed to Figure 5 Squid Anatomy on Page S-5.
2. Lay squid flat on a newspaper with the head or anterior end to the left and the siphon facing up so that the ventral side is showing. See Figure 2.
3. Remove the pen. Grasp firmly with your fingers and pull pen free from mantle.

4. Using the razor blade, cut the mantle from its anterior edge next to the siphon to its posterior tip. Do not cut into the internal organs.

5. Locate the structures listed below and describe their function(s). Sketch them in Figure 2.

   a. siphon and associated retractor muscles
   b. gills
   c. pallial cartilage
   d. ink sac
   e. ovaries or testes
   f. tentacles
   g. fins
   h. mantle

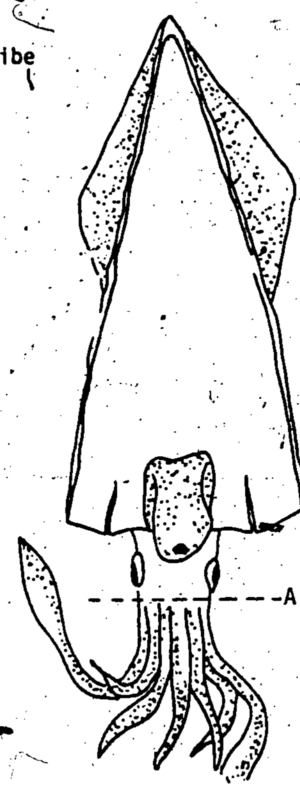


Figure 2. Squid ventral view.

6. Remove the ink sac. Test the solubility of the ink.

   a. Cut open ink sac. Place a few drops of ink into each of four test tubes.

   b. Try dissolving the ink using a different liquid in each test tube. Use tap water, salt water, alcohol or carbon tetrachloride and soapy water.

7. Observe features of a single sucker on the tentacle.

   a. Cut off a 0.5 cm piece of tentacle and place on a glass slide.

   b. View under the dissecting microscope.

   c. Draw a single sucker in the space provided.

Figure 3. Drawing of a Sucker.

8. Remove beak.
   a. Separate head from tentacles with a razor blade at line A as shown in Figure 2.
   b. Pull out the beak. Wash and save it. Make sketch of beak in the space provided.
   c. Remove and place viscera in a plastic bag or newspaper. Give to the teacher or save for feeding aquarium organisms.
   d. Wash the mantle and tentacles. Save.

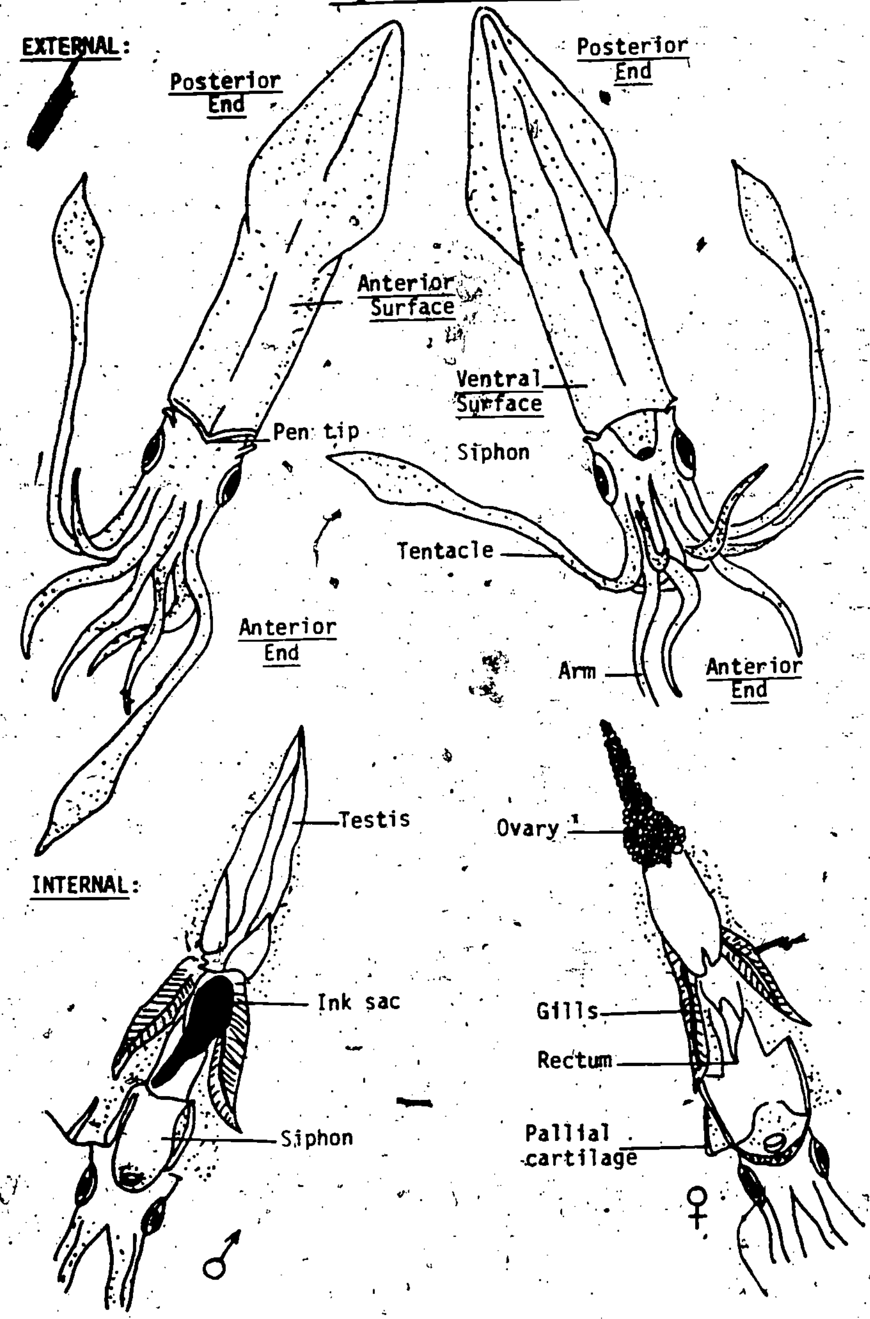
Figure 4. Drawing of Beak.

9. Slice and cook the mantle and tentacles:
   Saute the sliced Portuguese sausage and onion. Add tomatoes, chili beans, and herbs. Bring mixture to a boil. Add sliced tentacles and mantles. Simmer until mantle turns white (2-3 minutes). Serve hot.

Summary Questions

1. What are the distinguishing features of cephalopods? What features relate cephalopods to other mollusks? What features of mollusks are found in other phyla?
2. What is the primary food of the octopus? How does it locate, catch, and eat its prey?
3. How does the chemical composition of the cephalopod's "ink" aid in protecting the squid?
4. Describe the jet propulsion of a squid.
5. List several specialized methods of escape (defense mechanisms) used by cephalopods.
6. How does an octopus differ from a squid? List differences.

Figure 3. SQUID ANATOMY



Further Activities

1. Visit a local mollusk aquaculture site.
2. Collect discarded food debris from around octopus dens. Identify the species used as food.
3. Design and conduct behavioral studies on octopuses.
4. Try different cephalopod recipes and different cooking methods such as boiling, baking, broiling and smoking.

2. HEAD-FOOT MOLLUSKS

Objectives

1. To determine the distinguishing features of cephalopods using the squid as an example.
2. To describe cephalopod jet propulsion and to locate structures responsible for locomotion.
3. To describe methods of protection and feeding used by cephalopods.
4. To describe other cephalopod groups and to relate cephalopods to mollusks.
5. To sample squid as a food.

Materials

Initial Preparation

Purchase frozen squid from a local market. One package usually contains enough squid for one class (about 15-20 squid). Specimens approximately 15 cm (including head and arms) are suitable. Thaw before first class. Refrigerate squid to be used later in other classes. Have students bring the sausage, herbs and canned food to class.

If possible, have an octopus on display in the classroom aquarium. In Hawaii, the "day" species is best for aquarium observation as it can tolerate daylight, whereas the "night" species moves away from light.

Equipment per Class

See Student page S-1.

Teacher References

Berry, F.	1912	Cephalopods of the Hawaiian Islands. Fish. Bull. Vol. 32: 255-362.
Buchsbaum, R.	1974	Animals Without Backbones. pp. 198-206.
Kay, A.	1970	Biology of Mollusks, A Symposium. HIMB tech. Report No. 21.

Storer, T. and R. Usinger 1965 General Zoology. pp. 421-423.

Van Heukelem, W. 1975 The Growth, Bioenergetics and Lifespan of the Octopus Cyanea and O. Maya. PhD. Thesis, University of Hawaii.

Anticipated Time

One periods.

Introduction (Contains some information needed to answer Summary Questions, S-4).

Cephalopods have their molluscan foot subdivided into "arms" that extend from the head. The squid's pair of extra-long arms are sometimes called tentacles. The squid mouth is located at the base of the head inside the umbrella of arms. It contains a horny beak made up of two jaws. The shape of the jaws is used to distinguish varieties within species. A rádula or horny strip on the floor of the mouth is also present.

Squids and octopuses have three specialized means to escape predators: camouflage, illusion by ink-cloud, and jet propulsion. They can camouflage their skin color in chameleon-like fashion to blend with the surrounding environment and can also create a shadow image by throwing out an ink-cloud which predators confuse for the real, escaping animal. The shadow image lasts long enough for escape because the ink contains a waxy substance that retards diffusion into the surrounding water. Predators such as tuna, sharks and eels, which commonly prey on cephalopods often fail to catch them or are only able to bite off an arm or tentacle. It is not unusual to find an octopus or squid with one or more stubs among its remaining tentacles. If caught, the octopus can bite it's attacker with its powerful beak.

Shells of cephalopods range from the complete external covering of the nautilus to the complete absence of shell in the octopus. Between these extremes is the reduced internal shell of the squid.

In Hawaii, there are two shallow water species of octopus commonly found. The "day" octopus, is a brownish animal which can grow up to 2 m long and weigh from 2.5 kilos. The "night" octopus is a smaller, reddish animal with longer tentacles.

The presence of empty clam and crab shells often indicates the entrance to a "day" octopus den, as these invertebrates are often eaten by octopuses.

Octopuses are bottom dwellers and are found inside the reef, while most squids are nektonic, (free swimming) and live outside the reef. In Hawaii, people mistakenly think they are catching squid when they go "squiding", but they are really hunting for octopuses inside the reef.

Farming octopuses has been tried in Hawaii. Dr. W. Van Heukelem, who has worked with fertilized eggs of both Hawaiian species and a Mexican veriety, has found that to date only the Mexican species, which has a larger egg, can be farmed commercially. This may be because the greater nutrient content in the larger egg helps the newly hatched Mexican species to survive under artificial conditions.

Investigation (numbers refer to Student Procedures)

1. Ask students to keep Summary Questions in mind as you present background information to them on cephalopods.

   a. Trace the passage of water through a cephalopod's jet propulsion system for the class. The mantle dilates and water enters under the dorsal surface margin. The water exits upon contraction of the mantle muscle via the siphon. At this moment, the mantle margin is tightly pressed to the squid's body. The pallial cartilages maintain mantle shape and direction of water flow. The siphon can be directed forward or backward.

   b. Emphasize cephalopod ecology and escape mechanisms, such as jet propulsion, ink cloud formation, and camouflage.

2. Show students how to place squid on newspaper aligning it as shown in Figure 2.

3. Demonstrate how to remove the pen. Discuss how the cephalopod skeleton evolved.

6. The waxy ink will not dissolve well in water. It will diffuse better in alcohol or carbon tetrachloride.

7. Examine a sucker cup for design. Inform the students that sucker design is taxonomically important to differentiate varieties within a species.

8. Remove beak. It is easy to eject by squeezing the mouth area.

   c. Freeze all viscera from the squid. Periodically, slice off a piece of frozen viscera and feed to aquarium inhabitants as a variation of their daily diets.

9. Collect the cleaned mantles and tentacles. Prior to cooking, you can remove the pigmented covering of the mantle. It's not essential, but the mantle will be whiter when cooked. Have a student do the cooking. The squid cooks rapidly and turns white when done. Overcooking results in toughness.

Summary

1. Cephalopods | Mollusks

Cephalopods	Mollusks
-foot divided into arms	-foot
-shell reduction	-shell
-mantle as swimming organ	-radula
-suckers on tentacles	
-image perceiving eyes	

Commonalities with Other Phyla

Bilateral symmetry; complete digestive tract; etc.

2. Crabs and mollusks. Eyes. Tentacles. Beak.

3. The waxy ink keeps it from diffusing rapidly.

4. Discussed under Investigation 1 on previous page.

5. Refer to Introduction, page T-2.

6. Octopus | Squid

Octopus	Squid
-eight arms of the same length	-ten arms, one pair longer
-bulbous body form	-cigar-shaped body
-benthic	-midwater


UNIT 1
TRANSPORT

an excerpt from

UNIT 1. TRANSPORTATION

Unit 1. Transportation is one of four units in the theme Technology and the Ocean. Unit 1 examines the size, structure, and function of sea transport in terms of stability, buoyancy, and relative carrying capacity.

Topic 4. The Size of Transport Conveyances provides students with concrete representations of various ships. Comparisons can then be made with airplanes, railroad trains, and trucks on the relative capacity and efficiency of various modes of transportation.

4. THE SIZE OF TRANSPORT CONVEYANCES

There are often tremendous differences in size and weight of different vehicles. For example, a Volkswagen bug is four meters long and weighs 643 kg (1800 pounds). By comparison, some oil tankers (Figure 1), the largest vehicles on earth, have a length of 435 m (about four and a half football fields) and a weight of 500,000,000 kg (500,000 tons). Although we can readily visualize the dimensions of a Volkswagen, most of us cannot as easily picture the size of a huge supertanker.

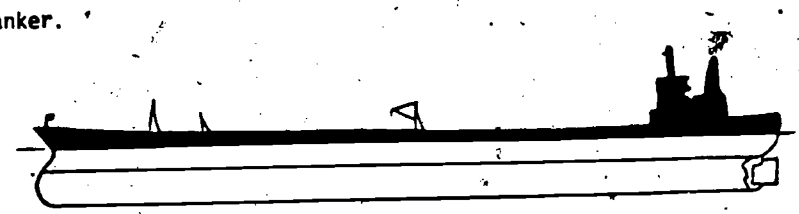


Figure 1. Supertanker

Activities

1. Construct profiles to scale of various transport conveyances.
2. Compare the sizes and carrying capacities of various conveyances.

Procedure

1. Choose one type of conveyance to study. Select one of the land, sea, or air transport vehicles described in the Reference Pages, or choose another type of interest to you.
2. Using the Reference on Conveyance Statistics or other resources, describe the size of the conveyance. Use the following terms and others that are appropriate:

a. overall length (distance between extreme ends)
b. width (the beam of a ship)
c. height (the distance from a ship's top deck to its hull bottom)
d. cargo capacity (either as weight or volume)
e. speed
f. cruising range
g. fuel efficiency

3. Construct a profile to scale using the scale 1 cm = 2 m.
   a. Draw the outline of the conveyance on poster board.
   b. Attach a card describing the features of the conveyance.
   c. Post the profile on the bulletin board.
4. Demonstrate the cargo weight capacity of your conveyance. Represent this by using 1 gram of sand for every 100 tons or cargo. Display the sand on a piece of paper labelled with information describing the conveyance.
5. Compare the relative sizes of conveyances in terms of length, width and cargo capacity. Express your comparisons in terms of ratios.

Summary Questions

1. How does your conveyance compare in size and capacity
   a. to the largest conveyance in the class?
   b. to the smallest conveyance?
2. How large is a supertanker? How may Volkswagens would be equivalent in carrying capacity to a supertanker? How many Boeing 747's?

3. Which can transport a greater weight of cargo, a 100 car freight train or a supertanker? How do they compare in terms of speed and fuel efficiency?
4. Some supertankers are so large that only a few harbors in the world will hold them. What possible advantages could there be in making them so supertankers so large? What disadvantages?

Further Activities

Construct profiles to scale of large marine animals. Include porpoises, whales and giant squid. Compare sizes.

4. THE SIZE OF TRANSPORT CONVEYANCES

Objectives

To aid students in conceptualizing size and weight differences of various ships, planes and land vehicles.

Materials

Equipment per Class
- 20 liters of sand

Equipment per Group
- poster board
- scissors
- ruler

Teacher References

Dodman, F.	1973	The Observers Book of Ships. Frederick Warne & Company, Ltd.
Landstrom, B.	1976	The Ship. Doubleday and Company Inc.
Lewis, E. and R. O'Brian	1965	Ships. Time, Inc.
Matson Navigation Company	1976	What's So Different About Hawaii?
Mostert, N.	1975	Supership.
Sweeney, J.	1970	A Pictorial Histroy of Oceanographic Submersibles.
Walker, C.F.	1967	The World's Passenger Ships.

Handouts
- References on Conveyances Statistics

Anticpated Time

Two periods.

Introduction

Some of the Ultra-Large Crude Carriers (supertankers) being built today are so enormous they are difficult to imagine. Comparing such a means of transportation with vehicles in everyday use (e.g., cars) is helpful when trying to conceptualize them. Mostert (Supership, 1975) describes one of eight tanks in a supertanker as being the size of a cathedral! Merchant sailors ride bicycles to get from their living quarters to the bow of a tanker. These ships are the length of the world's tallest buildings. Yet a student may never see such a ship, since supertankers can't fit into most ports. It has been estimated, though, that a supertanker carrying crude oil from Saudi Arabia to the East Coast of the U.S.A. can pay for itself after about four successful voyages!

The volume of a ship increases as a function of the cube of its length. So if you double the length of a ship, keeping all dimensions proportional, you increase its size and cargo capacity by eight times. Also, the ship will probably cost eight times as much to build.

Investigation

1. Gather a collection of books with pictures of boats, planes and ships that students may refer to. One set of Reference on Conveyances Statistics should be available to each class.

2. Review the Procedure with the class.

3. The size of the student group assigned to the cutting out of a profile depends on the size of the vehicle. It will, for example, take three or four students to cut out a supertanker and one student on a Volkswagen.

4. When statistics about a vehicle are not available have the students estimate these statistics from the information they already have.

Summary Questions

1. Depends on the student's choice.

2. Stress that only "ballpark" answers are being sought. The essential point is that the student realizes that one vehicle's volume must be divided into the other vehicle's volume.

3. A supertanker carries many times the weight that a 100 car freight train does. Their fuel efficiencies are comparable. The train can travel about 87 km/hr, which is 2.5 times the speed of a supertanker. (Although students in Hawaii are unfamiliar with railroad trains, they are familiar with containerized cargo ships and with trucks hauling these containers from the docks. Each railroad car typically carries two or three containers.)

4. Crew size hardly varies with ship size. Also, the larger a ship is, the more fuel-efficient it is. This is because wind and water resistance are proportional to the surface area of the ship, not the volume. A ship with twice the volume of another ship of comparable proportions needs to develop less than twice the propulsive force to move at the same speed.

REFERENCE

4. CONVEYANCE STATISTICS

A. Sedan automobile

Volkswagen Bug

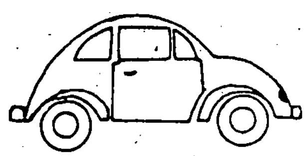
-built 1940's - 1970's

-weight: 643 kg (1800 pounds)

-length: 4 m

-speed: up to 80-90 mph (128-144 km/hr)

Volkswagen bugs can carry up to four (cramped) passengers, and get 20-30 miles per gallon (or 8-12 km/l). They are no longer being built for the United States.



B. Supertanker

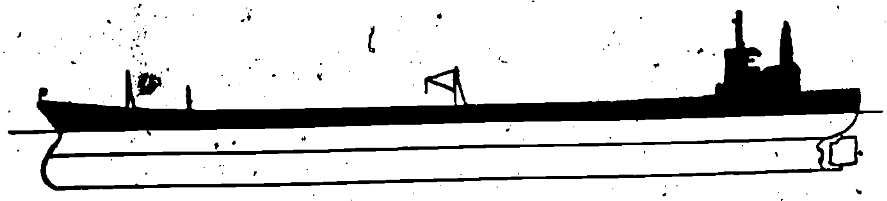
S.S. Ardshiel

-length: 330 m

-width: 52 m

-displacement: 214,000 tons deadweight of 214,000,000 kg

-speed: 20 knots or 39 km/hr



*1 tonne is 1,103 tons or 2204 lbs.

C. Airplane

Boeing 747

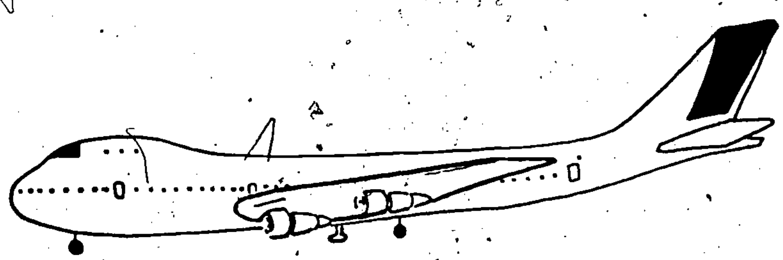
-built 1967 - 1970

-weight: 315,000 lb (14,100 kg)

-length: 70.5 meters

-speed: 600 mph (960 km/hr)

The 747's first went into service in 1970. They're capable of carrying up to 590 passengers and can fly around the world in record time (46 hours, 50 seconds) for a subsonic aircraft. 747's have proven to be extremely save and reliable.



D. Container Ship

Hawaiian Enterprise

-length: 245 m

-height: 45 m

-displacement: 3,000,000,000 lbs or 135,000,000 kg

-speed: 21 knots or 39 km/hr

Most of the non-petroleum crago entering and leaving the Hawaiian Islands is transported on container ships.

E. Nuclear Submarine

George Washington

-built 1959; U.S.

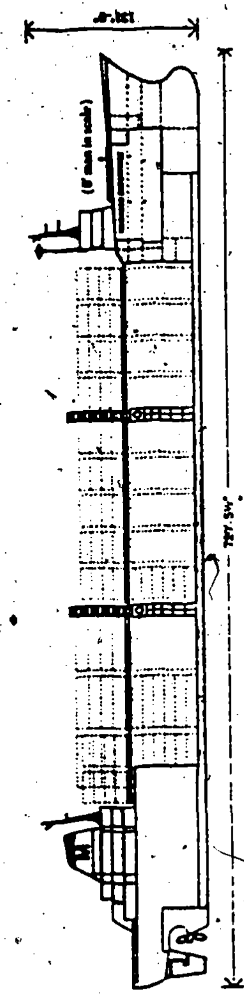
-length: 131 m

-width: 11 m

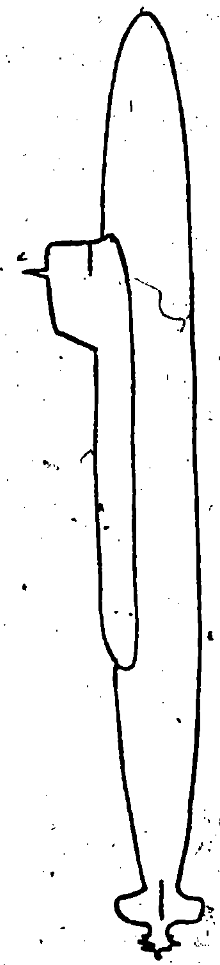
-displacement: 5,600 tonnes, 12,300,000 lbs or 5,600,000 kg

-speed: over 30 knots or 56 km/hr

The George Washington is armed with 16 Polaris missiles which are 10 m long, 1.3 m wide and possess a nuclear warhead.



D. (Container Ship - Hawaiian Enterprise)



E. (Nuclear Submarine - George Washington)

F. Passenger Liner

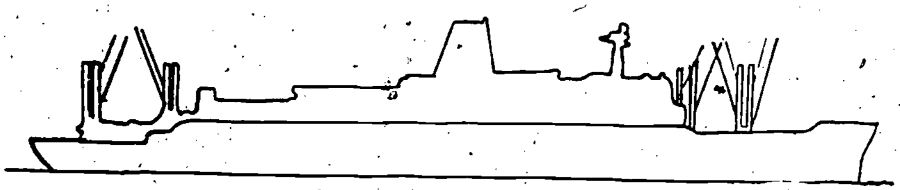
Mariposa

-built 1953; U.S.

-length: 171 m

-speed: 20 knots or about 37 km/hr

The Mariposa can hold 365 passengers, and was built as a luxury liner for first class passengers only. The ship was the last U.S. passenger liner, having discontinued operation in April, 1978.



G. Fishing Boat

Tuna Clipper

-built 1960's; U.S.

-length: 160 ft. or 42 m

-width: 30 ft. or 9 m

-speed: 12 knots or 22 km/hr

-cruising range:

This type of boat is used for tuna fishing. Individual fishers have their own rod and line, and fish from a platform which projects all around the hull. Live bait is kept in tanks on the deck.