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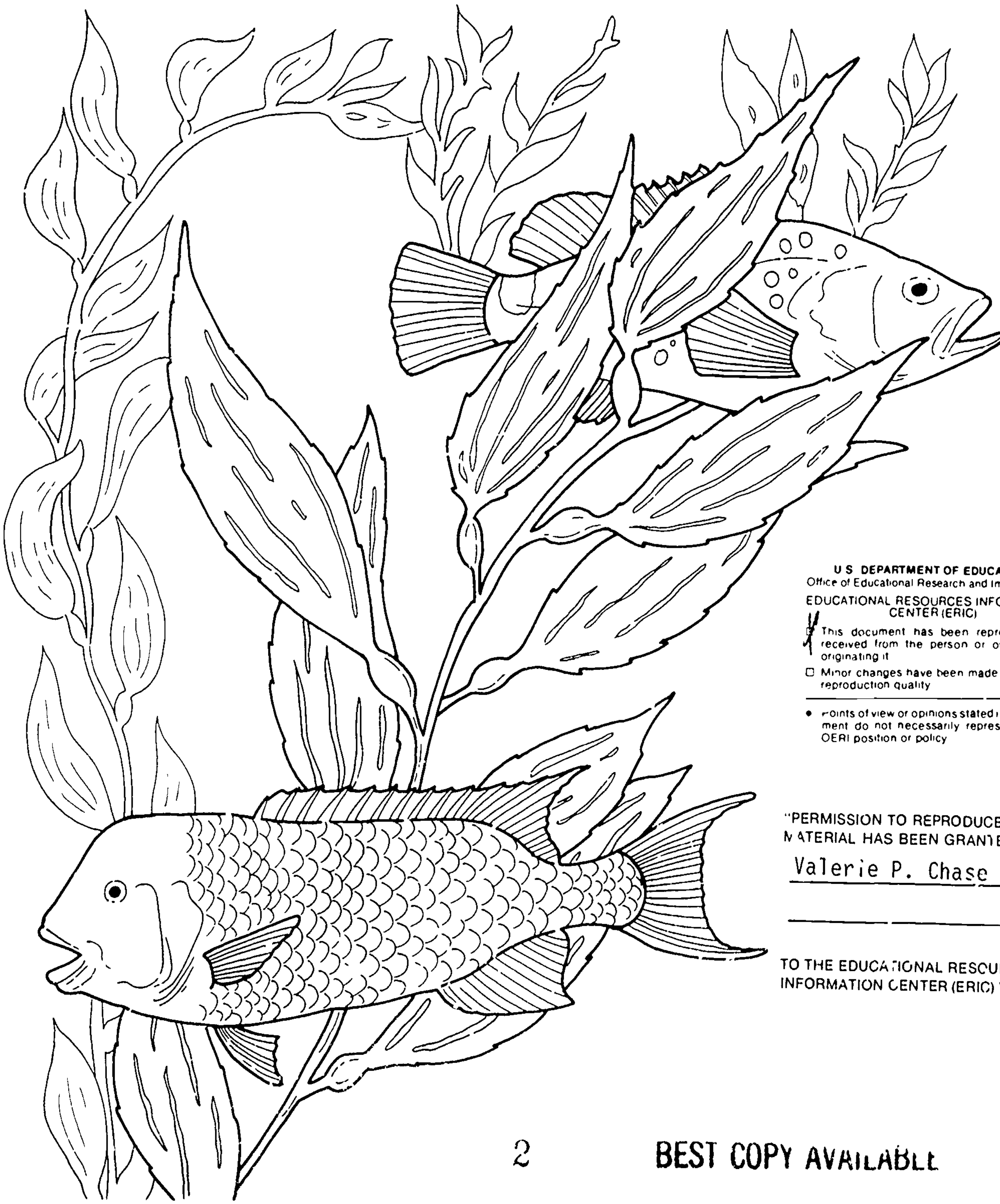
ABSTRACT

This document is a scientific study of water, aquatic environments and the plants and animals that live in water. It was written for grades 4-6 but many activities may also be of interest for use with older students. This curriculum covers both marine and freshwater habitats. Each of five sections addresses a question about water which is then answered by a variety of activities using an experimental, science process approach to enable the students themselves to arrive at answers. Each section is preceded by teachers' information with science content related to the activities written for the teacher. The emphasis for the students is on process rather than on content. In addition to experiments and classification activities, several exercises test the application of basic principles through the development of models. Following each exercise, extension activities enable students to pursue a variety of related topics. Some allow students to apply the results of their experiments to specific environmental problems. Supporting materials offer information on preparation of materials and sources of supplies. Worksheets and information sheets may be used directly or may be replaced by materials prepared by the teacher. The review of what science education research says about the "hands-on" approach to teaching elementary science will help teachers understand the emphasis on process. A glossary of terms used is provided. (Author/CW)

LIVING IN WATER

an aquatic science curriculum for grades 4-6

National Aquarium in Baltimore



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2nd Edition, 1989

TEACHER EVALUATION FOR LIVING IN WATER

Please remove and complete this form. Your comments will help us with future projects. Return it to the address below.

State in which you teach ______________________ date ______________________

Grade level ___________ Subjects ____

Circle all answers that apply.
My school is: **urban** **suburban** **rural.**
My students are: **at grade level** **below grade level** **gifted.**
My students are economically: **advantaged** **disadvantaged** **average.**

Did you receive this curriculum through a workshop? If yes, who did the workshop? __________________________________ Please indicate how you felt about the workshop and about this mode of dissemination.

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Have you used this curriculum in class yet? If no, do you plan to use it and how?

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Please tell us what you like best about **Living in Water.**

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STUDENT PAGES FOR DUPLICATION

INTRODUCTION

"Living in Water" is a scientific study of water, aquatic environments and the plants and animals that live in water. It was written for grades four through six, but many activities may also be of interest for use with older students. This curriculum covers both marine and freshwater habitats. Each of five sections addresses a question about water which is then answered by a variety of activities using an experimental, science process approach to enable the students themselves to arrive at answers. Each section is preceded by teachers' information with science content related to the activities written for the teacher. The emphasis for the students is not on content, but on process.

While a teacher may pick and choose from among these activities, the curriculum is organized in a way that builds a body of experience in a logical sequence. Teachers may also find ideas for science fair projects or learning centers among these activities.

In addition to experiments and classification activities, several exercises test the application of basic principles through the development of models. Following each exercise, extension activities enable students to pursue a variety of related topics. Some allow students to apply the results of their experiments to specific environmental problems. Other extensions include art and language arts projects. Math is integrated into many of the activities as are graphing skills. There are also suggestions for using a classroom aquarium to further enhance the curriculum.

Supporting materials offer how-to information on preparation of materials and sources of supplies. Worksheets and student information sheets may be used directly or may be replaced by materials prepared by the teacher. The review of what science education research says about the "hands-on" approach to teaching elementary science will help teachers understand why the emphasis in this curriculum is on process. A glossary of terms used is provided for teachers who lack extensive science background.

SUPPORT FOR PROJECT

"Living in Water" was developed by the Department of Education and Interpretation of the National Aquarium in Baltimore under National Science Foundation grant no. MDR-8470190. The LaMotte Chemical Co., the White Rose Paper Co. and the National Aquarium in Baltimore provided additional support.

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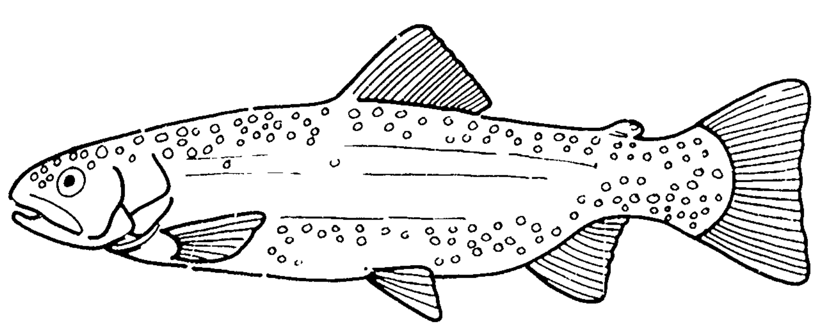


PROJECT PARTICIPANTS AND SEQUENCE

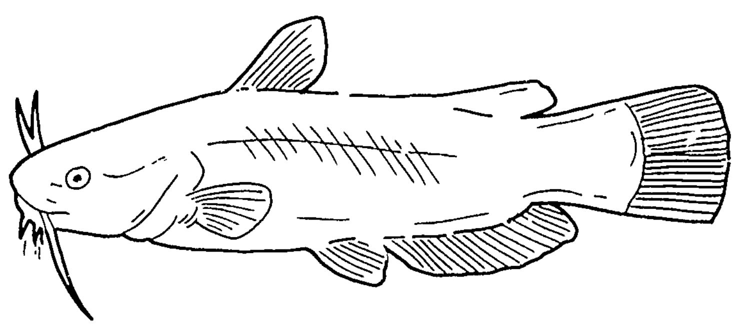
The project started with a three day meeting in July, 1985, of the authors, eight consulting teachers from the Mid-Atlantic states and a science educator. The consulting teachers were: Bonnie Bracey (Washington, DC), Cindy Dean (Delaware), Sarah Duff (Maryland), Margaret Gregory (Virginia), Jean McBean (Maryland), Jo Anne Moore (Maryland). Martin Tillett (Maryland) and Harold Wolf (Pennsylvania). Dr. Leon Ukens, Department of Physics, Towson State University, served as science education consultant. During the following school year, the authors produced first and second drafts of thirty-six activities. In July, 1986, sixteen children tested the activities during a two week class at the Aquarium. Following revision, third drafts went to the consulting teachers, who tested them in their own classes during fall of 1986 and reviewed each activity. The third drafts were read for science education and science content by Dr. Leon Ukens and Gary Heath, environmental education specialist for the Maryland State Department of Education. Dr. Thomas Malone, a biological oceanographer at the University of Maryland Horn Point Environmental Laboratories, and Dr. William S. Johnson, a marine ecologist at Goucher College, read the text for scientific content. During spring of 1987 the activities were rewritten, using comments from the above persons. First distribution was accomplished through two graduate courses for master teachers taught by the authors at Goucher College during July, 1987.

Activities 4, 5 and 24 were written by Karen Aspinwall, education specialist, NAIB. Activities 21, 22 and 23 were done by Lee Anne Campbell, education specialist, NAIB. Activity 18 was written jointly by Lee Anne and Martha Nichols, education specialist trainee, NAIB. Activity 16 was contributed by consulting teacher, Martin Tillett, Howard B. Owens Science Center. All other activities were the work of Dr. Valerie Chase, staff biologist, NAIB, who also served as editor and project director. Martha Nichols proofed final drafts and typeset copy for the entire curriculum. Layout, design and illustration are the work of Cindy Belcher, illustrator, NAIB.

The design, production and dissemination of this material is based upon work supported by the National Science Foundation under grant no. MDR 8470190. However, any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Valerie Chase, Ph. D.
Department of Education and Interpretation
National Aquarium in Baltimore
Pier 3, 501 East Pratt Street
Baltimore, Maryland 21202

May, 1987



THE "HANDS-ON" APPROACH: WHAT THE RESEARCH SAYS

by
Leon Ukens
Towson State University

The activities in this book are based on a philosophy of science education in the elementary school that has children invoi ed in doing and thinking about science instead of memorizing a lot of factual information in short, it is a "hands-on" approach. The choice for using this approach is based on years of research evidence on the effectiveness this approach has in helping children learn science. As pointed out by Thier, children need to think about what they are doing. In other words, "hands-on" science needs to be coupled with "heads-on" science (Thier, 1986).

Unfortunately for most children, the "hands-on" approach is seldom used. Instead, in most classes, the textbook has become the sole basis for instruction. Even if the textbook has activities, there is little evidence of children being taught science through firsthand experiences (Stake and Easley, 1978). Secretary of Education Bennett has also noted this in his remarks on elementary education. About science, he said, "We need a revolution in elementary school science. There is probably no other subject whose teaching is so at odds with its true nature. We have come to think of science as a grab-bag of esoteric facts and stunts . . . we have also given students the impression that science is a dry and arcane matter gleaned solely from the pages of a textbook" (Bennett, 1986).

"Hands-on" elementary school science is not new. You probably know about the activity-oriented science curricula developed in the 60's and 70's. Perhaps you even taught, or are teaching, one. The three most widely known of these curricula were the Elementary Science Study (ESS), the Science Curriculum Improvement Study (SCIS), and Science, A Process Approach (SAPA). How effecti ere they? Did they get children to use higher level thought processes? Many research studies have been conducted in the years since their development to attempt to answer questions such as these. An analysis of analyses (termed a meta-analysis) of these numerous independent research studies comparing the above mentioned projects and other "hands-on" curricula to textbook approaches has been done. Shymansky, Kyle, and Alport (1982) surveyed research studies comparing the performance of children in the above three curriculum projects plus other innovative curricula with the more commonly used textbook approach. In an analysis of 105 experimental studies over the past 25 years involving over 45,000 students, they found that children in the "hands-on" approach out-performed children in textbook programs on every criterion measured. These criteria included academic achievement, attitudes, process skill development, creativity, intellectual development, and performance in related school subjects. As a result of their study, Shymansky and his colleagues concluded that children in "hands-on" science programs "achieved more, liked science more, and improved their skills more than did students in traditional, textbook-based classrooms."

Bredderman (1982) also investigated the effects of the activity-oriented curriculum with textbooks in an analysis involving th experiences of 13,000 students in over 1,000 classrooms in sixty studies over the past 15 years. His findings state: "with the use of activity-based science programs, teachers can expect substantially improved performance in science process and creativity; modestly increased performance on tests of perception, logic, language development, science content, and math; modestly improved attitudes toward science and science class; and pronounced benefits for disadvantaged students." Beane (1985) and Rowe (1975) also point out the positive effects "hands-on" elementary science can have on the disadvantaged child.

Wise and Okey (1983), also using meta-analysis, looked at how various teaching strategies affected achievement in science. They concluded that in an effective classroom, "students get opportunities to physically interact with instructional materials and engage in varied kinds of activities." They go on to say that "the effective science classroom reflects considerable teacher planning. The plans, however, are not of a 'cookbook' nature. Students have some responsibility for defining tasks.'

Renner (1973) did several research studies involving the effectiveness of SCIS. In one done with fifth graders comparing a "hands-on" approach to one that was not, he concluded that not only were the science processes of manipulating data and interpreting graphs and tables better for the "hands-on" group, but also that the content areas of reading, mathematics and social studies were being enhanced. There seems to be a basic skills development that "hands-on" science does quite well.

In summarizing several research studies, Blosser (1985) concluded that "teachers can help students learn to think scientifically . . . the indirect approach to instruction does appear of value when a teacher's goal is to help students think at a higher level than factual recall.

As a result of the research, Mechling and Oliver (1983) have summarized six important reasons for teaching science from a "hands-on" approach.

1 Students in activity-based science programs outperform students in non-activity programs. The research studies mentioned previously point this out time and time again. The performance is in content areas as well as in the processes of science.
2. Students who have "hands-on" experiences develop thinking skills. The thinking skills include classifying, inferring, hypothesizing, collection and analysis of data, and designing investigations.
3. "Hands-on" activities help students take responsibility for their own learning. The ignited curiosity about things helps to motivate the child to continue questioning and learning in and out of school situations.
4. "Hands-on" activities reinforce what we know about how youngsters learn. From a Piagetian perspective, children learn best by manipulating concrete objects. Language and concepts are learned best by providing the experience first, then the concepts.
5. "Hands-on" activities can reinforce learning in other curricular areas. Wellman (1978) after synthesizing research evidence, concluded that:
   a. Active experience with science helps language and logic development.
   b. Science instruction appears especially helpful for children who are considered physically or culturally different.
   c. Science activities provide a strong stimulus and a shared framework for converting experience into language.
   d. Reading skill development stems from language and logic development, which comes after concepts are formed from repeated encounters with objects and events through science activities.
6. "Hands-on" activities help us avoid the "mindless" curriculum. The mindless curriculum is one that forces children to memorize a lot of factual information without regard to how it all fits together. As an example, probably the most saluted man in America is a man named Richard Stans. Each day numerous children rise and "pledge allegiance to the flag of the United States of America, and to the Republic for Richard Stans . . ."

The challenge you face is to involve your students with this curriculum through a "hands on" approach. There is much evidence to support this method of teaching if you are interested in bringing science content as well as the methods of science to your students. Challenge them!!

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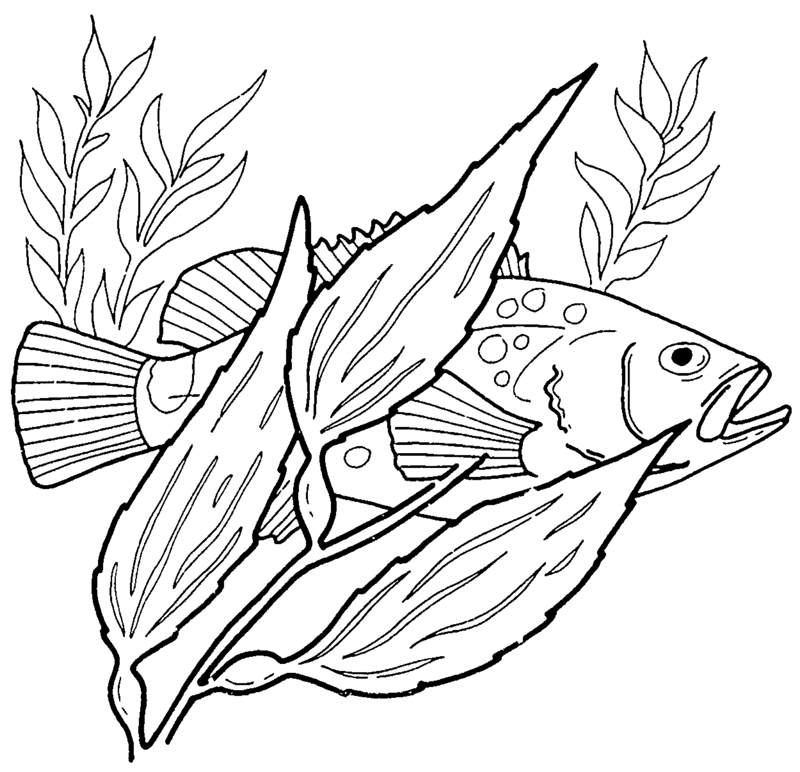


SCIENCE PROCESS SKILLS USED IN THIS CURRICULUM

These are science skills that are used in the activities in this curriculum. They are skills that are within the abilities of most children in grades 4-6. The last two are border line for children in this age group and may require special instruction.

Observing: using all five senses; taste is ruled out in many cases as children should not be encouraged to taste unknown substances.

Classifying: identifying like and unlike, and grouping into sets.

Measuring: using numbers to describe size, weight, quantity, volume or time.

Organizing: analyzing and interpreting data, including the use of graphs, charts and tables.

Inferring: drawing conclusions from facts.

Communicating: verbal, written, drawn or other forms of informing others about results.

Predicting: forming hypotheses based on past observations and results.

Experimenting: identifying and controlling variables in testing hypotheses.

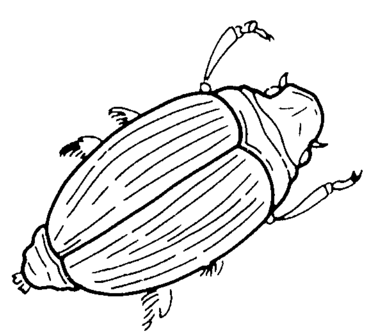
TEACHING HANDS-ON SCIENCE

Principals and Parents: Will they understand why your classroom is wet and noisy? Educate your principal and parents by telling them what you plan to do and giving them a copy of Dr. Ukens' article from the preceding pages to help them understand the value of hands-on science.

Materials: Collecting and storing materials can be a pain. We hope the master materials list and addresses of suppliers will help. The entire set of materials other than the classroom aquarium will fit in 6 or 8 copier paper boxes for storage.

Motivation: The best motivation for this curriculum is a good classroom aquarium. Instructions for setting up and maintaining a classroom aquarium are included in the Recipes and Resources section.

Worksheets and Instructions: The "canned" instructions and worksheets are provided for teachers who are short of time or experience in teaching science experiments. If you have the time and teaching experience, please be more creative in having the children work with you to design the activity and the worksheet for reporting their findings. Graph paper that can be copied is provided.



SECTION I.
SUBSTANCES THAT DISSOLVE IN WATER

TEACHER'S INFORMATION

Many substances DISSOLVE (go into SOLUTION) in water. Solids such as salts or sugar, liquids such as alcohol or acetone, and gases from the air all dissolve in water. Water is frequently called the "universal solvent" because so many different kinds of things dissolve in it. Some things do not dissolve in water. The saying that "oil and water do not mix" is based on fact.

Substances that are in solution in the water of a pond, stream, lake or ocean have a direct effect on the plants and animals that live there. Each environment is unique because of these substances. This section discusses the most common things that are in solution in water and the ways that these substances affect plants and animals.

SALTS

SALTS are special compounds that go into solution in water easily. They consist of IONS which are atoms or molecules that have a charge. Positive ions are missing one or more electrons. An example is the sodium ion written Na^+. Negative ions have one or more extra electrons. Negative chloride ions, Cl^-, join with positive sodium ions, Na^+, in a loose lattice in which the positive and negative charges are balanced and the ratio of sodium to chloride is 1:1. The combination is called sodium chloride or NaCl, also known as table salt. There are many different kinds of salts besides table salt. If salts are put into water, they dissolve very rapidly because the ions are not firmly bound to each other and are attracted to the water molecules.

Because salts dissolve so easily, rain water or melting snow pick them up from the soil as the water runs off to streams or percolates into the ground. Eventually these weak solutions of salts and water reach the ocean or a lake such as the Great Salt Lake which has no outlet. Here the water EVAPORATES into the air, is carried aloft, CONDENSES into rain or snow and falls again on the land where it picks up more salts. Each time the salts remain behind. This water cycle constantly carries more salts to the sea. Over millions of years the oceans have become quite salty. Ocean water is called SALT WATER because of this saltiness. If 1000 g of ocean water is evaporated, 35 g of salts are left behind. This means that 35/1000ths of the weight of sea water is salts. The percent by weight that is salts is calculated by dividing 1000 into 35, which equals 0.035, and then multiplying by 100 to get the percentage. Thus sea water is 3.5% salts by weight. This is also expressed as 35 parts per thousand (ppt). The world's oceans are fairly uniformly 35 ppt salts. In lagoons where evaporation is high, it may be saltier. Salt lakes may also be saltier than the sea. Where a river runs into the sea, the saltiness is lower and is referred to as BRACKISH. The area of brackish water at the river mouth is an estuary.

Not all of the saltiness of the ocean is caused by table salt, NaCl. If you try to keep sea creatures in a solution of table salt, they will die because they require the whole range of kinds of salts in the sea. There are many kinds of things in solution in salt water. The major ions found dissolved in sea water are:

positive ions	ppt	negative ions	ppt
sodium (Na^+)	10.6	chloride (Cl^-)	17.3
magnesium (Mg^{+2})	1.3	sulfate (SO_4^{-2})	2.7
calcium (Ca^{+2})	0.4	bicarbonate (HCO_3^-)	0.7
potassium (K^+)	0.4		

Water that has little dissolved salts is called FRESH WATER. Fresh water is not absolutely pure, however. Even rain picks up things as it falls, hence problems like acid rain. Different bodies of fresh water have different compositions of things in solution, depending on the characteristics of

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the rock and soil of the region, the plant material that enters the water and the human activities that influence the system.

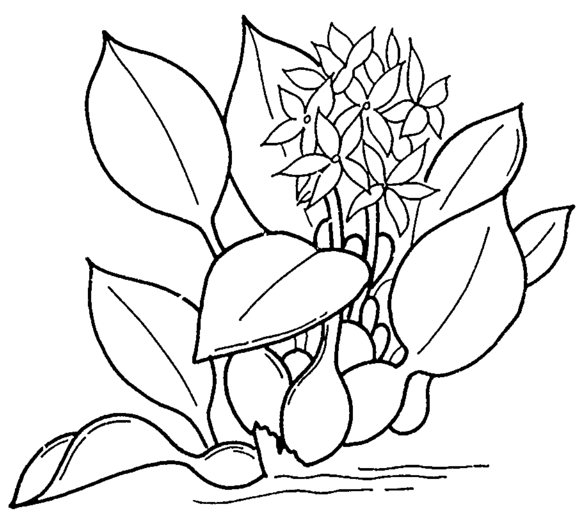
By definition fresh water is less than 0.5 ppt dissolved salts. This may not seem like much, but fresh water that has a good deal of calcium leaves a white residue behind in tea kettles and coffee makers and requires extra soap in the washing machine. It is often called "hard" water. By comparison "soft" water has little calcium. The differences from one freshwater system to another can directly influence the kinds of plants and animals found there.

OXYGEN

The gases found in air are also in solution in water. The most important to things that live in water is oxygen. In surface waters oxygen is present in the same proportions as in air. Under certain circumstances the amount of oxygen varies in different parts of a body of water. Biological activity, incomplete circulation and the slow DIFFUSION or movement of gases through water contribute to this unequal distribution of oxygen. In a shallow pond rich with plants and animals, the oxygen level may be higher than expected during the day when the plants are producing oxygen during PHOTOSYNTHESIS in excess of the use of oxygen by both plants and animals in RESPIRATION. At night the oxygen falls rapidly as the plants and animals use it during respiration. In the oceans and lakes there are areas where oxygen is low, and mixing and diffusion do not replace it as fast as it is used.

MINERALS

Many other ions and elements are also found dissolved in sea water, including the two MINERALS that are the most essential nutrients for plant growth: PHOSPHORUS as phosphate (PO_4^{-3}) and NITROGEN as ammonium (NH_4^+) or nitrate (NO_3^{-2}).



POLLUTANTS

All sorts of other things end up in solution in water. Many of them are natural products, although human actions may cause levels of these that are higher than would occur naturally. Mercury or nitrates are examples. Others are products which we have manufactured that are entirely new such as pesticides and herbicides and other organic chemicals. Run off may carry farm chemicals into streams and rivers. Factories and cities dump their sewage into SURFACE WATERS (rivers, bays and oceans). Water that percolates down into the soil to the GROUND WATER can carry chemicals from farms or waste disposal sites. Pollution of ground water is a major problem because over half the people in the United States get their drinking water from wells.

Water pollution constitutes a direct health hazard. It also may destroy the plants and animals that live in water environments or may disrupt the relationships between them in such a way that the community structure is changed.

One way of classifying pollution is to separate materials which come from an identifiable source (POINT SOURCE POLLUTION) from those that enter water all along its course (NON-POINT SOURCE POLLUTION). In the past most attention was focused on point source pollution because it was easier to see and identify. Regulators were able to write laws that specified how much pollution came out of a factory or sewage treatment plant. As point source pollution is beginning to come under some degree of control, attention is turning to non-point source pollution. It is important, but hard to define and regulate.

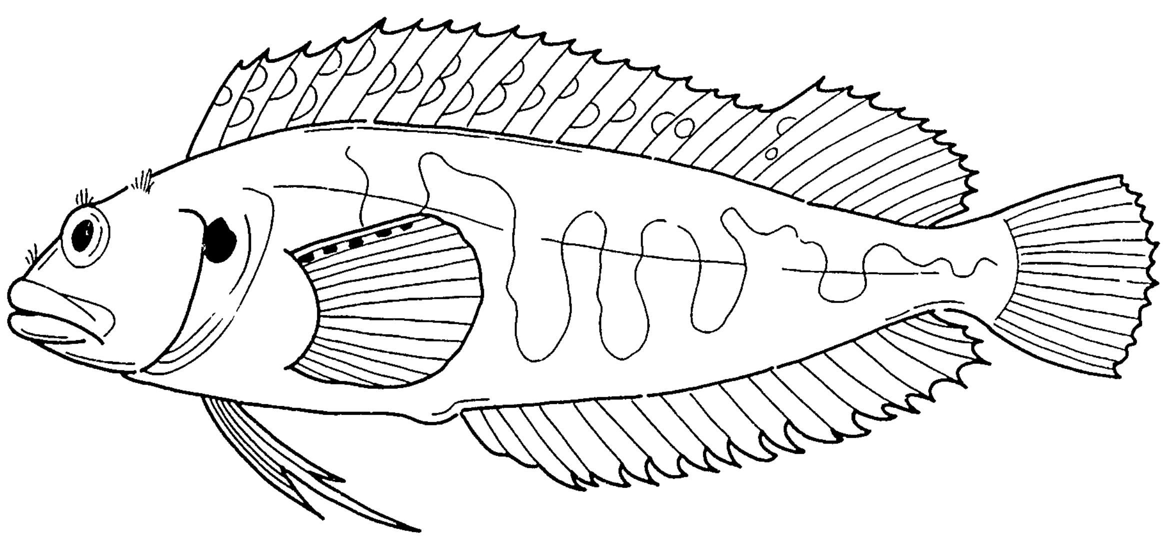
This table shows the basic kinds of water pollution, the sources and forms of discharge or entry to the water. Some of these are under reasonably good control. Others are just beginning to be studied.

kinds of pollution	point source pollution	non-point source pollution
disease organisms	human wastes from sewage treatment plants	some problems where people camp or backpack
man-made and naturally occuring organic compounds	chemical manufacturing plants and disposal; oil spills	agricultural run-off from pesticides, herbicides, and fertilizer
inorganic or mineral compounds; plant nutrients	mining and manufacturing electric power generation; sewage	agricultural run off of fertilizer
radioactive material	mining, manufacturing, accidental, discharge and disposal	airborne following testing or an accident
biological wastes that use oxygen in decomposition	human sewage, animal wastes, agricultural wastes, paper and food processing	some run-off manure
sediment	storm water from drains carrying eroded soil	erosion from fields and developments
heated water	primarily from electrical generating plants; also some from manufacturing	

A problem common in many bodies of water is pollution that results in oxygen use or low DISSOLVED OXYGEN (DO). Oxygen is used faster than it diffuses into the water. It is used by DECOMPOSING organisms which are acting upon such pollutants as sewage or animal wastes. The decomposing organisms may also be feeding on the remains of plants that grew in over-abundance due to excessive fertilization of the water with plant nutrients from human sewage or farm fertilizer. Environments that are very low in oxygen are said to be ANOXIC and are difficult places for most animals to survive. Bodies of water with very low dissolved oxygen may experience major fish kills, especially in summer. Warm water holds less oxygen but at the same time fosters faster decomposition.

As you can see, all sorts of human activities lead to problems of water quality. Different areas have different problems. Depending on where you live, you may want to discuss in some detail certain of these problems. For example, if you are in the northeastern U.S., acid rain may be the biggest current threat to water quality for wildlife. If you are living along the Chesapeake Bay, sediment, human waste and agricultural run-off may be of the greatest concern. In the arid western U.S. agricultural run-off carries inorganic salts that make the run-off salty and may even be toxic to wildlife. If you lived in Russia near the Chernobyl power plant, radioactive waste in the water would be of concern. For many of us downstream from Three Mile Island, it was also a very real concern as the entire Chesapeake could have been contaminated with radioactive materials. Along Lake Superior asbestos particles from mining waste was a problem. Love Canal was ground water contamination in an extreme form. As we learn more, we find new issues to address and new problems to solve.

If you find all this discouraging, do not! We have made progress in some areas. Fish are swimming in some rivers that used to be empty. Lake Erie, once a death trap for fish, seems to be recovering from its abuse. Progress can be made. Public education is a very important part of that progress, because we learn to treat our environment more carefully when we understand the consequences of our actions.



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ACTIVITY 1

THE DISAPPEARING ACT

WHAT HAPPENS WHEN DIFFERENT SUBSTANCES ARE ADDED TO WATER?

SCIENCE SKILLS:

- observing
- measuring
- organizing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- Many substances form a solution when mixed with water; some do not.
- Some substances go into solution faster than others.

MATH AND MECHANICAL SKILLS PRACTICED:

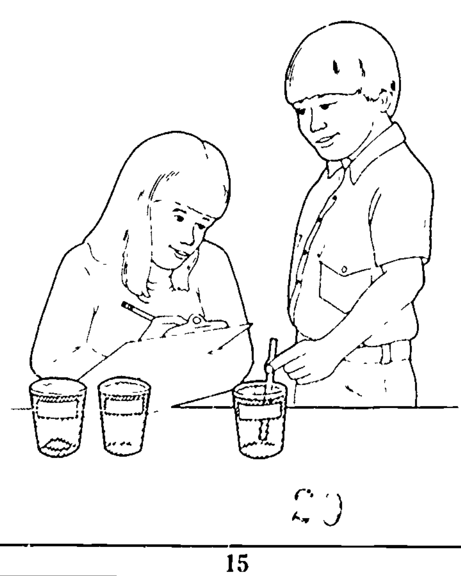
- bar graphing
- measuring volumes of fluids and powders

SAMPLE OBJECTIVES:

- Students will design and conduct an experiment to compare rates at which different substances dissolve in water.
- Students will compare different factors which affect rates at which some substances dissolve.
- Students will display data collected in a bar graph.

INTRODUCTION:

In this set of activities, students begin to explore the characteristics of water which relate to forming solutions and suspensions. Table salt and sugar are both among the substances which form a SOLUTION with water: that is, they DISSOLVE, mixing completely with the water and staying mixed. Some substances appear to mix completely, but do not go into solution. When they are allowed to sit undisturbed, they settle out. These compounds are said to form a SUSPENSION. Corn starch is a household compound that forms a suspension with water.



MATERIALS:

FOR CLASS:

- water
- table salt (use canning or kosher salt; see Recipes for discussion)
- granulated table sugar
- corn starch
- large clear glass jar
- package of a dark flavor of unsweetened Kool-aid

FOR EACH GROUP OF STUDENTS:

- 3 clear plastic glasses
- 3 plastic straws or stirrers
- a plastic teaspoon
- 3 pieces of tape or sticky labels
- a graduated measuring cup
- data sheets
- crayons or colored pencils

LESSON PLAN:

BEFORE CLASS:

Read the lesson and gather the materials.

DURING CLASS:

METHODS: As a demonstration, show the students a large clear glass jar of water and a package of unsweetened Kool-aid. Ask them to predict what will happen if you pour the Kool-aid into the water. Do they all agree? Pour the Kool-aid in and see what happens. It should sink and then begin to dissolve and spread (diffuse) through the water. Can the students suggest a way to speed up the process of dissolving? Stirring is one approach. A second would be to use hot water. Introduce the word SOLUTION for the mixture and the word DISSOLVE for the process of mixing completely.

What other things can the students name which they would find around the house that dissolve in water? List them. Show the students the table salt, sugar and corn starch. Ask them to predict whether each will go into solution. If they predict that these substances go into solution, could they design a test of their prediction? Secondly, could the students design a test to discover which dissolves fastest?

Here is a test they might try. Each group should label one clear plastic cup each as salt, sugar and corn starch. Fill each of three plastic cups with about the same volume of water at room temperature. Leave about 1 in of space at the top. Add the equal amounts of salt, sugar and corn starch to the cup of water labelled with that substance. For example, 2 heaping teaspoons to each. Observe what happens for two minutes. Then stir each cup by making a circle around the edge of the cup with the stirrer ten times. Was there a change? Repeat stirring ten times in each until one has completely disappeared or dissolved. Record how many time it was stirred. Continue stirring and observing the other two to find out which dissolves next fastest. Last?

In order for this to be a "fair test" each cup has to be treated exactly the same way. The only thing that can be different is the substance added to each. This is referred to as controlling variables. How you discuss this concept depends on the age of your children.

RESULTS:

Each group should have three numbers which are the number of times each substance was stirred before it dissolved. How do you display such information? A bar graph would be a good way to compare three different things. Make the bar graph of the results. Now compare the results with the predictions. Were there any surprises? Sugar or salt may be faster depending on the size of the crystals in the particular brand you buy. What happened to the corn starch can be the subject of heated debate. Some will say it is in solution and others may not.

Do not throw all the solutions away when students clean up. Save two sets of solutions and place them in a safe place over night. When you check them a day later, you will have proof that the sugar and salt are completely mixed and are in solution while tne corn starch was in suspension and has settled out.

CONCLUSIONS:

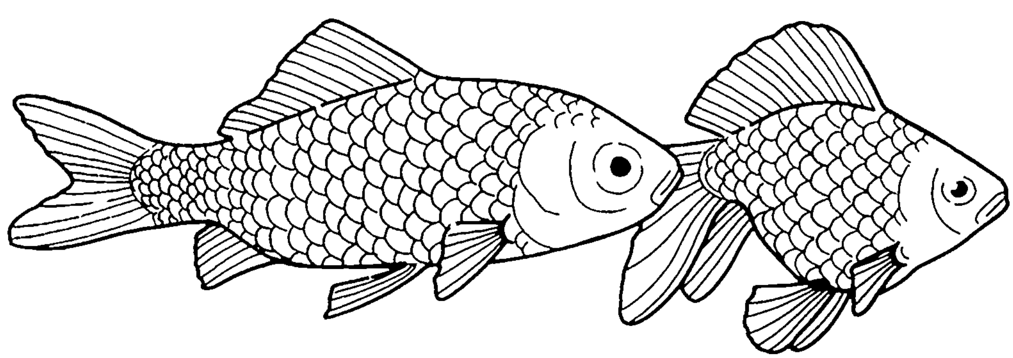
What conclusions can your students draw from their results? They should be able to state that not all substances go into solution. Corn starch forms a suspension which settles out. They should also be able to observe that some things dissolve faster than others.

EXTENSIONS:

1. Can your students design an experiment to test whether things go into solution faster in hot water? They should be able to state the question, design an experiment in which there is a test (hot water) and a CONTROL for comparison (room temperature water) and carry out their test.

2. Since you have some corn starch around, you might have fun with this demonstration of the fact that corn starch will mix with water when stirred to form a suspension but settles out when allowed to sit. Mix a quarter of a cup of corn starch with just enough water to form a ball. As long as you work it in your hand, it will remain a ball. Let it sit and it collapses into mush.

3. Children enjoy growing crystals, a way of demonstrating how to get subtances out of solution by EVAPORATION of the water. Use very hot water to make a very concentrated solution of salt or sugar. Put the cooled solution in a jar and suspend a nail or nut tied to a string from the surface to the bottom. Put the solutions in a warm, dry spot and check them daily. For details see *Science Scope*, February-March, 1987, pages 8-9.



ACTIVITY 1 Name Possible answers

THE DISAPPEARING ACT!

You are going to add table salt, sugar and corn starch to cups of water. What do you guess (predict) will happen to the substance in each cup?

Salt: salt will go away so you can't see it

Sugar: sugar will make the water taste sweet

Corn starch: this looks like it will make lumps

Fill three clear plastic cups with about the same amount of water. Leave about an inch at the top so you can stir. Label each so you know which gets salt, sugar and corn starch.

How many teaspoons will you add to each cup? Circle 1 (2) or 3. Each gets the same number.

After adding the substances, sit and observe for two minutes. What can you see happening?

Both the salt and the sugar fell to the bottom and spread out. The corn starch made lumps. Some floated, and some sank. The corn starch water started looking milky.

Stir each cup 10 times using the same technique. Did any dissolve?

Repeat stirring each 10 times and then observing all of them. Mark out the number of times stirred before a substance dissapeared if it did so.

Salt:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

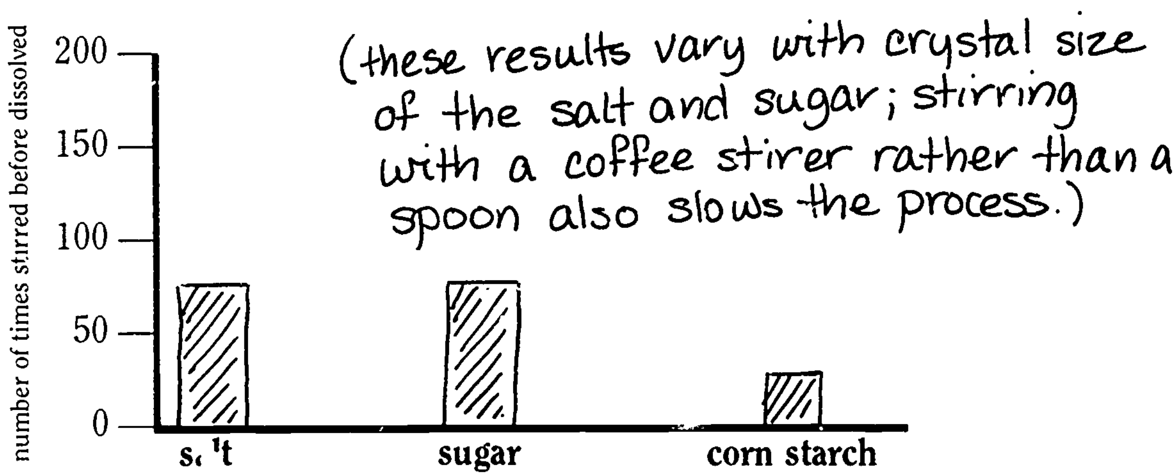
Sugar:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Corn starch:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Make a bar graph of these results:



Did each dissolve? yes, it looked like they did. Then I let the corn starch sit, and it settled out so it didn't really.

Which dissolved fastest? Salt and sugar tied (varies with crystal size)

Write a complete sentence that is one conclusion that you could make based on the results of your experiment.

In my experiment salt and sugar both went into solution, but corn starch did not. Salt and sugar dissolved at the same rate.

Note: Compare results from different groups. Why weren't they all the same? Variables were controlled within each group but not between groups. Some used different amounts of H_20 and substances.

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ACTIVITY 2

WATER, WATER EVERYWHERE

CLASSIFYING DIFFERENT KINDS OF AQUATIC HABITATS

SCIENCE SKILLS:

- classifying

CONCEPTS:

- Characteristics observed about a thing allow you to find its name and to place it in a system that groups similar things.
- An introduction to aquatic habitats.

MATH AND MECHANICAL SKILLS PRACTICED:

- following a flow chart
- using a key

SAMPLE OBJECTIVES:

- Students will be able to classify different kinds of aquatic habitats.
- Students will use a flow chart and/or a scientific key.

INTRODUCTION:

This activity introduces students to classification of habitats using their physical characteristics. Students use a FLOW CHART to visualize the process of classification. At each step they must choose between two characters in order to proceed to the next step. They may also use a scientific KEY to identify aquatic habitats. Students will learn about these habitats as they do the exercise.

MATERIALS:

- blow-up of habitat flow chart on blackboard or bulletin board
- duplicates of habitat cards (1 per student) (may use line drawings or may add photographs of appropriate aquatic habitats from magazines
- copies of flow charts and keys for students

OPTIONAL:

- salt water made with 35 gm (3 tbsp) table salt per liter (quart) water
- tap water for fresh water
- mix of tap water and salt water for brackish water
- small disposable paper cups for each child

INFORMATION:

When humans name things, they are CLASSIFYING them. Things that are classified are first named and then placed in larger groups of things that share similar characteristics. For example, many kinds of tables are lumped under the term "table" as are many kinds of chairs under "chairs." Both tables and chairs belong to a larger category, furniture. The inclusion in ever larger groups results in a hierarchical organization.

Why bother with classifying things? Classification requires that we look for relationships among things which enhance our understanding of their functions and characters. Also, knowing that something belongs to a certain group means that you know something about it if you are familiar with the characteristics of the group.

LESSON PLAN

BEFORE CLASS:

Read the exercise and plan which parts you will do. Make habitat cards. You may just duplicate the cards at the end of this section. For nicer cards, glue them to one side of stiff paper and add pictures of the same habitat to the reverse side. Ask parents to donate magazines like *National Geographic*. Aides or students may cut out pictures. Laminate the cards to last for years. You might not find pictures of all of the habitats — it's okay to leave some out. Make duplicates of the most common ones. Duplicate the flow chart and key.

DURING CLASS:

METHODS: Begin by asking if the students know what the word HABITAT means. It is the place where a plant or animal normally lives and is usually characterized by a dominant plant or a set of physical characters. Can they name any AQUATIC places (water habitats) where plants and animals live? Write their suggestions on the board. Can they tell you what kind of water each has? Make sure that they know the terms SALT WATER, FRESH WATER and BRACKISH WATER. Salt water has the salinity of the oceans, fresh water has little or no salt (you cannot taste any) and brackish water is a mix of salty ocean water and fresh water so it tastes less salty than the ocean. If you would like, you can have your students taste samples of each. A sip of salty water made with table salt will not hurt though it does taste bad. To make your point about brackish water, mix the fresh water with the salt water while they watch.

Now each student is going to become a mystery aquatic habitat. Each will discover what he/she is by following a CLASSIFICATION system that divides habitats up by their CHARACTERISTICS. Students will know what their characteristics or traits are from cards that tell them what they are like.

Explain that when identifying things using a system of classification, one starts with the biggest category and begins to work down to small groups. Here the first category is aquatic habitats, and the characteristic they have in common is that they all are in water. Use the flow chart on the board and have a student read one card aloud to demonstrate that at each stage, they must make a choice between two things until they come to a group in which all the things have the same characters and cannot be divided further. This is their aquatic habitat.

Pass out the cards and give all time to read them. Would they like to make a guess about what kind of habitat they are? Have them write their guess. Distribute flow charts and let them work until they have identified themselves. Trade cards for more practice.

The key is harder to use. With younger children you may delete it. With older children you may repeat the same process of one demonstration followed by independent work that you used for the flow chart.

RESULTS:

Check results of following the flow chart or keying habitats out by comparing answers with the teacher's answers provided.

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CONCLUSIONS:

Have the class make a list of the important characteristics used in this exercise to classify aquatic environments. These are some of them:

- salt or fresh water
- flowing or still water
- tides or currents or waves
- shallow or deep
- sandy, rocky or muddy bottom
- plants submerged or sticking out of the water
- near shore or away from land

USING YOUR CLASSROOM AQUARIUM:

Discuss with your students the following questions:

- Which aquatic habitat most resembles your classroom aquarium?
- Does it have fresh or salt water?
- What kind of bottom does it have?
- Does the water flow or stand still?

Try keying it out. The gravel on the bottom may be a problem.

EXTENSIONS:

1. One way for students to test their own knowledge of aquatic habitats following this activity is to have the pictures of water habitats mounted on cards with a string long enough to hang them around the students' necks. The name of the habitat should be written on the back of each card. Students must find out what kind of water habitat they are by asking other students yes/no questions about themselves.

2. Have each student write several paragraphs about how it would feel to be an animal that lived in his/her aquatic habitat. Include a discussion of some of the problems each would face in making a living. Make sure the student has a picture of the habitat to help with writing.

3. On a map of your state, help your students locate the aquatic habitats they may have seen locally. While landlocked states are limited to freshwater habitats or salt lakes, states like Florida have almost everything but kelp forests. A U.S. map with markings for depth in the ocean would help you locate the saltwater habitats.

4. Research naming in other societies. Different cultures use different degrees of refinement when they create categories of names. This degree of detail in naming is frequently based on the importance of the items in their culture. For example: the South American cowboys, gauchos, have some two hundred different words or names for horse colors, but divide all plants into only four categories depending on their use in ranching.

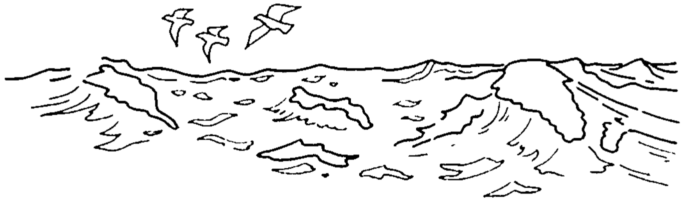
5. Compare common names and their local origins with scientific names. Scientists use a formal classification system in giving names to plants and animals which gives each kind of plant or animal a name consisting of two words which is unique to that species. An animal's scientific name is the same anywhere in the world. Since the scientific name is based on Latin and Greek words, most people give plants and animals a common name in their own language. Because these are arrived at informally, they vary from place to place and can be very confusing because the same animal may have several different common names.

6. To test student understanding of the principles governing classification and the construction of keys, have students classify groups of other things and make their own key. Creative choices of things might include keys to different groups of adventure toys, model collections or rock groups. Let them trade keys to test the quality of their work. There should be at least ten items in each key.

AQUATIC HABITAT CARDS:

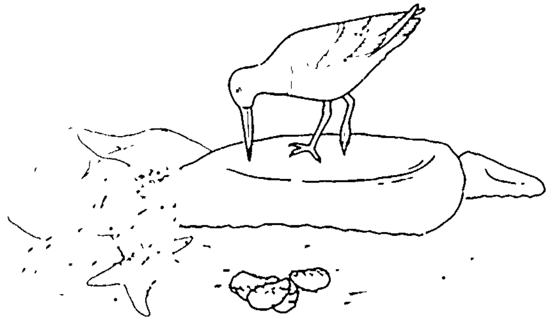
You have salt water and are a big body of water. When the wind blows, waves roll over your surface. During storms the waves get huge. Things on you are far from land.

YOU ARE an ocean



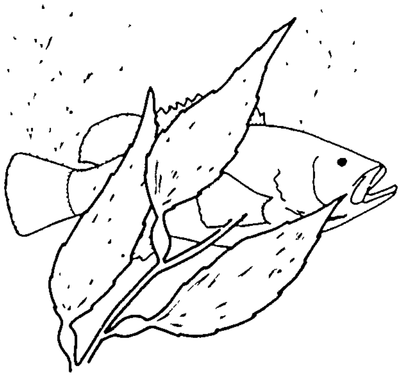
Your rocky shore is covered with seaweeds that live attached to the rocks. When the salt water is at low tide, the sun or snow or rain falls on your seaweeds and animals. Waves crash into you, so animals and plants have ways of clinging tightly to your rocks.

YOU ARE a rocky intertidal



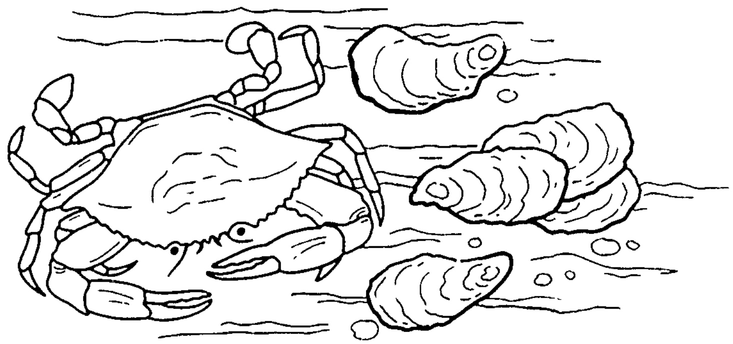
You have cold, salt water. You are found near rocky shores. Your plants and animals are always covered by your cold water. You have forests of seaweeds called kelp which hide hundreds of kinds of animals.

YOU ARE a kelp forest



Salt water mixes with fresh water from a river in your wide shallow waters. You have lots of food for fish and crabs in your open waters above your muddy bottom. You are a nursery for many ocean animals.

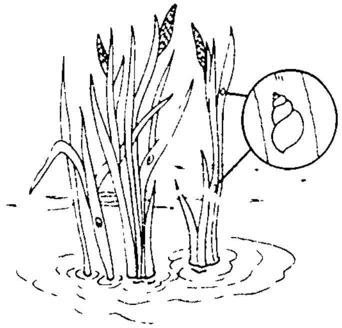
YOU ARE an estuary



AQUATIC HABITAT CARDS:

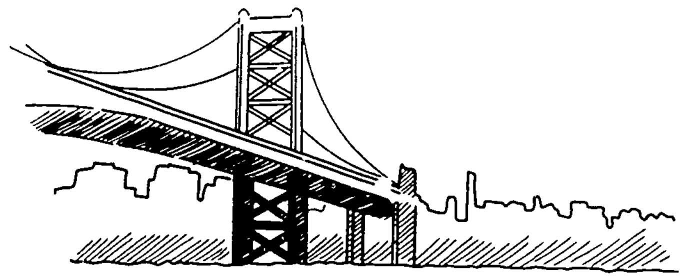
Your brackish water is full of nutrients for the tall grasses that emerge along your shore. In the winter these grasses die, but each spring they come back from their strong roots. The decaying grass particles are food for crabs and oysters. The grasses protect the shore from storms.

YOU ARE a salt marsh



Your fresh water flows over a wide, muddy bottom. Big catfish lurk in your murky waters. Cities were located on you because in the old days you were the easiest place to travel. Barges are towed up and down you in many states even today.

YOU ARE a river

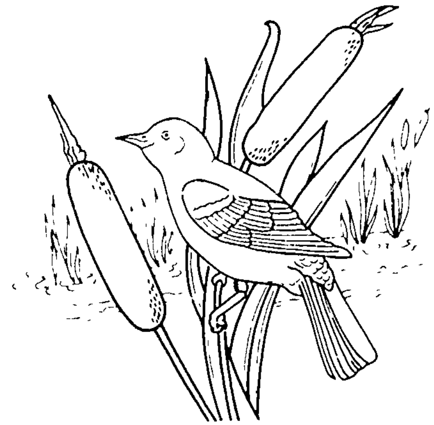


Your quiet, fresh waters are home to many fish which hide deep beneath your surface. Storms may make waves on your wide surface. Where winters are very cold, you may be covered with ice.

YOU ARE a lake

Grasses grow out of your still, fresh waters. Red-winged blackbirds build nests in the grasses. The air is filled with the calls of the male blackbirds.

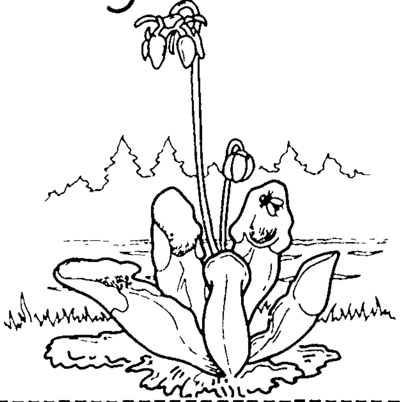
YOU ARE freshwater marsh



AQUATIC HABITAT CARDS:

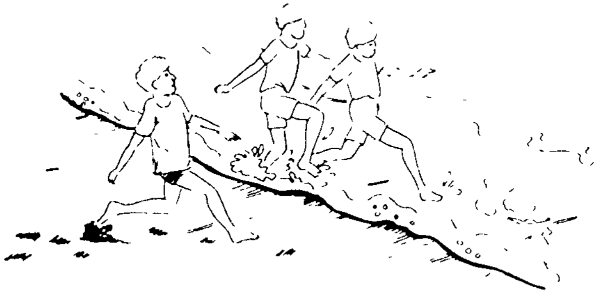
Bushes and mosses grow in your shallow, still water. Patches of very wet ground are home to pitcher plants which get their nutrients from the insects they catch in their leaves. Your water is fresh, but very acid.

YOU ARE a bog



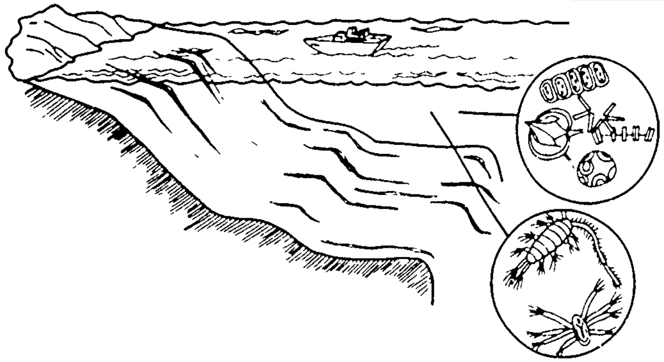
You have salt water that rises and falls with the tides. Sometimes the waves roll way up on your sand while at other times much of your sand is not covered with water. Children play on you. When a storm comes, your sand is moved all around.

YOU ARE a sandy beach



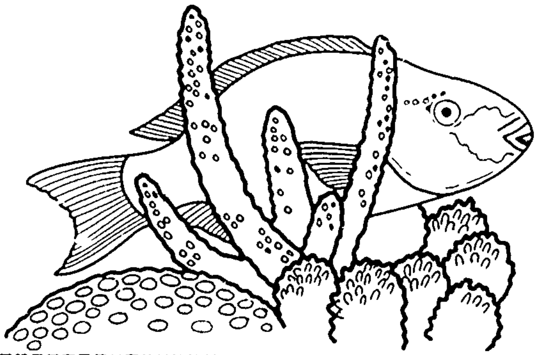
Your sandy or muddy bottom is under salt water. In some places the water is deep, but you are along the shore. Animals burrow in your sand or mud. Your water is rich in tiny plants which provide food for many animals. Fishermen harvest your animals.

YOU ARE the continental shelf



Your warm, salt water and rocky bottom provide the perfect place for animals called corals to grow. Their skeletons make a great place for fish to live. Because you are in a place that is warm all year-round, you are a tropical habitat. Tourists swim out from the beach to visit you.

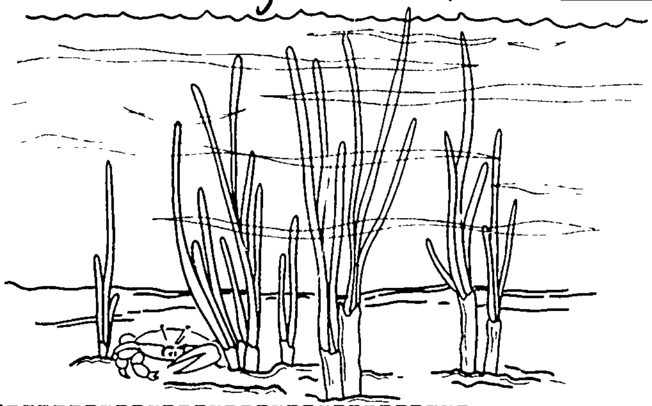
YOU ARE a coral reef



AQUATIC HABITAT CARDS:

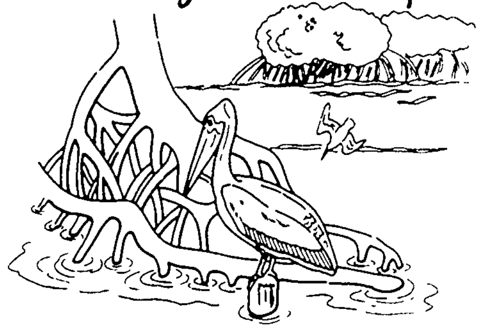
Underwater fields of plants grow in your shallow, brackish water or salt water. Many animals find food and shelter among the plants. The plants protect the nearby shore from erosion because they break the force of the waves.

YOU ARE a sea grass bed



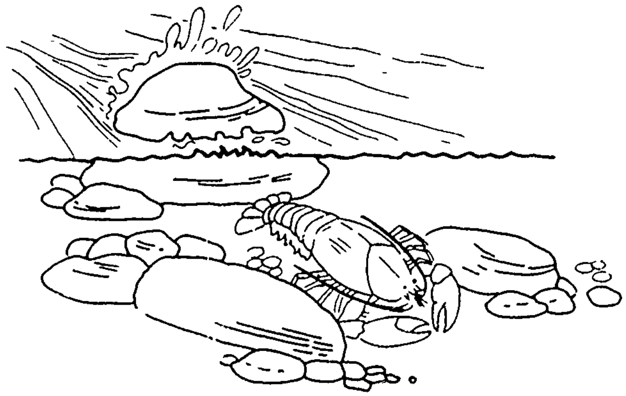
Short trees line the shores of your brackish or salt water. Their big roots hold the trees in the mud, even when hurricanes disturb your constant warm days. Many animals and plants find a home on your tree roots or in your waters. Because it is warm all year-round, you are said to be a tropical habitat.

YOU ARE a mangrove swamp



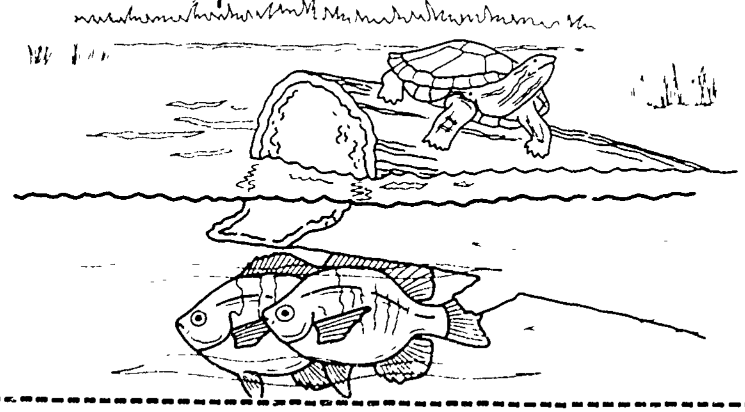
Your fresh water tumbles down over rocks and through small pools where fish and crayfish hide. Your water comes from rain that runs off the land and from springs that bring underground water to the surface.

YOU ARE a stream or creek



Sun shines through your shallow, open, fresh water, allowing underwater plants to grow on the bottom. Still and small, you may freeze solid where winters are cold. In the summer turtles bask on your shore and deer drink from you.

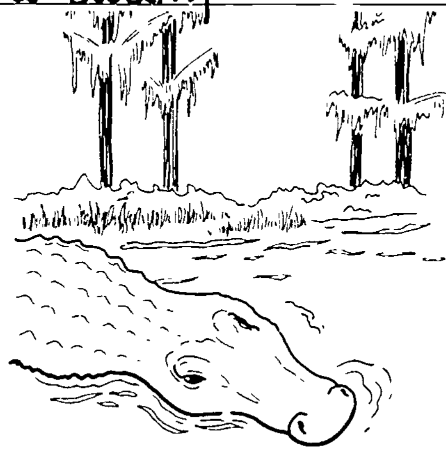
YOU ARE a pond



AQUATIC HABITAT CARDS:

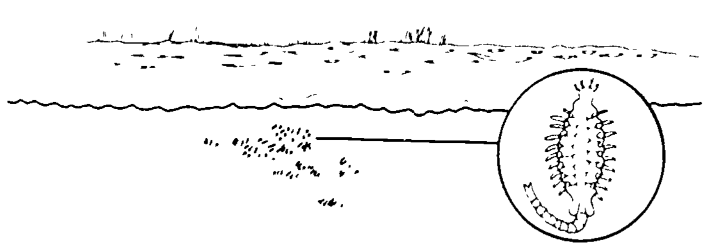
Tall trees stand in your quiet water. Freshwater turtles bask in a patch of sun while mosquitos buzz. It is very dark in the shade of the trees.

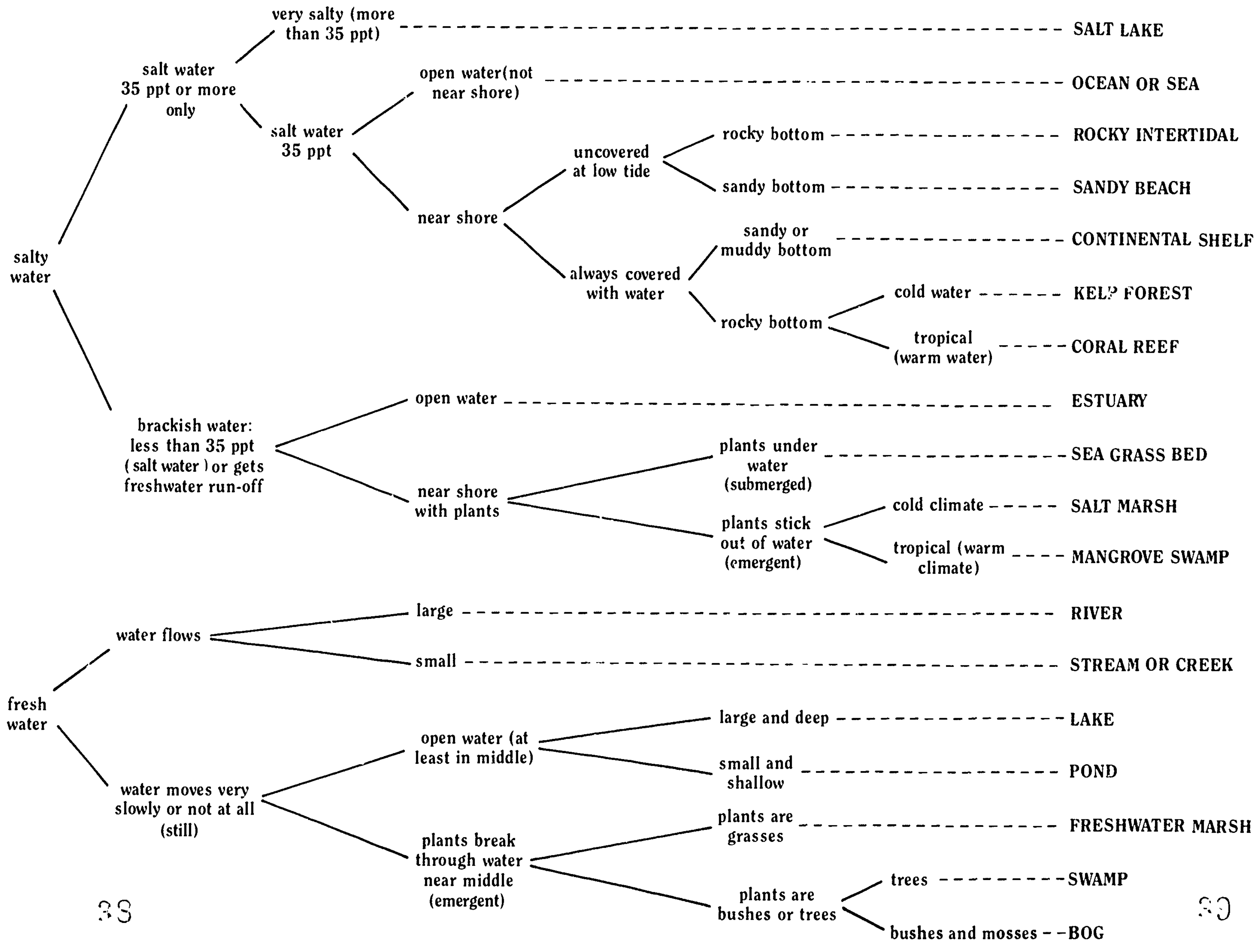
YOU ARE a swamp



Your water is very salty, saltier than the sea. Water flows into you, but there is no way for it to leave except by evaporation in the hot sun. You form in low areas in deserts.

YOU ARE a salt lake

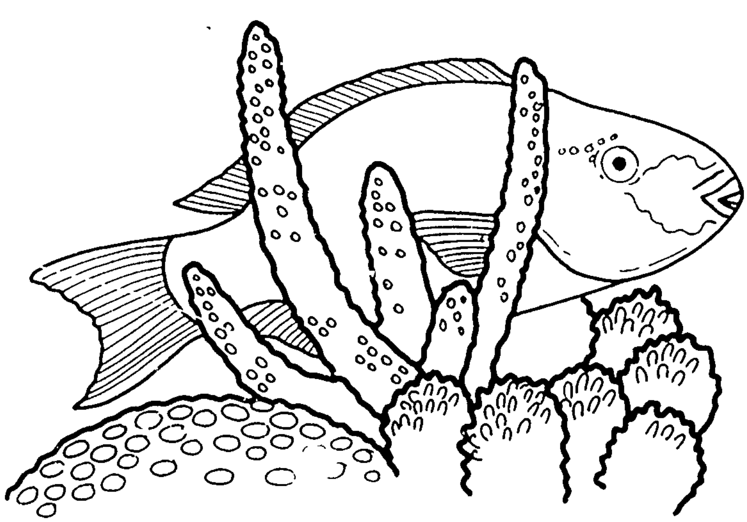



salty water
salt water 35 ppt or more only
very salty (more than 35 ppt)
SALT LAKE
salt water 35 ppt
open water(not near shore)
OCEAN OR SEA
near shore
uncovered at low tide
rocky bottom
ROCKY INTERTIDAL
sandy bottom
SANDY BEACH
always covered with water
sandy or muddy bottom
CONTINENTAL SHELF
rocky bottom
cold water
KELP FOREST
tropical (warm water)
CORAL REEF
brackish water: less than 35 ppt (salt water) or gets freshwater run-off
open water
ESTUARY
near shore with plants
plants under water (submerged)
SEA GRASS BED
plants stick out of water (emergent)
cold climate
SALT MARSH
tropical (warm climate)
MANGROVE SWAMP
fresh water
water flows
large
RIVER
small
STREAM OR CREEK
water moves very slowly or not at all (still)
open water (at least in middle)
large and deep
LAKE
small and shallow
POND
plants break through water near middle (emergent)
plants are grasses
FRESHWATER MARSH
plants are bushes or trees
trees
SWAMP
bushes and mosses
BOG

WATER HABITATS

1. Water is salty ... 2
1. Water is fresh ... 12
2. Water is salt water (sea water) or saltier than sea water only ... 3
2. Water is brackish, less salty than the sea or salt water ... 9
3. Water is saltier than sea water ... **SALT LAKE**
3. Water is salt water, 35 ppt* ... 4
4. Open water, not near shore ... **OCEAN OR SEA**
4. Near shore ... 5
5. Part uncovered at low tide ... 6
5. Always covered with water ... 7
6. Sandy ... **SANDY BEACH**
6. Rocky ... **ROCKY INTERTIDAL**
7. Bottom of sand or mud ... **CONTINENTAL SHELF**
7. Bottom hard and rocky ... 8
8. Cold water and cold winters (temperate) ... **KELP FOREST**
8. Warm waters and warm climate year-round (tropical) ... **CORAL REEF**
9. Open water ... **ESTUARY**
9. Near or at shore with green, rooted plants ... 10
10. Plants are entirely under the water (submerged) ... **SEA GRASS BED**
10. Plants grow out of the water (emergent) ... 11
11. Climate is cold during winter (temperate) ... **SALT MARSH**
11. Climate stays warm all year (tropical) ... **MANGROVE SWAMP**
12. Water flows in a definite bed ... 13
12. Water appears not to move at all unless windy (still) ... 14
13. Large, flowing over muddy bottom ... **RIVER**
13. Small, flowing over sandy or rocky bottom ... **STREAM OR CREEK**
14. Has open water although shores with plants are around it ... 15
14. Plants grow out of the water all over (emergent) ... 16
15. Large and deep; plants grow under water only near shore ... **LAKE**
15. Small and shallow; plants grow under water everywhere ... **POND**
16. Plants are grasses ... **FRESHWATER MARSH**
16. Plants have woody branches: they are trees or bushes ... 17
17. Plants are trees with definite trunk ... **SWAMP**
17. Plants are bushes: moss grows on ground ... **BOG**

**35 ppt is a way of expressing how salty the water is in the ocean or other saltwater habitats. If you had one kilogram of sea water, 35 grams of the weight would be salt.*



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ACTIVITY 3

SALTY OR FRESH?

WHICH IS HEAVIER, FRESH WATER OR SALT WATER?

SCIENCE SKILLS:

- observing
- measuring
- predicting
- experimenting
- inferring
- communicating

CONCEPTS:

- If temperatures are the same, salt water is heavier than fresh water.
- Fresh water floats on salt water because it is lighter (less dense).

MATH AND MECHANICAL SKILLS PRACTICED:

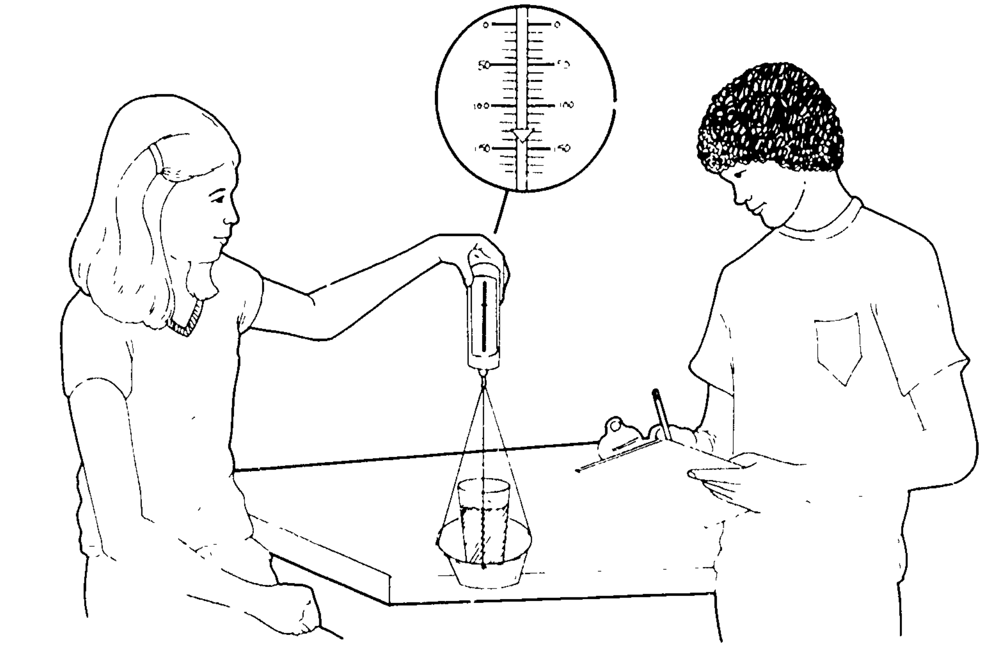
- use of spring scale, simple balance or triple beam balance

SAMPLE OBJECTIVES:

- Students will be able to state experimental evidence proving that salt water is heavier than fresh water.
- Students will learn to control variables.
- Students will be able to compare relative weights.

INTRODUCTION:

This exercise examines the relationship of salinity to weight (density) of solutions. Subsequent studies show how these relationships determine the distribution of fresh and salt water where a river enters the ocean and forms an ESTUARY.



MAT ERIALS:

FOR EACH GROUP:

- tape or marking pen
- food coloring in dropper bottle
- 4 clear plastic cups
- plastic teaspoon

FOR CLASS:

- measuring cups or plastic graduated cylinders
- simple balances (if you use triple beam balances instead, have a training session on use)
- simple 250 gm spring scales if available
- one gallon of salt water (1 cup salt per gallon) at room temperature
- one gallon of tap water (fresh water) at room temperature
- a heavy coffee mug or cup

LESSON PLAN:

BEFORE CLASS:

Assemble the materials and read the entire lesson. If you use triple beam balances, you will have to train students to use them ahead of time. Simple balances that compare two items at once may require some testing by students before they believe that the heavier item pulls its side down and lifts the other up. Simple spring scales may require a bit of practice with reading the scale. If the spring scales lack pans, make them from small aluminum or plastic pans (frozen meat pies) and three pieces of string.

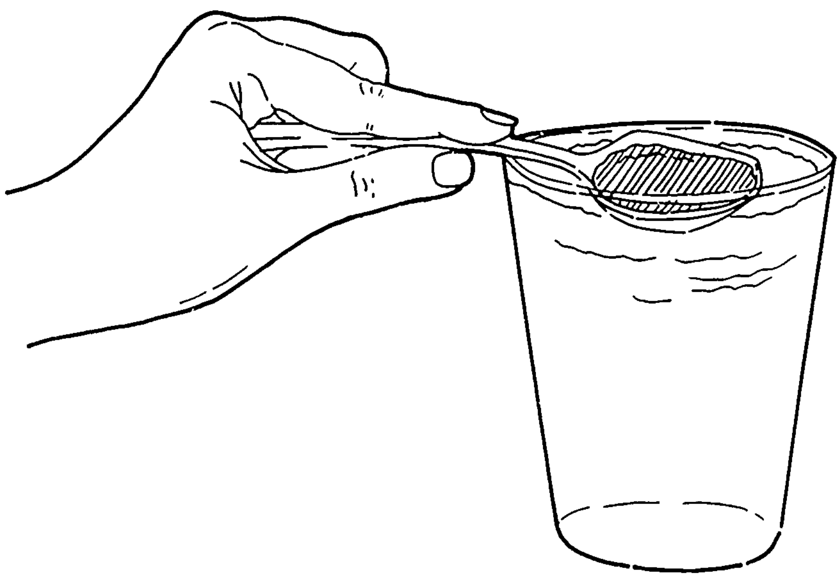
DURIN' CLASS:

Ask the class how they would determine which was heavier: salt water or fresh water? They will probably suggest weighing the solutions. Use a balance and two clear plastic cups of water, one wit twice as much water as the other to demonstrate. Ask them if this is a "fair test". Why not? The students should be able to tell you that you must use the same amount or volume of water to tell which is heavier. Then demonstrate with a plastic glass and a heavy ceramic coffee cup filled with equal volumes of water. Is this a "fair test"? Again, they should say no and identify the difference in weight of the two containers as the problem. What rule would they have to follow for this to be a "fair test"? Th re can be only one difference between the two items tested, in this case, the amount of salt in the water.

Can your students do a "fair test" to answer the question you first asked: which is heavier, salt water or fresh water? Let individual groups try without telling them exactly what to do. Let them make mistakes and discuss these mistakes among themselves. They may compare equal volumes of salt and fresh water on a simple balance or they may weigh equal volumes with a scale or triple beam balance.

After most groups have answered the question, have everyone settle down and state his/her results. Salt water is heavier. Now can the students predict what would happen when fresh water meets salt water? This happens where a river flows into the sea. Have them state their predictions. Now how can they test their predictions using clear plastic glasses, salt and fresh water, food coloring and a teaspoon? Give them these materials and let them experiment. Do not tell them what to do right away.

They may add food coloring to the salt water as a marker and see what happens when a little salt water is carefully laid on top of a cup of fresh water with the teaspoon. (See the illustration for technique.) The salt water should sink to the bottom, indicating that it is heavier. Try the reverse with colored fresh water and plain salt water to prove that the food coloring is not causing the result.



RESULTS:

If equal volumes of salt and fresh water are compared in containers that are identical, the salt water weighs more than the fresh water. When salt water is gently placed on the surface of fresh water, it can be seen to sink. Fresh water gently placed on the surface of salt water floats at the surface.

CONCLUSIONS:

Salt water is heavier than fresh water when both solutions are the same temperature. (Temperature as a variable will come in a later activity.) When two things of equal volume are compared, the heavier is said to be more DENSE.

USING YOUR CLASSROOM AQUARIUM:

Is your classroom aquarium fresh water or salt water? How could your students test the water to find out? It could be compared with fresh and salt water in the same tests done above.

ACTIVITY 3

SALTY OR FRESH?

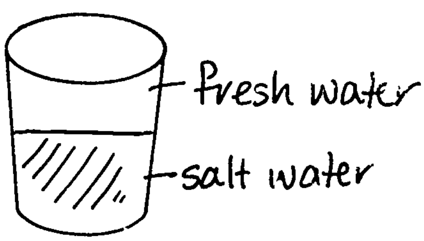
Name Possible answers

Which is heavier: salt water or fresh water? Salt water

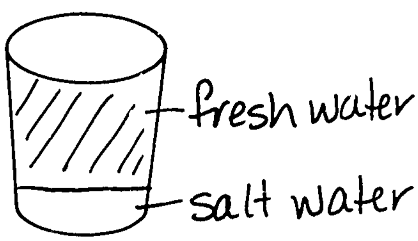
How did you compare salt and fresh water to reach your conclusion?

I used a spring scale to compare equal volumes of salt and fresh water. Salt water weighed more. Then I layered salt water onto fresh water.

What happened when salt water and fresh water were very gently layered on each other? Draw and label your results.



when I layered fresh water onto salt water, the fresh water floated.



When I layered salt water onto fresh water, the salt water sank.

Predict what might happen to the distribution of salt and fresh water in the mouth of a river where it meets the sea.

I think the salt and fresh water might form layers the way the water in my glass did.

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ACTIVITY 4

THE LAYERED LOOK

A DEMONSTRATION OF THE DISTRIBUTION OF FRESH AND SALT WATER IN AREAS WHERE FRESH AND SALT WATER MEET IN ESTUARIES.

SCIENCE SKILLS:

- observing
- predicting
- communicating

CONCEPTS:

- Stratification occurs in estuaries where fresh water meets salt water.
- Fresh water will tend to flow above the saltwater layer.
- Some mixing occurs where the two layers meet.

SAMPLE OBJECTIVE:

- Students will be able to describe and explain the distribution of salt and fresh water in an e'tuary.

INTRODUCTION:

An ESTUARY is defined as a semi-enclosed body of water where incoming seawater is diluted with fresh water coming from the land. Because of the differences in weight (density) between fresh and salt water, salt water will move upstream in the estuary along the bottom, while fresh water will flow downstream along the surface. This causes a layered condition. Some mixing occurs at the interface where fresh and salt water meet. The layered condition is said to be STRATIFED. This teacher-led demonstration illustrates the stratification that may occur in estuaries. You can go directly from this activity to Activity 5 as this is the set-up for the next demonstration. *The thin separator tank from Concepts of Science for the fifth grade may be used in this activity.*

MATERIALS:

- colored markers or crayons
- 2 clear plastic containers such as sweater boxes or small aquaria; may use clear glass 1 gallon jars or large glass or plastic bowls
- 2 siphons — clear plastic tubing (see Recipes)
- 1 gallon of clear aged fresh water
- 1 gallon of aged fresh water with 8 drops of green food coloring
- 1 gallon of clear aged salt water (1 cup salt per gallon)
- 1 gallon of aged salt water (1 cup salt per gallon) with 8 drops of green food coloring

LESSON PLAN:

BEFORE CLASS:

Gather all materials. Make up the saltwater solutions and label bottles. This exercise works best as a teacher-led demonstration so plan a spot where all the children have a clear view on a solid surface that they cannot move as they crowd around. Aged water which has been sitting open at least overnight insures that the next activity will not hurt the animals.

DURING CLASS:

METHODS: Start by asking the students what happens when salt water meets fresh water. They may remember from Activity 2 that salt water and fresh water mixed give BRACKISH water. After Activity 3, they may also suggest that the heavier salt water will settle near the bottom, while the fresh water floats near the top.

Let's see what happens when a large body of salt water meets fresh water in a model ESTUARY. Have the students place themselves so that they can see without bumping the demonstration.

Fill one container 1/3 full with clear aged fresh water. Then slowly siphon in the colored salt-water solution, keeping the siphon tube near, but not on, the bottom of the container. A colored salt solution layer will form on the bottom of the container. Have a student hold this siphon while you do the reverse with clear salt water and colored fresh water in another container. You should end up with two stratified systems with the color on top in one and on the bottom in the other. The best way to see this is to look from the side, not the top.

RESULTS:

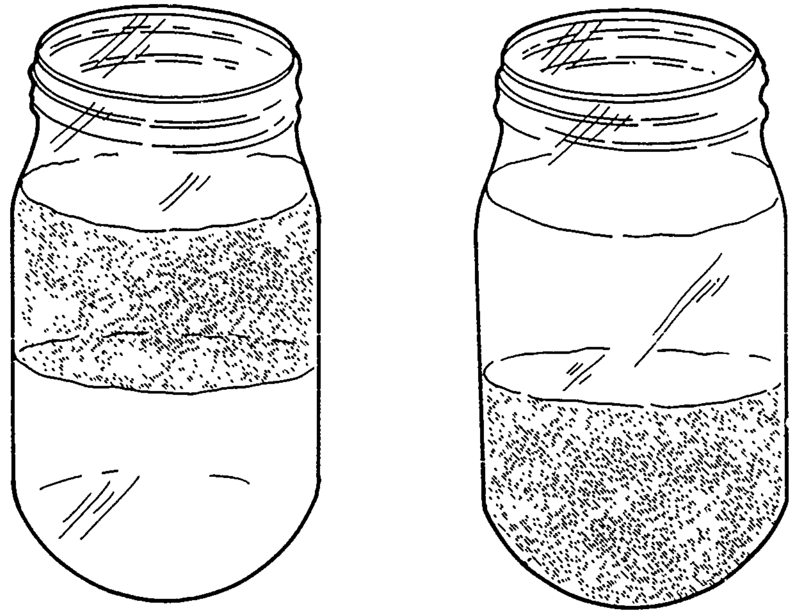
Ask the students to observe the containers of water. Questions to get a discussion going might include: How many layers formed? Two. Which layer is salty? Bottom. Which layer is fresh? Top. Are they completely separate? No. Is something happening at the interface between the two layers? Yes. What? Mixing is occurring. What would happen if one measured the salinity at differing depths from surface to bottom in an estuary? Salinity would increase with depth.

Why did we do this twice? The food coloring added a second variable. When it was used in the reverse order in the second experiment, you proved it was not the cause of the results.

Have the students record the results on their data sheets, using crayons or markers to indicate the location of the colored water layer. Have them label each layer of water in each container, and then fill out the rest of the data sheet.

CONCLUSIONS:

Because salty water is more dense than fresh water, it sinks below fresh water when the two come into contact. While there is some mixing at the boundary, a stratified system with regard to salinity is formed. The distribution of salinities in an estuary reflects this relationship.



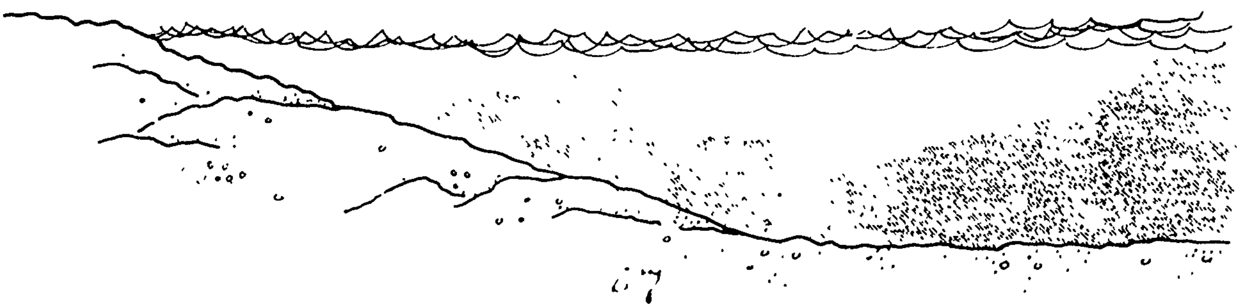
USING YOUR CLASSROOM AQUARIUM:

If you do this exercise before you set up your classroom aquarium, use the tank for one model estuary.

EXTENSIONS:

1. Challenge the students to decide how they could more clearly see the mixing. Try using two different food colors in the fresh and salt water solutions which when combined produce a third where mixing takes place (for example, yellow and blue to make green).

2. Draw the distribution of salt and fresh water on the board in a cross section of a typical estuary as shown here. Include the directions of water flow. Have the students consider how the animals in an estuary might use these currents. Can they think of what animals could do with these currents of water in an estuary? Travel or MIGRATE. Animals that cannot actively swim, like ZOOPLANKTON, but that can go up and down in the water, could travel up and down the estuary by staying near the top or the bottom.



ACTIVITY 4:
THE LAYERED LOOK

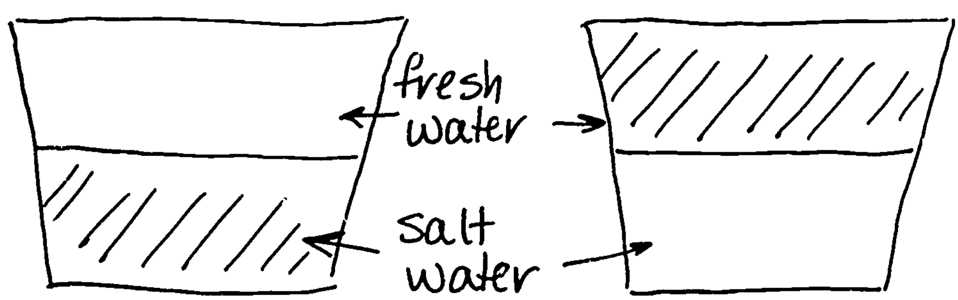
Name Possible answers

State the question you are trying to answer by observing this demonstration.

What happens when salt water and fresh water are gently added to each other? What might happen where a river meets the sea?

Draw the results of the demonstration here:

First tank or jar second tank or jar



Based on the results of this demonstration, where would you expect to find the saltiest water if you were studying the mouth of a river where it formed an estuary as it meets the ocean? The top of the water or the bottom?

I would expect the salt water to be on the bottom. If the water were mixed, maybe by the wind, the two kinds of water might mix as it did when John kept bumping the table.

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ACTIVITY 5

SOME LIKE IT SALTY—SOME DO NOT!

A TEACHER-LED DEMONSTRATION THAT SHOWS HOW SALINITY MAY AFFECT THE DISTRIBUTION OF SOME AQUATIC ANIMALS.

SCIENCE SKILLS:

- observing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- Salinity is one factor which helps determine where animals and plants live in an estuary.
- Animals can sense the salinity and move to the best location.

SAMPLE OBJECTIVE:

- Students will be able to explain how adaptation to a particular salinity may affect where an aquatic animal lives.

INTRODUCTION:

This demonstration uses the two stratified systems made in Activity 4. It shows that animals may select a position in the water based on the distribution of salinities. Do this as a demonstration and do not substitute species of fish. The species suggested are tolerant to salt and will not be harmed by short exposure. If you cannot find adult brine shrimp, skip that part of the activity.

MATERIALS:

- both demonstration jars or tanks from Activity 4
- small dip net
- 2 or more small goldfish or tropical guppies (see Recipes)
- several dozen adult brine shrimp (see Recipes)

INFORMATION:

Salinity is an important factor in determining the distribution of living things in an estuary. Marine organisms inhabit the mouth of the estuary, where high salinity occurs. Travelling up the estuary along decreasing salinity gradients, marine populations decline and are replaced by organisms that can TOLERATE different ranges of salinities. Freshwater species are found at the mouths of tributaries leading into the estuary and in upper estuarine waters. In part, due to this wide range of salinities, there are many different habitats in an estuary.

Some species of animals and plants can TOLERATE wide ranges of salinities while others have NARROW requirements. In both cases, they will seek the water with salinities within their range of tolerance. In the case of plants and those animals like oysters which live attached as adults, their location is determined by salinities present when the seeds germinated or the animal larvae settled. Animals that can swim may move to remain in the OPTIMAL or best salinity. Other factors that influence habitat selection include temperature, food supply, predators and oxygen levels.

LESSON PLAN:

BEFORE CLASS:

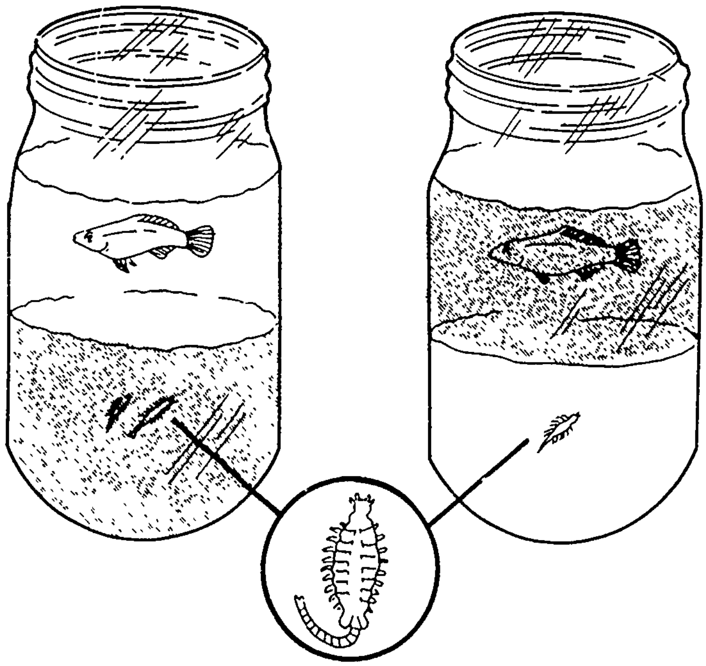
Order brine shrimp and fish. If brine shrimp are not available from a pet store or supply catalog, skip them. Do not use newly hatched brine shrimp as they are too small to see. Do not use fish other than goldfish or guppies. Feed the fish well.

DURING CLASS:

METHODS: Begin by asking the students what would happen if animals were introduced to the estuarine model you have created. The amount of salt in the water might influence where the animals stay in the container. How might the stratification of salt/fresh water influence their behavior? Animals that live in fresh water normally might migrate to the top and stay there. Those that live in salt water might stay near the bottom.

Introduce the guppies or goldfish and adult brine shrimp. Have the students predict which part of the model estuary each might prefer. Since guppies/goldfish are freshwater animals, they might prefer fresh while the name brine shrimp might imply that these residents of salt lakes would do best in salt water. Using the net, gently transfer fish into each container and let the students observe their swimming pattern. The students must remain quiet and not scare the fish. Questions to get a discussion going might include: How many times does each animal swim the entire depth of the container? Where does it end up swimming most of the time? You may get numerical data by assigning students to record how many fish are in each layer every minute for 5 minutes.

Next drop adult brine shrimp into each container. Observe the behavior exhibited for several minutes, and ask the same questions. Did the addition of brine shrimp alter the fishes' behavior? They may try to eat the brine shrimp, indicating that food also influences distribution.



RESULTS:

Record results. Ask the students in what water habitats they might look for these fish and brine shrimp in nature, based on their observations. Goldfish and guppies prefer fresh water while brine shrimp live in salt lakes and can tolerate very high salinity.

Why did you use two tanks, one with colored fresh water and the other with colored salt water? Coloring might have affected distribution. If you use too much food coloring, the guppies may try to avoid it.

CONCLUSIONS:

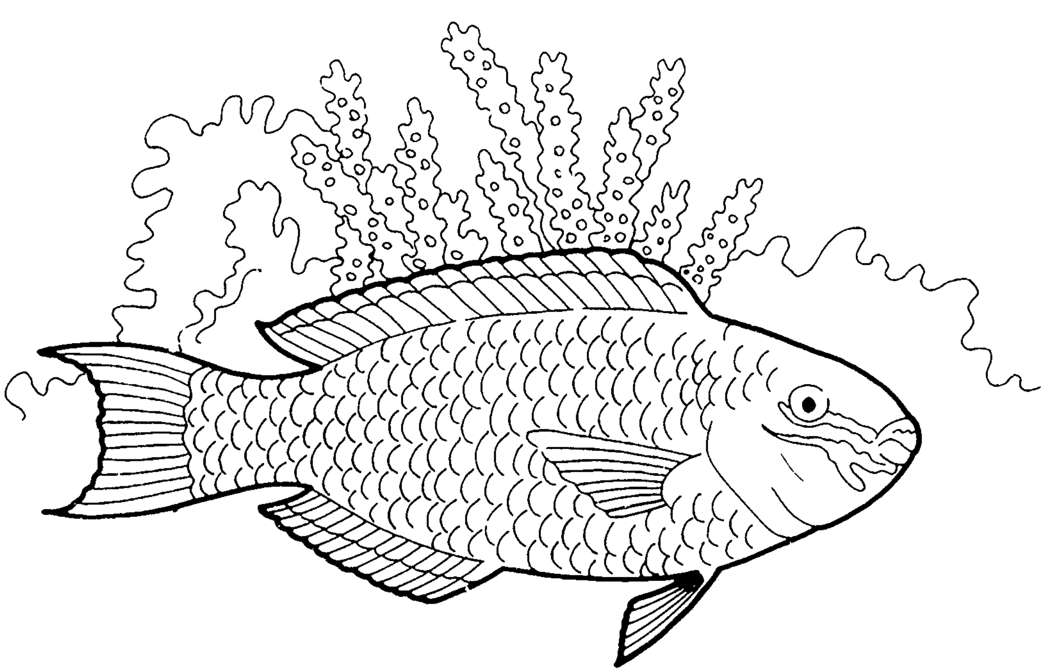
Aquatic animals that can swim choose the place where they live based on many factors, one of which is salinity. In a stratified system some species might always be at the surface while others are always at the bottom. Even though they are at the same spot on a map, in three dimensions they may be vertically separated and will not come in contact with eac other. When possible, aquatic animals will avoid water in which the salinity is outside their range of TOLERANCE and will seek OPTIMUM situations.

USING YOUR CLASSROOM AQUARIUM:

The fish from this exercise may come from your aquarium and may return there when done. The brine shrimp will make welcome food for your tank's inhabitants.

EXTENSIONS:

1. What are the effects of too much salt or too little salt on an organism? You could study this by immersing plant tissue (potato) in very salty and in fresh water. Generally, tissue loses water (weight) in salt water and gains it in fresh. The causes of this are somewhat difficult to adequately discuss at the elementary level and require an understanding of the diffusion of water through membranes. The what is easy to see, but the why is not. You might also put leaves from an aquatic plant in both fresh and salt water if you have microscopes to study the results. Draw the before and after of each.

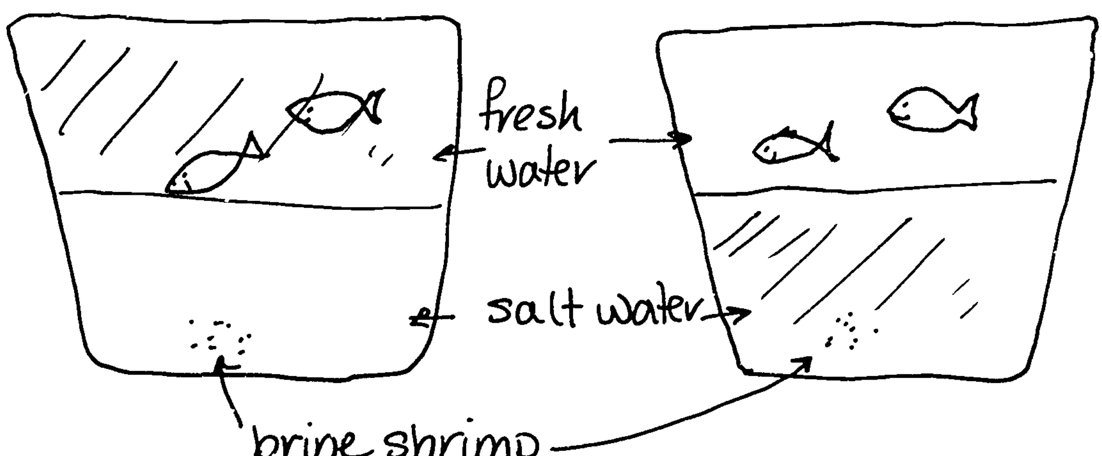


ACTIVITY 5 Name Possible answers

SOME LIKE IT SALTY — SOME DO NOT!

Predict which layer(s) the animals will prefer. Since my goldfish at home like water out of the tap, I think they will like the fresh water at the top. I don't know what the brine shrimp will like.

Draw the two tanks. Label the salty and fresh water. Draw the animals in the locations they prefer.



Did the animals always stay in the same kind of water? If not, describe their behavior.

No. The goldfish tried swimming in the salt water but they went back up to the fresh water.

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ACTIVITY 6

THE GREAT SALINITY CONTEST!

OR WHO HAS THE SALTIEST AND THE FRESHEST WATER?

SCIENCE SKILLS:
- observing
- measuring

CONCEPTS:
- Water containing dissolved salts is heavier (more dense) than fresh water.

MATH AND MECHANICAL SKILLS PRACTICED:
- measuring volume
- weighing
- use of balance

SAMPLE OBJECTIVE:
- Students will be able to apply their knowledge about weight (density) of salt and fresh water to determine the relative salinity of unknown solutions.

INTRODUCTION:

Now that your students have learned about the relationships of salinity and density, have them put their knowledge to work in a contest by discovering who has the saltiest and the freshest water samples. Students receive the samples at random, so the activity is a lottery of sorts. The prizes to the winners may be objects or rewards of special opportunities.

MATERIALS:

FOR EACH STUDENT:
- one sample jar of about a pint (plastic soft drink bottle, peanut butter jar, large paper cup)
- two small clear plastic cups
- a plastic spoon

SHARED BY CLASS:
- volume measuring devices such as measuring cups or plastic graduated cylinders
- scales and/or balances
- food coloring in dropper bottles
- water samples of three different salinities: fresh water, water with salt at 1/4 cup per quart and water at 1/2 cup salt per quart (use kosher or canning salt, not table salt; see Recipes)
- prizes for the contest: stickers, a puzzle or maze, pencils, free time, anything that is small, but fun to win

LESSON PLAN:

BEFORE CLASS:

Collect the containers for each student. (Students may have brought them from home.) Put a number on each jar. Fill each jar with one of the three solutions. Fill a few jars with fresh water. Most get the slightly salty solution. Fill one with the very salty water. Record which jars got which solutions so you know which wins. The saltiest wins the grand prize. The freshwater jars win second prizes. The rest lost in the lottery.

DURING CLASS:

METHODS: Explain that now is the time to put what the students have learned about salinity and density or heaviness to work. Show them the jars. Each jar contains an unknown solution. Some hold fresh water, some slightly salty water, and one very salty water. Have them pick randomly among the jars. The students who picked the jars with fresh water get a prize. The person who picked the jar with the saltiest water wins the grand prize. It is like a lottery. But how do they know what they have? To discover who won, they have to test the solutions in the jars. Can they tell by looking? No. Then how?

There is one thing they cannot do: DO NOT TASTE THEM! Make sure students know that they should NEVER taste unknown solutions. Some kinds of salts are very toxic. They are not all like table salt. For example, epsom salts can cause unpleasant diarrhea. Students should plan how to test the solutions, using knowledge gained in previous exercises. Show them the array of equipment available to spark ideas. Have students fill out the worksheet with their plan before they begin.

RESULTS:

How are they going to find out who won? They can do any physical test which will get at the relationship of density or heaviness to salinity. They can check with you to find out if their results are accurate since you recorded which solution was in which sample bottle. Award the prizes when they have correctly found the fresh water and the saltiest water.

CONCLUSIONS:

Have a brief class discussion of techniques used for testing. Which was best? Which was fastest?

EXTENSIONS:

1. How about asking the question: which is saltiest, the Dead Sea (276 gm of salt per kg of water) or the Great Salt Lake (266 gm salt per kg of water)? This can be solved in a number of ways. Everyone could compete to see who can dig the answer out of the library fastest. Or you could mix up two samples representing each using the information above and have the students test them. Locate each on the map.

2. How do salt lakes form? Water flowing over the ground dissolves salts which are carried to a low spot from which there is no way for water to flow out. As the water evaporates, the salt is left behind.

3. Do salt lakes always stay the same? No! For the last several years the Great Salt Lake has had more water flowing in than has evaporated out. In 1986 the lake was rising fast. To prevent homes, roads and businesses from disappearing under water, Utah is talking about pumping water out of the valley where it is and into another desert valley.

4. Can the students think of another habitat where salinity gets high? Tide pools can get very salty on a hot day during low tide! So do the pools of water in a salt marsh during low tide on a summer day.

ACTIVITY 6 Name Possible answers

THE GREAT SALINITY CONTEST!

My sample number is 14

These are the steps I will take to determine if I have fresh water, slightly salty water or the very salty sample:

I think I will try weighing my water and see if it is heavier or lighter than someone else has. I might also use food coloring and compare it to other students' samples. I can also get fresh water from the tap for comparison.

I think my sample is
___ fresh water X slightly salty ___ very salty.

This is the evidence for my conclusion:

I lost. My water sank in tap water and floated on Linda's sample. When I weighed my sample, it weighed in between the heaviest and the lightest which were the fresh water and the very salty water.

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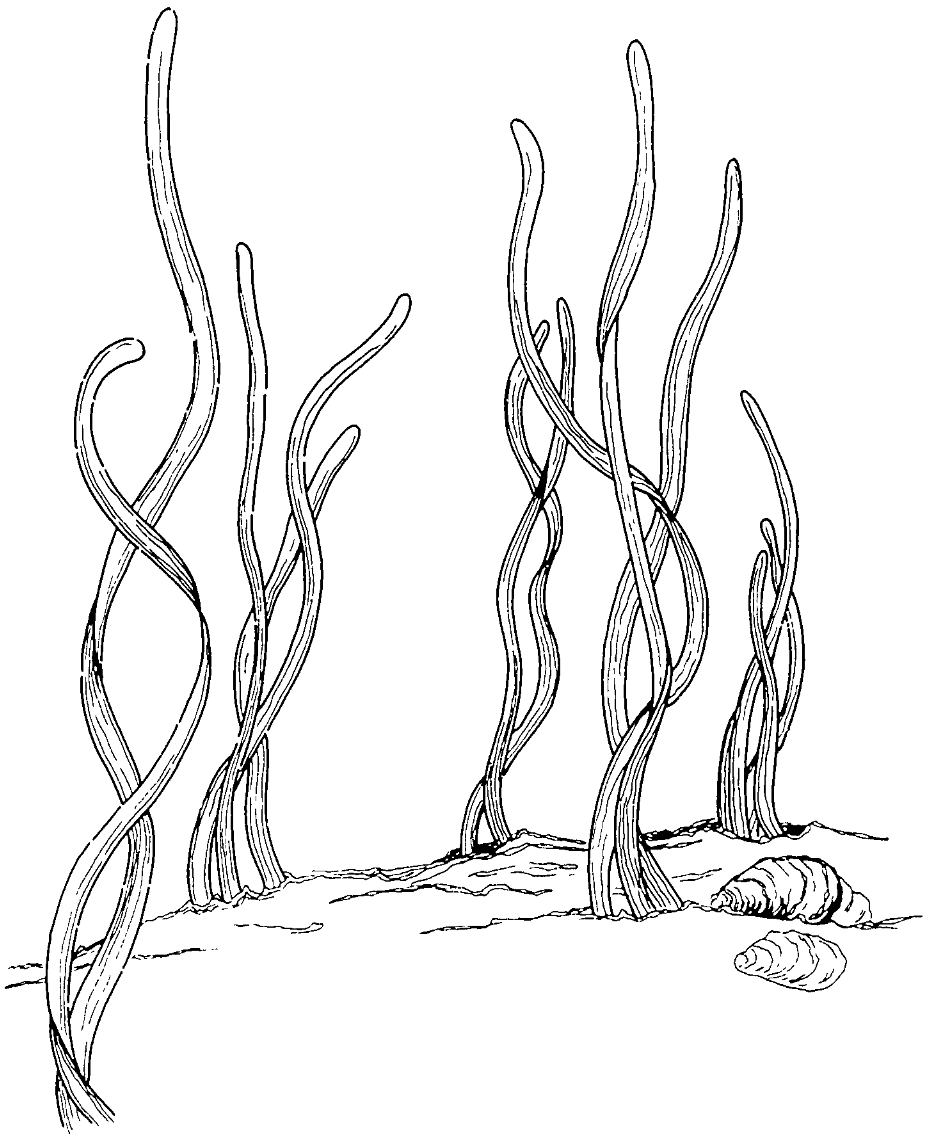


5C

ACTIVITY 7

OXYGEN FOR LIFE

WHERE DOES THE OXYGEN THAT IS DISSOLVED IN WATER COME FROM?

SCIENCE SKILLS:

- observing
- measuring
- organizing
- inferring
- communicating

CONCEPTS:

- The oxygen that is in water comes from air.
- The oxygen dissolved in water may vary depending on the conditions of the sample.

MATH AND MECHANICAL SKILLS:

- use of dissolved oxygen test kits
- computing averages

SAMPLE OBJECTIVES:

- Students will be able to follow instructions to test for dissolved oxygen.
- Students will be able to explain why experimental results from different sources vary.

INTRODUCTION:

Measuring dissolved oxygen is difficult, but rewarding. Oxygen is as important to the animals living in water as it is to those living on land. Oxygen in the water is DISSOLVED OXYGEN, not the oxygen atom in the water molecule. Plants may add dissolved oxygen when they photosynthesize. Much of it, however, comes from the air and enters the water at the surface. Oxygen DIFFUSES slowly in the water, more slowly than it does in air. Dissolved oxygen amounts may vary significantly from one place to another in aquatic habitats. In this exercise students will prove that oxygen from air does enter or dissolve in water.

Dissolved oxygen may be measured in several different ways. One way is in parts per million (ppm) which is based on the weight of the oxygen versus the weight of the water. Oxygen in natural environments can range from no oxygen (0 ppm) which is very bad to 6-10 ppm which is sufficient for most animals to more than 15 ppm in some cases.

MATERIALS:

FOR EACH GROUP:

- a clear plastic cup
- cold water
- sealed canning jar full to the top with boiled water(see Recipes)
- goggles for each child

SHARED:

- dissolved oxygen test kits (see Recipes)
- kitchen baster or large syringe to transfer water sample

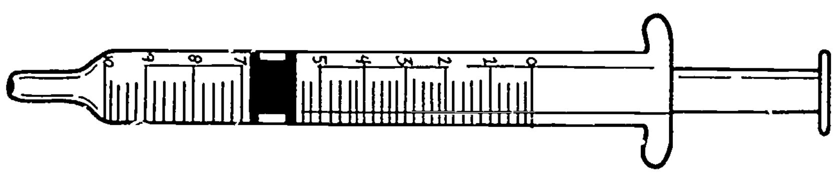
LESSON PLAN:

BEFORE CLASS:

This and all other dissolved oxygen exercises use the LaMotte Chemical Company dissolved oxygen test kit. This brand was chosen for two reasons: the results are numerical, and the kits are the kind most commonly available to teachers. The test for dissolved oxygen in these kits is the Winkler method, an old and very accurate one. Neither you nor the students need to understand the chemical transformations in this kit. You do need to understand what the results mean in terms of the natural world. The Recipes section gives you simplified directions for use of this kit. Make the modifications suggested.

After reading the exercise and assembling the materials, practice the oxygen test yourself. Then spend one science class having the students learn the techniques with tap water. Have the entire class work together under strict supervision for this first experience.

Boil and "can" water for this exercise at home. Allow the sealed jars to cool.



DURING CLASS:

Have the students fill a transparent plastic cup with cold water early in the day and let it sit on their desks. Observe it occasionally. If you have short periods, do this half an hour before class.

When it comes time for the science lesson, ask the students what they observed as their cup of water sat on the desk. Some of the students should have noticed that tiny bubbles formed on the sides of the cup. What do they think the bubbles are? Air. Where did it come from? It was DISSOLVED in the water. What do animals need that is in air? OXYGEN. The air is 21% oxygen.

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How can we prove that oxygen dissolves in water from the air? Distribute the sealed jars. Tell them that you have treated the water in the jar to remove most of the air. But they do not have to trust you. They can test the water for DISSOLVED OXYGEN themselves using a test kit. Make sure they understand that the color changes are INDICATORS of things that cannot be seen themselves but which cause the color changes.

Have the students working in groups take turns using the test kits following the instructions provided. Record their results. If students made serious errors that you can identify, you may choose to delete their data from the final chart. Make sure they understand that you are not just making sure that things come out right. Explain the nature of their error so that they can be careful to correct it.

Pour half the water out, put the lid on and shake the jar hard. Uncap and recap and shake several times. This speeds both diffusion and mixing. Now test the water for dissolved oxygen again.

RESULTS:

Compare the first oxygen measurements with the second. Make a table on the board or an overhead projector. Did everyone get the same results? No. Anytime a group of folks do a test, there is variation in the way they do it and the way they read it. That is one of the reasons that scientific tests must be repeated many times. Average the results for low oxygen and high oxygen.

CONCLUSION:

Where did the dissolved oxygen come from? From the air. Gases from the air dissolve in water.

USING YOUR AQUARIUM:

Have your students observe the movement of water in your classroom aquarium. The air lift columns create a current that causes the water to circulate, exposing all of the water to the air and mixing the oxygen. What would happen if there were no circulation? Oxygen would be lower at the bottom if it were being used by some of the tank's inhabitants.

EXTENSIONS:

1. Oxygen normally enters at the surface of the water. Decomposers use oxygen and are frequently located at the bottom of a body of water. Oxygen must enter the water at the surface and diffuse downward. Diffusion in water is slower than diffusion in air. How long does it take for oxygen to get to the bottom of a lake? Try seeing how fast it travels in a fruit jar.

Uncap a quart fruit jar of boiled water and let it sit for 30 min. First sample the water from right at the surface and then the water from the very bottom. Do this very carefully so that the water is not stirred.

You should get a differential, even over the shallow distance in a fruit jar. What does this mean in the real world? If the wind or a current is not stirring up the water in a lake or pond, there will be a good deal more oxygen in the surface water than in the water at the bottom if bottom-dwelling organisms are actively using oxygen.

ACTIVITY 7 Name Possible answers

OXYGEN FOR LIFE

What did you observe happen as the plastic cup of cold water warmed to room temperature?

Little bubbles appeared on the sides of the cup.

Record the results of your group's dissolved oxygen test here.

Amount of dissolved oxygen in the water when the jar was first opened:
2.2 ppm (parts per million)

Amount of dissolved oxygen in the water after it was exposed to the air:
5.6 ppm

How much change in dissolved oxygen did you measure in your water sample?

5.6 − 2.2 ppm = 3.4 ppm dissolved oxygen; an increase.

2.2
1.8
2.4
2.0
1.6
10.0

5/10 = 2
5/26.8 = 5.3

Record the results for the class on this table:

group number

	1	2	3	4	5	6	average
dissolved oxygen in newly opened jar in ppm	2.2	1.8	2.4	2.0	1.6		2
dissolved oxygen in water exposed to air in ppm	5.6	4.8	5.4	5.2	5.8		5.3

5.6
4.8
5.4
5.2
5.8
26.8

5.3
−2
3.3

average difference 3.3 ppm

How can you explain the difference in dissolved oxygen in the two samples?

When we shook the jar, oxygen from the air must have gotten into the water.

ACTIVITY 8

DIRTY WATER

WHAT HAPPENS WHEN SOIL WASHES FROM THE LAND AND ENTERS AQUATIC HABITATS?

SCIENCE SKILLS:

- observing
- inferring
- experimenting
- communicating

CONCEPTS:

- Plant nutrients from soil dissolve in water.
- Plant nutrients increase the growth of algae in aquatic habitats.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of a camera

SAMPLE OBJECTIVES:

- Students will be able to compare the results of soil erosion and nutrient enrichment on aquatic systems.
- Students will be able to describe the effects of soil erosion on aquatic habitats.

INTRODUCTION:

This activity will take several weeks to complete. Model "ponds" in clear jars reveal what happens when soil ERODES from land and washes into an aquatic habitat. The NUTRIENTS from the soil over-fertilize the pond, causing abnormal growth of ALGAE. Data collection is difficult due to subjective evaluation. The use of a camera to record changes simplifies this problem. To be scientifically correct, each test should be done twice to insure that the results can be repeated. If possible, double the materials and do two replicates of each treatment group.

MATERIALS:

- five clear containers one quart or more (plastic soft drink bottles or canning jars)
- water with algae from a freshwater classroom aquarium or a pond. may also be purchased pond water from a biological supply company
- soil from a yard or flower bed or garden, or potting soil
- cloth to filter soil from water; old sheeting is okay
- plant fertilizer such as Peters or other well-balanced mix (some have green dye that goes away when exposed to light)
- aged tap water
- good light source, either indirect sun light or strong artifical light
- camera and roll of 12 exposure print film (35mm or Polaroid best)

LESSON PLAN:

BEFORE CLASS:

After reading this exercise, consider starting this exercise and Activity 9 at the same time if you have sufficient containers. Otherwise, start Activity 9 after completing this one if the same containers must be used again.

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Do these preparations before class. Mix two cups of soil with a quart of water and shake vigorously. Let the mix sit until the dirt settles and then strain the water through cloth into another container. Collect the algae-pond water sample or order a sample. In northern climates you will have trouble finding good natural samples during cold months.

DURING CLASS:

METHODS: Ask if the students have ever seen a creek, pond or river after a very hard rain. Is the water a different color? Why? The rain running over the surface of the soil has picked up soil particles and carried them into the water. Can the students identify human activities that increase this process called EROSION? Housing developments, newly logged forests plowed fields, and tire tracks from recreational vehicles all destroy vegetation and leave soil vulnerable to erosion. Plants help hold the soil in place.

What is the immediate effect of erosion? Have students help you with these preparations. Add soil to water in one of the jars and shake. The water becomes TURBID as the soil particles become suspended. What are the short term consequences of soil erosion? Would animals and plants be affected by sediment in the water? Plants would have light blocked. Animals might have their gills clogged. Put this jar aside for future observation.

What does the soil do to the bodies of water it enters? How would we do a test to find out? Label the remaining four jars tap water (your control), 1 tsp fertilizer, 1 tbsp fertilizer and soil. Fill three jars with aged tap water and the fourth (soil) with the water you prepared at home. (Explain that this water was prepared in the same manner as the shaken soil and water demonstration.) Add the correct plant fertilizer to two jars. Now add aquarium water with algae or pond water with algae to each jar. Use equal amounts up to one cup in each. Why did one jar just get tap water? It is the CONTROL against which the other jars are measured. The control gets no treatment and differs by just one VARIABLE from each of the tests. Set all four jars where there is good light. Do not place them in a location that gets very cold. Observe them over the next several weeks to a month, recording changes two to three times each week by photographing the jars side-by-side in good light from close-up. Write the date on a piece of paper that shows in the photograph and make sure the labels show. Keep the plants in the same place in each picture.

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RESULTS:

What happened? The exact results will vary depending on your algal source and growing conditions. Arrange the photographs in order. Over the weeks, the jars with soil water and fertilizer should show a much more luxurious growth of algae than the plain tap water. Why? Plant growth was facilitated by something that stayed in the water as the soil particles settled out: PLANT NUTRIENTS which DISSOLVED in the water. Plant nutrients are chemicals that are in SOLUTION in the water. Was there a difference in the amount of growth with the two dosages of fertilizer? Compare all with the control.

CONCLUSIONS:

Soil erosion can cause serious problems in aquatic environments. What are some long term results that you observed? The plant growth in the container with soil was greater. It should have resembled that of the fertilized water. A little plant growth is good. Plant nutrients in natural systems come from the surrounding land. Too much plant growth can cause serious problems, however. Under over-fertilized conditions, the kinds of algae that grow may change to undesirable toxic or foul-smelling species. Also, when the algae die, the bacteria and fungi that feed on them may use up much of the oxygen in the system during decomposition.

USING YOUR CLASSROOM AQUARIUM:

Compare your classroom aquarium with these small environments. How are they the same? Different? Where do the nutrients that support algal growth on the walls of your aquarium come from? The waste products from fish urine and feces. Think about what is used as fertilizer in organic gardens. Animal manures. Where did the animals get the nutrients in the wastes. From the food they ate which directly or indirectly came from plants. Nutrients CYCLE between plants and animals.

EXTENSIONS:

1. Study the label of the plant fertilizer container to discover what some plant nutrients are. Students should find compounds containing nitrogen, phosphate and potassium, three primary plant nutrients. Many brands have a number of other chemicals as well.

2. Can you identify a problem with soil erosion in your area that affects aquatic environments? If you cannot, you might call your local soil conservation district and ask about a local problem that your class might study. Sediment from farms and development contributes to the problems of the Chesapeake Bay. Erosion from logging smothers fish eggs in Pacific Northwest streams. Midwest farms are losing soil at an alarming rate

3. *Conserving Soil* is an excellent book with classroom activities ready for duplication.
To inquire about getting a copy, contact:

National Association of Conservation Districts
P.O. Box 8855
League City, TX 77573

It was first published by the U.S. Department of Agriculture, which cares because soil that stays on farms keeps the farms fertile.

ACTIVITY 8

DIRTY WATER

Name Possible answers

Arrange all the pictures in order from the first date to the last. Study the changes you can observe with over time in each. Describe them here:

Tap water: The algae grew a little bit and got greener. There really was not very much change.

One teaspoon of fertilizer: At first this got greener than the control (tap water), but then it stayed the same.

One tablespoon of fertilizer: This just kept getting greener as the algae grew.

Water from soil: This grew best, but there must have been special things in the soil because it had some algae we didn't see in the others.

Which grew the most algae? one tablespoon (answers vary)

Which grew the least algae? tap water

One tablespoon is three times as much as one teaspoon. What was the result of one jar having three times as much fertilizer as another?

More fertilizer grows more plants. (If you used very strong fertitizer, the heavier dose may be toxic.)

Why did one jar get only tap water? It was the control. We had to have something to compare the others to.)

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ACTIVITY 9

WHAT'S IN THE WATER?

WHAT IS WATER POLLUTION? WHAT ARE THE EFFECTS OF SEVERAL KINDS OF WATER POLLUTION ON SOME AQUATIC ORGANISMS?

SCIENCE SKILLS:
- classifying
- observing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:
- There are many different forms of water pollution.
- Human activities are a primary cause of water pollution.
- Some forms of pollution have a definite point at which they enter the water, while others do not.
- Water pollution can affect plants and animals and humans.

MATH AND MECHANICAL SKILLS PRACTICED:
- use of a camera

SAMPLE OBJECTIVES:
- Students will be able to test the effects of several common household chemicals that frequently find their way into aquatic environments.
- Students will be able to classify pollution sources.

INTRODUCTION:

This exercise, like Activity 8, is spread out over about one month. It takes a simplistic look at the effects water pollution has on aquatic systems. Use several household chemicals that are safe and that students pour down the drain without thinking. The results vary with your choice of materials. Students enjoy checking daily for changes. Like Activity 8, to be scientifically correct you should do two of each test if you possibly can which would double the number of jars needed.

MATERIALS:

TWO WEEKS BEFORE CLASS:
- four clear containers one quart or more (plastic soft drink bottles or canning jars)
- water with algae from a freshwater classroom aquarium or a pond, or purchased pond water from a biological supply company
- plant fertilizer such as Peters or other well-balanced mix (the dye in most of these will fade when exposed to light)
- aged tap water
- good light source, either indirect sunlight or strong artificial light

FOR CLASS:
- "pollutants" of choice by students; the safest to handle might include detergent (not green), motor oil, vinegar
- camera and roll of 12 exposure print film (35mm or Polaroid best)

INFORMATION:

Detailed information on water pollution is in the Information for Teachers section.

LESSON PLAN:

BEFORE CLASS:

Set up the bottles or jars at least two weeks before the experiment begins. Fill the jars with aged tap water. Add one teaspoon of plant fertilizer to each jar and stir it thoroughly. The plants need some nutrients to grow. Nutrients are found in all natural systems. (Add to as much pond water as you can.) Try a bit of soil from the bottom of a pond or gravel from your aquarium tank along with the water. Put the jars near a window where they will get good indirect light or give them strong incandescent or fluorescent light. Do not place them in a location that gets very cold.

When pollutants are selected, be careful to consider safety. Animal products of any kind could grow dangerous bacteria. Do not cover jars tightly as you might grow some undesirable bacteria this way. Regular household items should do fine. Vinegar is an acid which acts as acid rain or an acid discharge such as the "pickling liquor" from steel production or the run-off of acid from strip mines. Detergent is a common component of human sewage. Motor oil is commonly poured down storm drains. Regardless of what you use, make all your observations without coming into contact with the water and dispose of the material carefully after the experiment is over.

DURING THE LESSON:

METHODS: Start with a classification exercise on the blackboard, explaining that you want the students to see if they can organize what they already know about water pollution. Explain that some water pollution comes from specific sources such as outfalls (and is called POINT SOURCE pollution) while other kinds come from many widespread sources (called NON-POINT SOURCE pollution). Write those words at the head of two columns and have the students begin to suggest things that pollute water. Put them in the general categories found in the chart given in the Information for Teachers section. Students will not name everything in the list.

Explain that they are going to test some pollutants on model water environments. Would it be acceptable to test them by dumping them in a natural environment? No. Models are used for tests to avoid damaging the natural world. Show the students the jars with algae growing in them. Now what does the class choose to test for its effect on an artifical water environment? Let them decide with guidance. For example, if a child wants to test the effect of a dangerous compound, try to discuss why that might not be safe in the classroom environment. Settle on three pollutants. The fourth set of jars are CONTROLS.

When the class has decided what to test, you may have to wait until the following day to add the material, since it might have to come from home. Add a reasonable amount: two tablespoons of a strong detergent; enough motor oil to just cover the surface; 1/4-1/2 cup of vinegar. Leave the jars or tanks in the light as before. Have the children write their predictions for what will happen to each test container. Two or three times each week for several weeks photograph the jars with labels and a date showing.

RESULTS:

These depend on what you used. A few kinds of pollutants favor plant growth and will cause an algal population explosion. This is not healthy as it disrupts the balance of organisms. When the algae die, the oxygen is used as they decompose. Other pollutants, such as acids, will cause very clear water because they kill everything in it. Needless to say, they are not good for natural systems either. The sample with an oil spill may do better than you expect. If the algae have enough sunlight, they may make enough oxygen to keep things alive below the oxygen impervious oil layer.

CONCLUSIONS:

Human activities which result in water pollution can affect water environments in ways that are very bad for natural communities.

USING YOUR CLASSROOM AQUARIUM:

Does your classroom aquarium grow lots of algae? If you feed fish, they will produce waste products which are very much like fertilizer. Have your students discuss the procedures you use to avoid water pollution in your classroom aquarium. You are careful not to overfeed the fish, you remove algae from the sides of the tank and do water changes which reduce the level of waste products.

EXTENSIONS:

1. There are a number of social studies activities related to this experiment. Who regulates water pollution in your city, county or state? What are the federal regulations on water quality? What is the impact of these regulations on industries? What are the greatest water quality problems in your local area? How do they affect the jobs and health of people living in your area? The natural environment in your area? Have students research these topics.

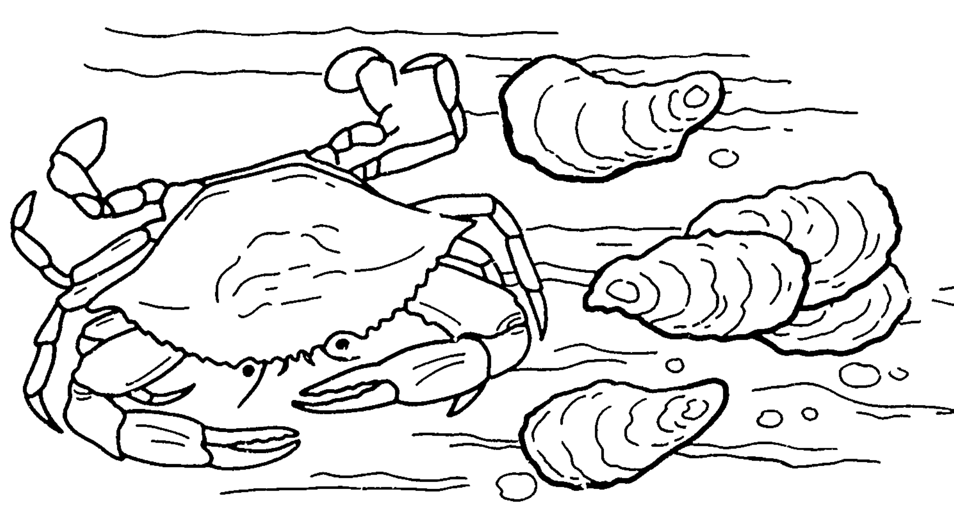
2. Can any of the polluted systems be reversed and improved?

a. Countries such as Sweden have added lime to their acid lakes in an attempt to correct the acidic condition. Your students could use baking soda to turn their acid test back into a neutral environment. Use litmus paper to test for neutrality. Add new algae and see what happens.

b. Oil spills may be mopped up with straw, feathers or cotton. Can they skim the oil off of their samples and let the oxygen get through again?

3. If you live in the Chesapeake Bay region, write these folks for booklets that tell what ordinary people can do to reduce water pollution in the Bay:

Alliance for the Chesapeake
6600 York Road
Baltimore, Maryland 21212



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ACTIVITY 9
WHAT'S IN THE WATER?

Name Possible answers

Arrange all the pictures in order from the first date to the last. Study the changes you can observe over time in each. Write in the pollutant used in each and describe the changes:

Tap water: This jar grew more green, but not very much. It changed just a little bit. The green was algae.

Vinegar (acid): Everything in this jar died right away, and the water became very clear. It looked clean, but nothing could grow in it.

Dish detergent: I thought this would kill everything but instead the algae grew a little bit. Another group used more, and their pond water died.

Salad oil: The pond water stayed green which was a big surprise. How can they live without air?

Which pollutant had the greatest effect? vinegar-acid like acid rain

Which pollutant had the least effect? salad oil

Were you surprised at the results? How did they compare with your predictions?

Salad oil did not kill everything. Another group used motor oil, and it did kill the pond water plants and animals.

Why did one jar get only tap water? It was the control against which the others could be compared.

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SECTION II
TEMPERATURE CHANGES IN AQUATIC HABITATS

TEACHER'S INFORMATION

Different substances change temperatures at different RATES even when they are placed in the same conditions because different materials have different SPECIFIC HEATS. The *same* amount of heat added to different substances with the same initial temperature will result in different final temperatures. Water has a very high specific heat. It absorbs a great deal of heat before its temperature rises much. Likewise, water cools very slowly and gives off a great deal of heat when it cools. Consequently, aquatic environments do not change temperature very fast and they change much slower than land habitats. Water is a stable place to live with regard to temperature. The larger the body of water, the more stable.

One consequence of the high specific heat of water is that land masses next to large bodies of water have more moderate climates than those at the same latitude and altitude farther away from water. The water gives off heat during periods when the land is colder and absorbs heat when the land mass is warmer, thus buffering the temperature of the land. You can see this effect by looking up the planting diagram for trees and shrubs given in seed catalogs or in garden books. There are warm bands that extend up both coasts, especially the east coast with its Gulf Stream current that carries warm water up from the tropics to the northern Atlantic Ocean.

Temperature affects the density of water. Differences in density may result in thermal STRATIFICATION in many bodies of water, with warmer surface waters floating on more dense, colder bottom water. The area of the water where cold and warm water meet is called the THERMOCLINE. It is the region at which the temperature changes rapidly. When stratification is caused by salinity differences, the point at which the saltier water meets the fresh water floating on it is called the HALOCLINE.

Fresh water is most dense, or heaviest, at 4°C (39°F). Water colder or warmer than 4°C floats on the 4°C water. Because of this, ice forms at the surface of a lake or pond which may remain unfrozen at the bottom during winter, providing a place for animals to live. The ice may prevent oxygen from entering the water, however.

These density differences also affect the distribution of nutrients and oxygen in water environments. Cold bottom water is frequently nutrient-rich because things that die sink to the bottom and are decomposed there, releasing nutrients like nitrogen and phosphate to the water. The act of decomposition may also deplete bottom water of oxygen. Wind and currents or upwellings may help to mix bottom water with surface water. Bottom water may also reach the surface as surface water cools in fall and its density becomes greater than that of the bottom water. When this happens, surface water sinks and displaces bottom water in a process called TURNOVER. Turnover is often followed by a rapid increase in algal growth as the needed nutrients have been delivered to the surface where algae are doing PHOTOSYNTHESIS.

Water temperature has a direct effect on the plants and animals living there. Plants and most animals are said to be cold-blooded or ECTOTHERMIC, meaning that their temperature is determined by the environment. Their respiration rates may change with temperature. Thus, their rates of oxygen usage are dependent on their temperature. They use less oxygen when it is cold and more when it is warm because respiration, which is a chemical reaction, goes faster at a warm temperature than a cold one. The increased rates of respiration in warm weather may allow greater activity. Most aquatic organisms are ectothermic.

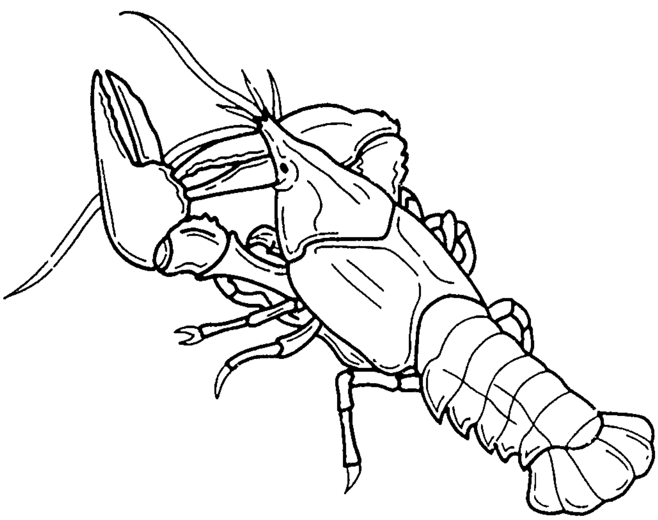
Birds, mammals and special members of some other groups are said to be warm-blooded or ENDOTHERMIC. They maintain a constant internal temperature or at least maintain an internal temperature above that of the environment in a cold environment. This constant, warm temperature means that respiration can take place in their cells at the same rate whether it is warm or cold outside. In this case, their oxygen use is greatest in very cold or very hot environments in which they have to do increased respiration to regulate their temperature.

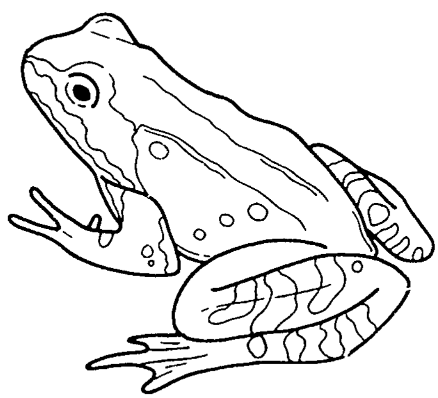
Many ectothermic plants and animals can change their respiration rates over time to be most efficient at the temperature at which they are held. They ACCLIMATE to a specific temperature. The plants you use may be acclimated at a high or low temperature. This will not negate your results, but may account for high respiration rates at low temperatures if your plants have been living in the cold for a long time and are acclimated to the cold.

Animals that live in deep water in the ocean or near the poles experience such constant water temperatures that they are ADAPTED to these temperatures completely and may be killed by a rise of a very few degrees. On the other hand, plants and animals living in smaller bodies of water or in shallow water near shore in larger ones where greater temperature changes are common are generally adapted to seasonal changes in temperature.

RESPIRATION generally requires oxygen. Some kinds of animals are well adapted to low oxygen environments such as mud. Worms that live in mud or turtles that bury themselves in the mud over the winter have special ways of dealing with low oxygen. The worms have blood pigments (like hemoglobin in humans) that are very efficient at picking up what oxygen is available. The turtles go into a special state in which they use very little oxygen. They may even make cellular energy without using oxygen, a process referred to as ANAEROBIC RESPIRATION.

Most water animals, however, depend on a good supply of oxygen from their environment. When it is not available, they may have several options. They may increase the rate at which water passes over their gills. This is like breathing faster when you run because you are using oxygen faster. It is called increased VENTILATION. Another tactic is to move to a better location. In really low oxygen situations, animals like crabs and eels will even crawl out of the water.





Under natural circumstances animals generally are not exposed to great oxygen stress to which they are not adapted. Occasionally, unusual environmental conditions like prolonged high temperatures may cause abnormally low oxygen in some water habitats. A small pond on a very hot day or night might have low oxygen levels due to heated water and high biological activity (respiration). Frequently, low oxygen levels are caused by human activities. Heating water (thermal pollution) lowers the oxygen it holds. Humans also cause low oxygen in aquatic environments by adding material to the water which will be decayed or decomposed by bacteria. Sewage, plant and animal waste products from food processing plants, animal wastes from farms or feed lots, and organic waste from factories can all serve as food for bacteria living in the water. These bacteria use a great deal of oxygen in respiration as they decompose the wastes. When the problem is compounded by hot water due to climate or thermal pollution, animals that live in the water may die.

Temperature changes are a result of seasonal changes. Another seasonal phenomenon is the migration of many species for reproduction or feeding which is keyed to these temperature changes. Humpback whales migrate from warm tropical waters where they calve in the winter to colder temperate waters where food is abundant during the spring, summer and fall.

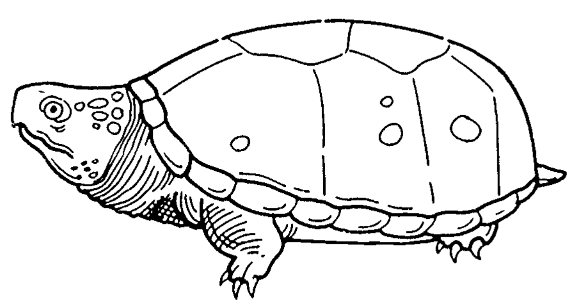
Many fish species migrate seasonally for the purpose of SPAWNING (laying eggs which get fertilized). Most are fish that live as adults in the oceans, but enter estuaries and spawn in the estuary or in its rivers. These fish are called ANADROMOUS (from the Greek for running upward). Familiar anadromous fish include salmon, herring, shad, and striped bass. There are some fish species which do the reverse. They live in fresh water and migrate to salt water to reproduce. The American and European eels are the best known members of this group called CATADROMOUS fish. Migrations are timed to take advantage of specific seasonal changes in water flow, salinity, water temperature and food availability.

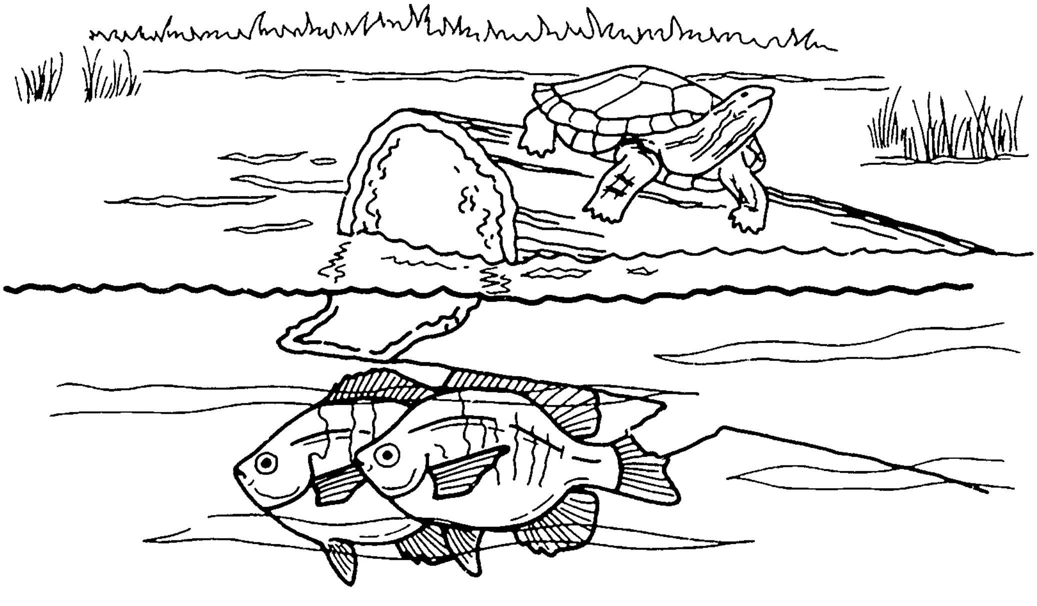
As with all species, the total possible number of offspring is much greater than the actual number in each generation because of predation, competition, variations in physical characteristics such as temperature or rain fall and other causes. In the case of some species, the difference between possible and actual is huge.

In the simulation game about seasonal migration in this section, herring are used as an example of an anadromous fish. Herring occur throughout the northern hemisphere. The herring family includes members which use a complete variety of reproductive strategies. Some species live and spawn at sea. Others may spawn at sea and mature and feed in estuaries (menhaden of eastern U. S. coast) or spawn in freshwater tributaries and migrate to the ocean as adults. It is these last, the anadromous herring of the eastern United States which are used in the game. Blueback herring are also called glut herring for the huge numbers which once glutted the streams each spring. Prior to the coming of Europeans, these fish existed in incredible numbers. They have been greatly reduced by human actions.

Another anadromous fish, the striped bass, is one of the most prized sportfish on the East Coast. Adult bass in the Chesapeake Bay region spend their winters in deep water in the mid or lower Bay. Since this is a stratified estuary, the deeper water is saltier. It also has more constant temperatures. Larger adults migrate out into the Atlantic Ocean as far north as Nova Scotia during the winter and early spring. Come late spring (April–June) the adult fish move up the Chesapeake Bay into its tributaries to tidal freshwater areas or only slightly brackish waters to spawn. Strong river flow is important to keep the eggs afloat. During the summer season, some striped bass remain in the tributaries, but many move great distances to feed. After the eggs hatch, the larvae migrate downstream as they feed and grow. By winter they join the older fish in deeper water. It appears that these fish, like other anadromous fish, return to spawn in the tributary in which they were born each year. If all the fish from one river are killed, that tributary will not have striped bass again.

For reasons that are subject to debate and that include barriers to migration, water pollution, lack of larval food, acid rain, and overfishing among others, the striped bass populations of the Chesapeake Bay are in serious decline. Maryland has a ban on catching them and is trying to discover the reasons for and solutions to this decrease in numbers.





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ACTIVITY 10

A CHANGE IN THE WEATHER?

WHICH CHANGES TEMPERATURE FASTER: WATER OR AIR? DOES VOLUME MAKE A DIFFERENCE IN HOW FAST A BODY OF WATER CHANGES TEMPERATURE?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- experimenting
- communicating

CONCEPTS:

- Under the same conditions, water changes temperature more slowly than air.
- In terms of temperature, aquatic habitats are more stable than land habitats.
- The larger the volume of water, the slower it changes temperature.

MATH AND MECHANICAL SKILLS PRACTICED:

- reading thermometers
- averaging numbers
- graphing data

SAMPLE OBJECTIVES:
- Students will be able to read a thermometer.
- Students will be able to compare temperature changes in water and air.
- Students will be able to graphically display results.

INTRODUCTION:

This exercise ties into earth science in that much weather is dependent on the fact that water absorbs more heat than air for each degree of temperature change. Bodies of water therefore change temperature more slowly and have more stable temperatures than land. Lakes and oceans warm adjacent land in winter and cool it in summer.

This activity depends on having access to a cold place: a refrigerator, ice chest or outside on a winter day. If you teach several sections of science, one class may start and others continue this project. Data analysis can be done on the following day. During test teaching, students reported liking to share a project with other classes.

Data manipulation will take several class periods if the students have not done averaging and graphing before. This is a good project to practice these skills because they will generate lots of numbers.

MATERIALS:

FOR CLASS:

- a cold (33-40° F) place—a refrigerator or ice chest

FOR EACH GROUP:

- 3 clear containers (two of same size and one four times as big) of the same material such as two pint bottles and a 2 liter plastic soft drink bottle or fruit jars
- lids or aluminum foil to cover tops of containers
- 3 safe, breakproof thermometers (see Recipes for sources)
- water

LESSON PLAN:

BEFORE CLASS:

In selecting containers, you may have to cheat and mix glass and plastic. Children should not try to handle large glass containers of water. In the interest of safety, you may have to accept a variable that is not controlled. Use containers that allow data collection without opening the jars. Modify the top of plastic containers to accept the thermometers. The thermometers need to fit inside, but may stick out through holes in the lids if necessary. Use cheap, small thermometers that are hard to break, not the long "scientific" glass ones. They should not break if dropped, nor should they contain mercury.

Have the students practice reading the thermometers the day before the experiment. Use tap water of several temperatures for practice.

Fill one of the smaller containers and the larger container with room temperature water, leaving a space at the top in case it freezes. Leave the third container filled with air. Add thermometers to each and record the time and temperature for each. Put lids on loosely or cover top with foil. Put them in a cold location: a refrigerator, outside on a cold day, in an ice chest. Leave in cold place overnight or until temperature near freezing is reached.

DURING CLASS:

METHODS: Introduce the exercise by asking the students which they think would be warmer on a hot day, a fish living in a big lake or a turtle sitting on a log next to the lake? How about in the dead of winter when snow is piled up, would it be colder to be under the ice in the pond or sitting on its shore? Generally, the temperature is more moderate in water than on land. Have they ever thought about why the climate is more moderate under water? Try a test to find out.

Remove the jars of cold water and air and place on desks where students can read the thermometers. Periodically record time and temperature in each (about every 5-10 minutes).

Students can calculate rates of change for each sample by:

- total temp. change (difference from start to finish) divided by
- total elapsed time (minutes or hours the experiment ran)

RESULTS:

The large body of water should change more slowly than the smaller one. Water should change more slowly than air. If you used small jars with lots of surface area, the water may not seem much different from air.

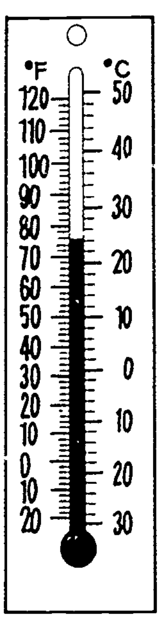
CONCLUSIONS:

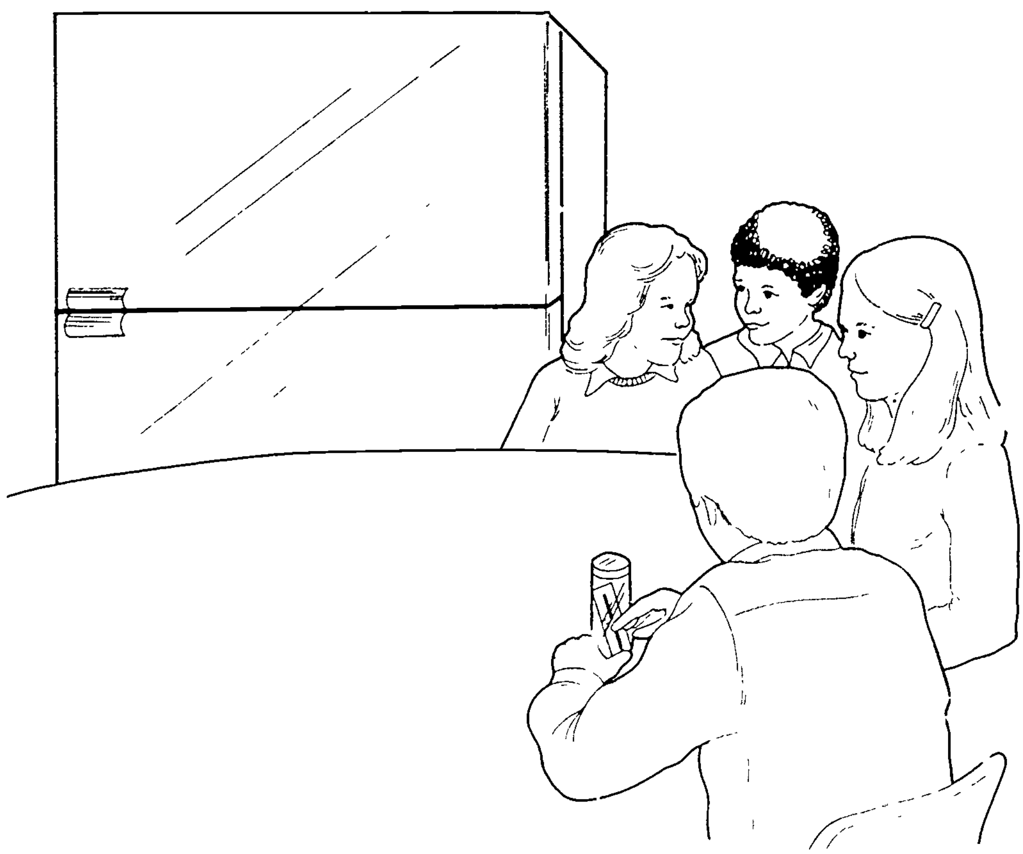
What would this mean for you if you lived in water? In air? Generally, animals and plants living in water are subjected to temperature changes that are not as radical as those that land-living organisms face.

If an animal needs to stay at nearly the same temperature all year, would it prefer to spend the winter and the summer in a big b ,dy of water or a little pond? The bigger the body of water, the smaller the changes with season. Can you make any generalizations about the relative seasonal temperature changes likely to be found in a pond, a lake, the ocean. Small ponds show greater changes in temperature with the seasons. Lakes show less, and oceans even less. But even oceans, at least at the surface, have temperature changes.

USING YOUR CLASSROOM AQUARIUM:

If your classroom experiences temperature changes during the night or over the weekend and you do not have a heater in your aquarium, have your students keep a log of the temperature changes that occur in the aquarium during the day from the time they arrive until they leave. Does it change temperature much during the day? If you have a maximum/minimum thermometer, leave it out at night or over the weekend to see how cold the room gets then. Does the room's temperature change? Record these temperatures also. Graph the temperature changes of both room and aquarium on the same chart. Is the amplitude of the change greater in the aquarium or the room? How does this compare with your findings in this activity?





EXTENSION:

1. Repeat the experiment using an incandescent light as a heat source. Make sure the jars are not sealed so that the air has room to expand as it warms.

ACTIVITY 10
A CHANGE IN THE WEATHER?

Name Possible answers

What is the question that this experiment will answer?

Actually, we can answer two questions: which changes temperature faster - air or water and which changes temperature faster - a big body of water or a small one?

Record the TEMPERATURES for your group here:

time in minutes since starting

container	start	5	10	15	20	25	30	35	40	45	50
air	10°	14.5°	18°	22°	25°						
small water	10°	13°	15°	18°	20°						
large water	10°	11°	12°	14°	16°						

These temperature readings are in Farenheit ____
Centigrade ✓

Calculate the average temperature for all groups and record here:

time in minutes since starting

container	start	5	10	15	20	25	30	35	40	45	50
air	9.8	14.7	18.3	22.4	24.9						
small water	10.1	12.9	14.8	18.1	20.2						
large water	9.9	11.1	12.2	14.1	15.4						

These temperature readings are in Farenheit ____
Centigrade ✓

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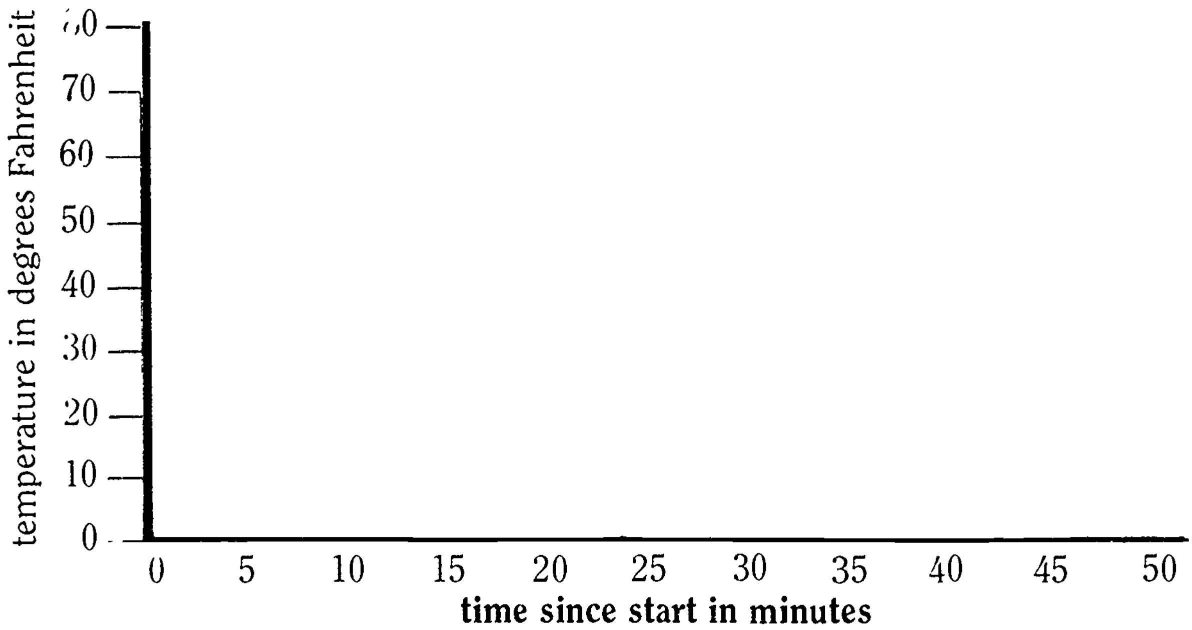
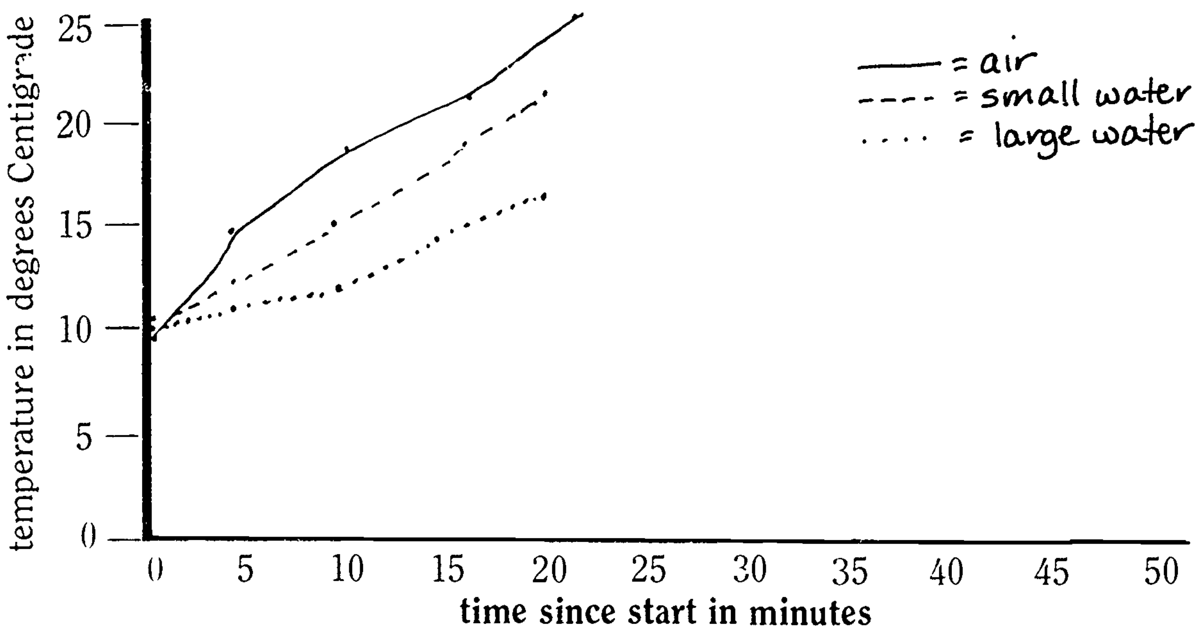
Graph the temperature changes with a line graph here for Farenheit scale:



Or graph here in Centigrade or Celsius scale:

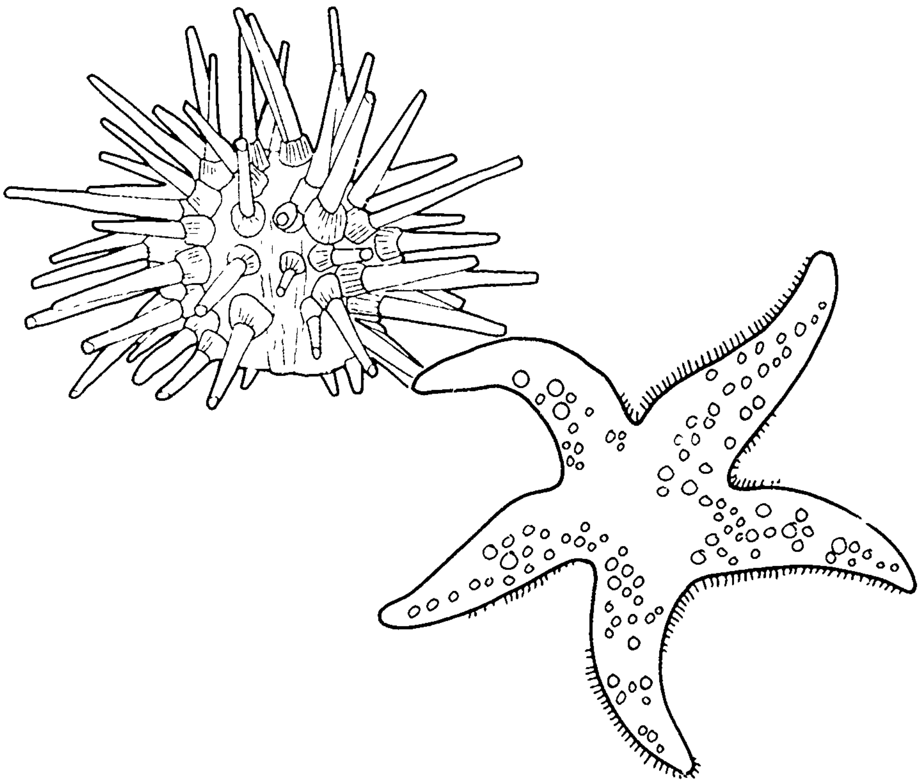


Which container changed temperature fastest? The container of air changed temperature fastest.

Which changed most slowly? The large water jar changed slowest

Based on your experiment, which of these would change temperatures through the seasons least? Most? Middle?

ocean least pond most lake middle



ACTIVITY 11

PLANTS USE OXYGEN?

DO THE PLANTS AND ANIMALS THAT LIVE IN WATER USE OXYGEN?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- communicating
- predicting
- experimenting

CONCEPTS:

- Animals and plants that live in water use oxygen from the water.
- Oxygen is used in a process called respiration.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of dissolved oxygen test kit
- averaging results
- weighing
- calculating rates

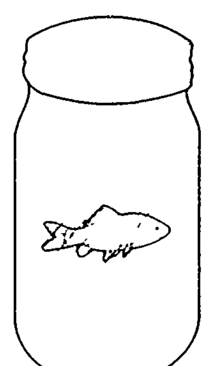
SAMPLE OBJECTIVE:
- Students will be able to give experimental evidence that plants and animals use oxygen.

INTRODUCTION:

This activity proves that both plants and animals use oxygen. Most people forget that plants constantly use oxygen in RESPIRATION because they think only about the daytime when plants are doing enough PHOTOSYNTHESIS that they produce more oxygen than they use. Plants do respiration *all the time,* not just at night, but have to be tested in the dark to remove the complication of photosynthesis.

This exercise will work fine with plants alone. Animals may also be used. Those in your classroom aquarium are ideal. It is most interesting when several kinds of animals are compared. At least two groups should do each experiment to be able to check for consistent results.

This activity begins one day and is completed on the following day. The materials used in this exercise are the same as Activity 12 and the two may be done at the same time, although results should be interpreted separately.



MATERIALS:

FOR EACH GROUP (MINIMUM OF TWO GROUPS):

- two quart or pint glass jars with wide screw tops; must all be the same size to compare results
- one big bunch of freshwater plants (*Elodea* is the kind most commonly available from biological supply houses and pet shops); need six 6 inch strands per quart aged tap water at room temperature
- brown paper grocery bag or dark place

SHARED BY CLASS:

- dissolved oxygen test kits
- turkey baster or large syringe (see Recipes)

OPTIONAL FOR EACH GROUP:

- 1 quart glass jar with top
- 1 guppy or goldfish less than 1 inch long or 1-2 dozen freshwater snails or a small crayfish (from pet shop, biological supply house or bait store)
- 250 gm spring scale or triple beam balance
- mineral or cooking oil

INFORMATION:

Plants and animals both use oxygen in a process called RESPIRATION which takes place in the cells of organisms. Respiration is not breathing in and out; it is a cellular process. Like all cellular processes, the rate at which respiration happens is dependent on temperature so be careful that the temperature is the same for all the test containers. Use room temperature.

LESSON PLAN:

BEFORE CLASS:

Set out jars with water to age two days ahead of time. Read through the lesson and decide what and how much will be used. Students will set the plant experiment up one day and finish it the next. The plant experiment can be completed in one class period. The animal experiment runs longer than one 45 minute class. If you have the same students all day, it can be completed by one group. Otherwise, start it in one class and finish it in others.

DURING CLASS:

METHODS (PLANTS): Do plants use oxygen? Many students will answer no. Do not tell them they are wrong. Ask them to design an experiment that will test this question. Show them the jars and plants. They already know how to use the dissolved oxygen test kits.

Here is one way to test this question: test the dissolved oxygen in a jar that has been standing open. Refill to the brim with aged tap water, place a lid on the jar and label it as the control. Since all the jars have been treated in the same way, you may assume the dissolved oxygen is the same in all. To the second jar, add the bunch of *Elodea*. Use about 6 strands 6 inches long per quart, or half that amount per pint. Each jar should be full to the top. Screw the caps on tightly.

Place both jars in a dark location at room temperature (around 70-75° F or 25° C) overnight. The plants must not be in the light. Put them in a cupboard, closet, or grocery bag. If you do this in winter and your school turns the heat way down at night, you might not get very good results as cold temperatures slow the chemical reactions of respiration.

Ask the class to predict which jar will have the most oxygen. The least. Do they have reasons for their predictions? The next day test the water from each of the jars using dissolved oxygen test kits.

RESULTS:

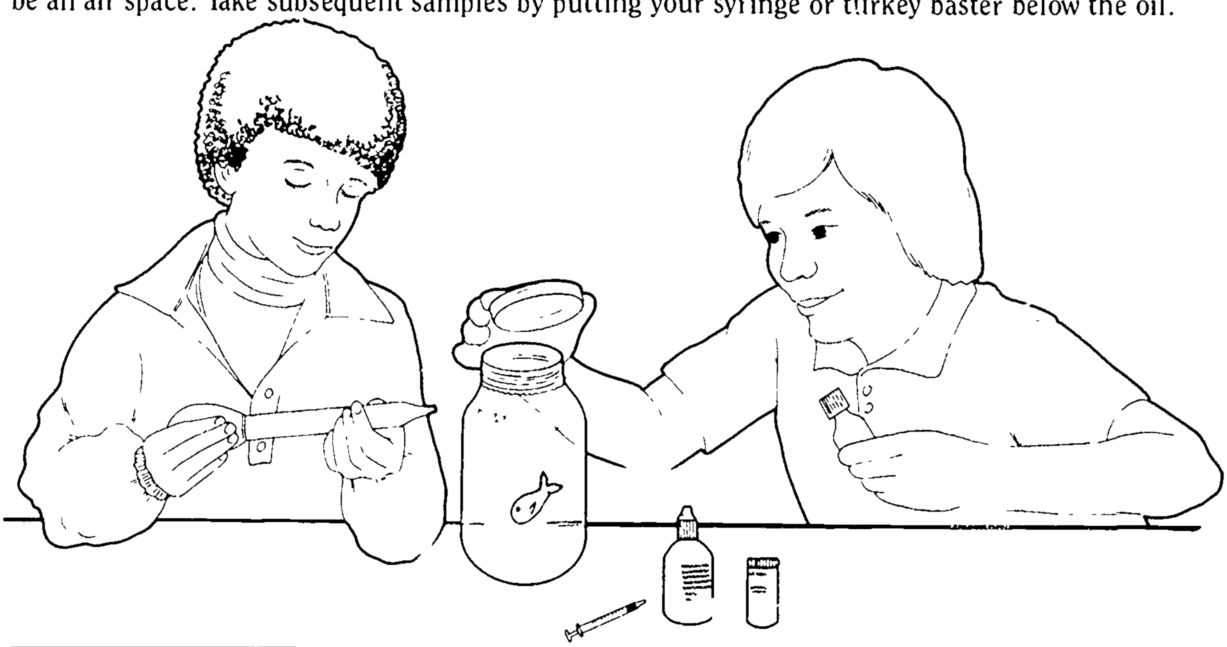
Did the results match the predictions? Since all the jars were treated the same before the plants were added, they should have started with the same dissolved oxygen levels. If you want to be sure of this, you could have tested them before the plants were added. You should find that the jars with nothing (controls) have the most oxygen and that the levels are lower in the jars with plants. Four jars averaged 0.8 ppm after sitting overnight in an experiment done by children at the Aquarium.

METHODS (ANIMALS):

During the second day of class use the third jar to test animal use of oxygen. Make sure that you handle the animals very carefully and do not use more of them or different kinds than are recommended. Fish may be transferred in an aquarium net or small plastic bags with water. Do not handle the animals.

Since this jar has been sitting open, you may assume the same starting dissolved oxygen as for the control the previous day. Gently place the animal(s) in the jar. Do not use large animals. A small crayfish or fish should have a quart jar. Seal the jar and let it sit quietly for about one hour. Do not leave it where students are moving and do not let them tap on it or bother the animal.

After one hour test for dissolved oxygen. IF THE OXYGEN IS BELOW 4 PPM, STOP AT THIS POINT. A 20 gm crayfish in a one quart jar at room temperature will use enough oxygen to hit 4 ppm in one hour. Snails or small fish will not. If you want to continue the experiment, pour about 1/4 inch of oil on the surface of the water to seal it. You cannot just put the lid back on as there will be an air space. Take subsequent samples by putting your syringe or turkey baster below the oil.



RESULTS:

Animals also use oxygen. If you want to compare oxygen use among different species, including plants, you may do so on a weight basis. It is not entirely fair since weight does not take into account the inorganic fraction such as the exoskeleton of the crayfish. You are not about to do what an ecologist would do: cook the animals to inorganic ash to obtain ash free dry weights. Shake the plants, snails or crayfish to remove excess water before weighing. Weigh fish in a small bag of water and then weigh the water alone after straining the fish into a net and returning it to its aquarium.

CONCLUSIONS:

Students who have had lessons on photosynthesis may insist that plants make oxygen, not use it. This experiment should prove that both plants and animals do respiration and use oxygen from the water in which they live. Do the students think it is important to have good, high levels of dissolved oxygen for animal and plant health? Yes! Without oxygen, the plants and animals will die just as the students would die if deprived of oxygen, which is why we were careful to keep the animals above 4 ppm dissolved oxygen.

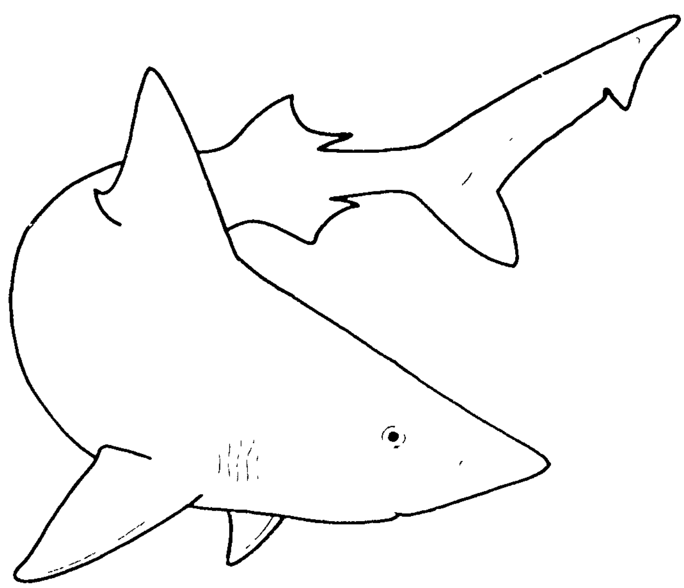
USING YOUR CLASSROOM AQUARIUM:

The plants and animals in this experiments come from a freshwater aquarium. With careful handling, they will go right back after the experience. Siphon the oil off the surface of the animals' jars before removing them. Following this exercise, discuss the means you use to make sure the oxygen levels remain high in your aquarium.

If you have a large number of plants in your aquarium, test the dissolved oxygen first thing and comp e it with later in the day after the plants have started doing photosynthesis as well as respiratic It should be lower early in the morning since both the plants and animals were using oxygen al night. Discuss hat might happen if the electricity went off during the night.

EXTENSION:

1. If you take a field trip to a pond with plants, follow the level of dissolved oxygen over a 24 hr period. You should see it go down at night and up in the day when plants are adding more oxygen than they use.



ACTIVITY 11
PLANTS USE OXYGEN?

Name *Possible answer*

PLANTS

What question are you going to answer by doing this experiment?

Do plants use oxygen when they are in the dark?

Record the results of your experiment here:

jars	dissolved oxygen in ppm		
	when plants are put in the jar	one day later	change with time
control	9.6	9.4	− 0.2
plants	9.6	[illegible].8	− 4.8

Record the class results here as change in dissolved oxygen in each jar. Write the numbers in parts per million (ppm).

	group number 1	2	3	4	5	6	average
control	−0.2	+ 0.4	−0.6	+0.2			-0.0
plants	−4.8	−4.2	− 5.4	− 5.0			-4.85

−0.2 +0.4
−0.6 +0.2
−0.8 +0.6
change is −0.2
.05
4 ⟌0.2

−4.8
−4.2
−5.4
−5.0
19.4
4.85
4 ⟌19.4
16
3.4
3.2
.20

Which changed more, the control or the plants? *the plants lost 4.85 ppm oxygen on average*

What conclusions about plants and dissolved oxygen can you make based on these results? *Plants that live in water use oxygen when they are kept in the dark.*

Note: Plants also use oxygen in the light but produce enough excess in photosynthesis to mask oxygen use.

AQUATIC ANIMALS AND OXYGEN

What kind of animal are you going to test? a crayfish

What question are you going to answer by doing this experiment?

How fast will a crayfish use oxygen from the water?

Record the results of your experiment here:

jars	dissolved oxygen in ppm		
	when animal is put in the jar	after 1 hour	after 2 hours
control	9.6	9.2	
animal(s)	9.4	4.4	

How much oxygen did your animal(s) use per hour? 5ppm/hr ppm per hr

How much did your animal(s) weigh? 21 grams

Divide oxygen used per hour by animals' weight 21) 5.00 = .24; 42; 80 — 0.24 ppm/gm

Now you can compare your results with those of other groups. Were your results the same as those of groups who had the same kind of animal(s)?

The crayfish both used about the same amount of oxygen on a per gram basis.

Can you make any comparisons about how much oxygen different kinds of animals use? Can you compare how much oxygen plants use with that of animals? To do this you will need to weigh the animals and plants so that you are comparing the same weights of crayfish to snails to plants.

The snails used less oxygen on a per gram basis. So did the plants.

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ACTIVITY 12

WHEN THE HEAT'S ON

WHAT IS THE EFFECT OF TEMPERATURE ON THE RATE AT WHICH "COLD-BLOODED" ORGANISMS THAT LIVE IN WATER USE OXYGEN?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- experimenting
- communicating

CONCEPTS:

- The temperature of the environment has a direct effect on the rate of oxygen use by "cold- blooded" living things.
- The warmer the environment is, the more oxygen "cold-blooded" organisms use.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of dissolved oxygen test kits
- use of a thermometer
- averaging numbers

SAMPLE OBJECTIVE:

- Students will be able to interpret experimental data about the effect of temperature on the rate at which plants use oxygen.

INTRODUCTION:

This experiment spans two days of class. It can easily be set up during the first and completed during the second. Data analysis may take additional class time.

This activity examines the relationship between temperature and dissolved oxygen usage (respiration rate) in "cold-blooded" organisms, which include plants as well as most animals except birds and mammals. If you have enough jars, this experiment can be done at the same time as Activity 11. All that is required is one more jar and set of pl[illegible] per group and a cold place to leave them overnight. These instructions are written as a sep[illegible] experiment.

MATERIALS:

FOR EACH GROUP (MINIMUM TWO GROUPS):

- two quart or pint glass jars with wide screw tops; must *all* be the same size to compare results
- one *big* bunch of freshwater plants (*Elodea* is the kind most commonly available from biological supply houses and pet shops); need six 6 inch strands per quart
- aged tap water at room temperature
- two brown paper grocery bags

SHARED BY CLASS:

- dissolved oxygen test kits
- turkey baster or large syringe (see Recipes)
- refrigerator or ice chest

LESSON PLAN:

BEFORE CLASS:

Set the water out ahead of time so that the chlorine will dissipate. When you use plants to test the effect of temperature on rates of oxygen usage, you avoid the possibility of hurting animals. The same kind of work could be done with any cold-blooded organisms living entirely in water, but aquatic animals may be very sensitive to temperature changes. Your results will depend to some extent on the temperature at which the plants have been maintained over the preceding weeks. They will be better if the plants have been in a warm (75° F) aquarium for several weeks. Also, make sure you use a yard of *Elodea* per quart.

DURING CLASS:

METHODS: Briefly review the results of the previous exercise in which students proved that things living in water used oxygen from the water. Do the students think that the temperature of the water might have an affect on how fast plants and animals use oxygen?

Have the students ever heard an animal referred to as cold-blooded? Warm-blooded? Have them write what they think these terms mean. There are some very strange misconceptions about these words. Discuss what they mean. Does a turtle sitting in the sun by a pond on a hot summer day really have cold blood? No, it might be very warm to the touch. It can be more active when warm. Can you name some animals that move slower when it is cold outside? Flies, crickets, frogs are possible answers. Introduce the term ectothermic which comes from roots that mean warmth from outside.

How about animals that move just as fast in winter as in summer, such as dogs, cats and birds? These animals are endothermic which means warmth from inside. They regulate their internal body temperature at the same level regardless of the cold or heat.

Plants are ectothermic too. Would cold-blooded be a good name for them? No, since they do not have blood. Their rate of oxygen use (which is a measure of respiration) is temperature dependent just like the rates of fish and frogs. Could we set up an experiment to test the effect of temperature on the rate that plants use oxygen?

This experiment is similar to Activity 11 in design. Set it up the first day. Test the dissolved oxygen in the aged water and record the amount. You should have at least four jars full of water. Two are controls and will have no plants. The other two will have aquatic plants. The hard part is to get similar amounts of plant material in each jar. If you use *Elodea,* measure them, putting the same total length in each jar. Seal the jars and put them in paper grocery bags for darkness. Pick two different temperatures. One of them might be in a refrigerator or in an ice chest or outside on a cold (but not freezing) night and the other at room temperature. Leave overnight. If your classroom is allowed to get very cold at night, put the room temperature jars in an ice chest with a gallon jug of very hot water when you leave.

The following class day, test the dissolved oxygen level in each jar. Record the temperature of the water in each jug after the oxygen sample is taken. Calculate the difference between the test and the control at each temperature:

control − test = oxygen used by the plants

RESULTS:

At which temperature was the most oxygen used? There should be a higher rate of use at higher temperatures. Why did we use a control at each temperature? Because temperature could have an effect on dissolved oxygen too, and we wanted to eliminate that as a cause of our results.

CONCLUSIONS:

Environmental temperatures have an effect on the rate at which ectothermic organisms use oxygen. Generally, the warmer the environment, the higher the oxygen usage.

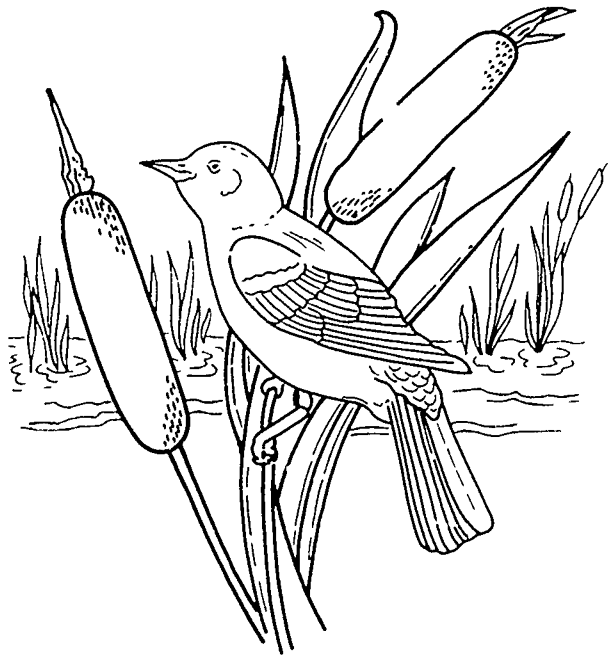
USING YOUR CLASSROOM AQUARIUM:

Add the *Elodea* to your aquarium.

Discuss with your students whether or not there are any warm-blooded animals in your aquarium. Can they name any warm-blooded animals that do live in fresh water? Beavers and river otters are two that come to mind.

EXTENSION:

1. Discuss the problems animals living in a small pond might have on a very hot day. In a crowded pond, they might exhaust the supply of oxygen. When would the problem be the worst? At the end of the night, because the plants would be using oxygen all night, but not making any with photosynthesis.



ACTIVITY 12
WHEN THE HEAT'S ON

Name Possible answers

Write what you think the word "cold-blooded" means: I think that this means that an animal has blood that is cold all the time just like I am warm all the time so I'm warm-blooded. But then how can plants be cold-blooded?

Note: You will get many such misconceptions here.

What question are you trying to answer by doing this experiment? Do plants use more or less oxygen when they are warm versus cold?

The original amount of dissolved oxygen in the water was 9.4 ppm
Record the results of your experiment here:

temperature	dissolved oxygen in ppm		
	beginning	after 24 hrs	difference
cold plants temp. 5°C	9.4	5.2	- 4.2
warm plants temp. 25°C	9.4	1.8	- 7.6

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Record the results for your class here:

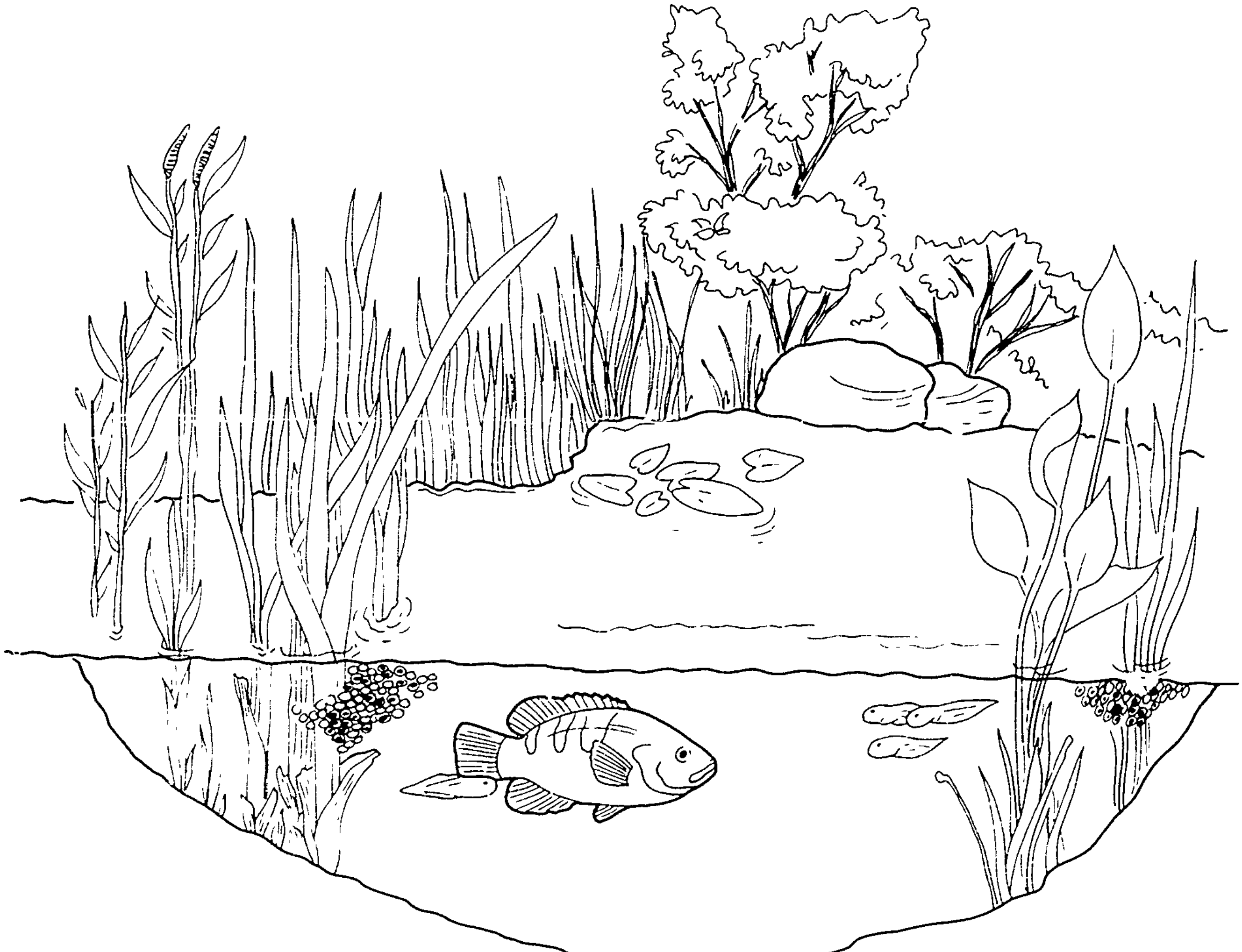
-0.2	-0.4
+0.4	-0.2
-0.2	+0.2
-0.2	-0.2
-0.2	-0.6
-4.2	-7.6
-4.6	-8.4
-5.0	-7.8
-4.4	-7.4
4⟌18.2	4⟌31.2
4.5	7.8

difference in dissolved oxygen in ppm

	1	2	3	4	5	6	average
cold plants	-4.2	-4.6	-5.0	-4.4			-4.5
warm plants	-7.6	-8.4	-7.8	-7.4			-7.8

Based on the class results, what conclusion can you draw about plants' use of oxygen in the dark as it relates to temperature? Higher temperatures Cause the plants to use more oxygen. Our teacher says plants are cold-blooded so higher temperatures may make cold-blooded organisms use more oxygen.

Why do you think you added all the class results together and took an average for your results? Because one group might make a mistake. Also, the same thing has to happen over and over before it can be taken as a fact.



ACTIVITY 13

WHEN THE OXYGEN GOES . . .

WHAT HAPPENS TO THE OXYGEN DISSOLVED IN WATER WHEN WATER TEMPERATURE INCREASES?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- experimenting
- communicating

CONCEPTS:

- Dissolved oxygen levels decrease as water temperature increases.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of dissolved oxygen test kit
- averaging
- graphing

SAMPLE OBJECTIVE:

- Students will complete an experiment to determine the relationship between water temperature and dissolved oxygen.

INTRODUCTION:

The relationship between water temperature and dissolved oxygen is critical for many aquatic animals. This exercise demonstrates that relationship. If you carefully prepare the samples, the students will get surprisingly good results.

MATERIALS:

SHARED BY CLASS:

- dissolved oxygen test kits
- turkey basters or large syringes (see Recipes)

MADE BY TEACHER AT HOME BEFORE CLASS DATE:

- four pint or quart canning jars or other jars that hold a set of four water samples sealed at temperatures indicated (see Recipes):
  - water open to air with ice in it or in a refrigerator (4° C) for 24 hrs
  - water at about 25° C (leave sitting open at room temp.) for 24 hrs
  - water heated to about 50° C (seal immediately after heating)
  - water boiled for 10 min and sealed immediately
- thermometer good to 100° C

LESSON PLAN:

BEFORE CLASS:

Read through the lesson. See Recipes for ways to expand your dissolved oxygen test kit potential. Check the chemicals in the test kit to make sure they are all there. Refill any materials that are low.

Prepare the water samples. The cold and room temperature samples should be left open at the indicated temperature for 24 hrs. Leave one sitting out in the classroom and another open in a refrigerator or ice chest. The "canned" heated samples may be prepared at home any time as they are good until opened. Heat the samples *slowly* and hold at the indicated temperature for 10 minutes. Pour the water gently into the jars and put on canning lids. If the water is sealed in canning jars, it can cool without picking up additional oxygen. Do not open until ready to take a sample.

DURING CLASS:

METHODS: Is there a relationship between dissolved oxygen in water and the temperature of the water? How could we find out? Can the students help you design a way to test this question? Explain how you have treated the water samples ahead of time and sealed those that were heated above room temperature. How would they put these to use? Divide into groups to share the work. If possible, test the water in each jar twice to check the results.

Test the oxygen levels in each water sample and record the results. Do not open until just before using it. Be especially careful not to transfer water vigorously as this will add oxygen to the sample. Let it flow down the side of the sample bottle from the turkey baster or large syringe. The sealed jars may require adult help to open them.

RESULTS:

The students should get very straightforward results: the higher water was heated, the less oxygen is present in solution in it.

CONCLUSIONS:

Cold water holds more dissolved oxygen than hot water. What is the consequence of this fact for the animals that live in warm water or in water that changes temperature? What happens to the dissolved oxygen in a shallow pond or marsh that heats up during a blistering hot summer day? Might this have consequences for the animals which must have oxygen for respiration during the heat of the day? Yes, in all these cases the animals may suffer from low oxygen availability. In very hot weather when bacteria that use oxygen are doing decomposition very rapidly, aquatic animals may die from lack oxygen.

USING YOU CLASSROOM AQUARIUM:

Have your students test the dissolved oxygen in the aquarium water. Record the temperature and the dissolved oxygen. Compare it to the results of this experiment. Does your aquarium have more or less oxygen than the water sample heated to the same temperature? It may have more if it is filled with plants that are doing PHOTOSYNTHESIS. It may have less if it is full of animals or bacteria using oxygen.

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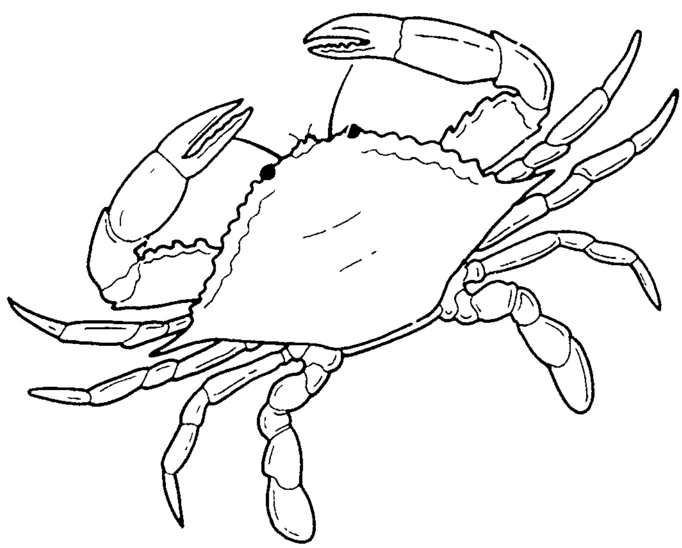
EXTENSION:

1. Can your students suggest human activities which might result in low dissolved oxygen due to water temperature increases? If electric power generating plants use natural bodies of water for cooling, could the heating of the natural water cause problems for the plants and animals that live in it? Thermal pollution can be a problem, especially on bodies of water that are relatively small such as rivers and lakes. Dissolved oxygen may get so low that animals die. Because of this, cooling towers which allow the heat to be lost to the air before the cooling water is returned to the river or lake are built next to the power plants. Sometimes special lakes are built which are used only for the power plant cooling.



ACTIVITY 13
WHEN THE OXYGEN GOES . . .

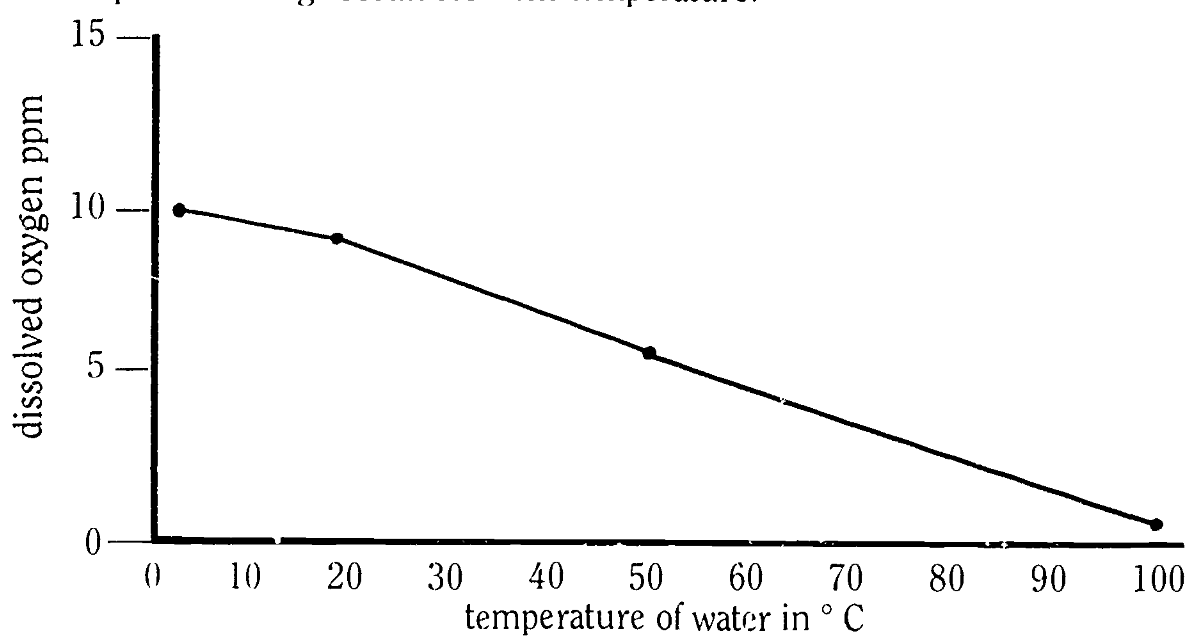
Name Possible answers

State the question you want to answer by doing this experiment. What happens to the dissolved oxygen in water when the water is heated.

Record the results from each group's tests:

temperature of water when sealed	dissolved oxygen in the water in parts per million		average
4°C	9.6	10.4	10 ppm
24°C	8.6	8.2	8.4ppm
50°C	5.6	5.2	5.4 ppm
100°C	1.8	0.8	1.3ppm

Graph the average result for each temperature:



What conclusion can you make based on the results of this experiment?

A water gets hot, it loses its dissolved oxygen.

ACTIVITY 14

WHEN THE OXYGEN IS GONE

HOW DO ANIMALS RESPOND TO LOW OXYGEN ENVIRONMENTS?

SCIENCE SKILLS:

- observing
- inferring
- communicating

CONCEPTS:

- Two possible animal responses to low oxygen environments are:
  1) increased movement of water over the gills
  2) moving to higher oxygen habitat.
- Animals experiencing low oxygen may be under stress.

MATH AND MECHANICAL SKILLS PRACTICED:

- averaging numbers

SAMPLE OBJECTIVES:

- Students will be able to list ways animals respond to low oxygen environments.

INTRODUCTION:

This activity demonstrates the responses of fish to exposure to low oxygen levels. It does not take long as the fish behave in obvious ways which are expressed promptly: they do not like doing without oxygen. Use fish from your aquarium if they are the correct kinds. Guppies and goldfish will not be hurt by this experiment if returned promptly to their aquarium home.

MATERIALS:

FOR EACH GROUP:

- 2 small (1 inch) guppies or goldfish (do not substitute other kinds of fish)
- 1 quart tap water briefly boiled and sealed in a wide mouth jar with no air space at the top; should be at room temperature
- 1 quart of aged tap water unsealed
- watch or clock that has seconds

LESSON PLAN:

BEFORE CLASS:

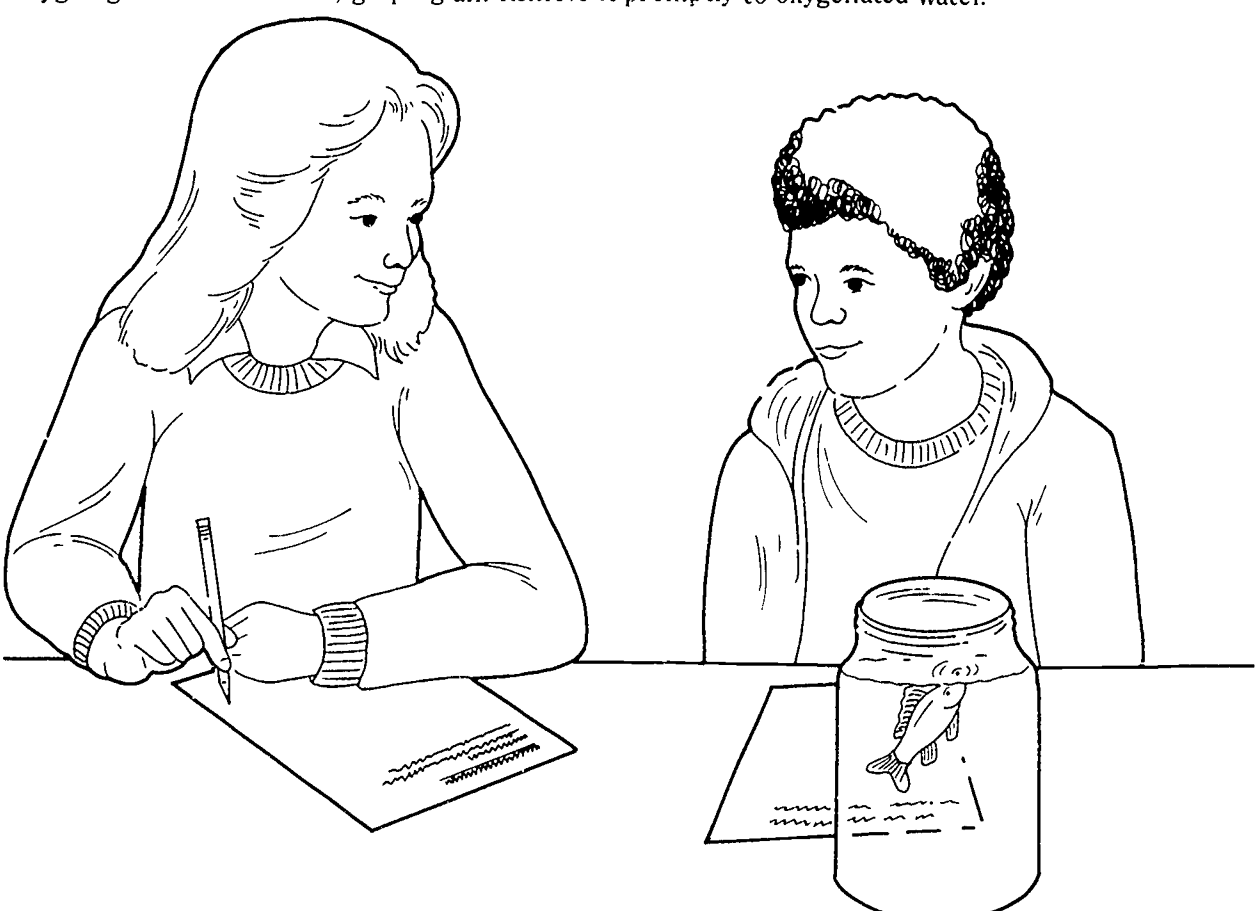
Make the boiled water at home. It should be at room temperature when used. Do not substitute fish species.

DURING CLASS:

METHODS: Most aquatic animals get oxygen from the water with GILLS. What would the students do if they were an aquatic animal that gets oxygen from their water environment and, suddenly, there was not enough? How might they test this question? One obvious way is to compare aquatic animals in low and normal oxygen environments and see what differences in behavior can be observed. How do we make water that is low in oxygen? Remember what they learned about water temperature and dissolved oxygen? Water that is heated has little dissolved oxygen so use boiled water that has been sealed in canning jars. Here are two tests they might do. With younger children, do only the second part.

1. Fill a jar with regular room temperature aged tap water and carefully place a fish in it. After one minute record the number of times it opens and closes its gill covers (opercula) and/or mouth in a minute. This is a way to measure how much water it is passing over its gills. Remove the fish and place it in a newly opened jar of room temperature boiled water. Watch it closely. Wait one minute and then count the number of times per minute that the fish opens its gill covers and record the results. If there is time, repeat this with a second fish. Do not leave the fish in the water lacking oxygen for more than 3 minutes.

2. Compare the behaviors of fish placed in water with dissolved oxygen and oxygen depleted water. Put them in at the same time and put the jars side-by-side to compare. Do they show the same responses? Where do they go in the jar? Is one more calm than the other? The fish without oxygen goes to the surface, gulping air. Remove it promptly to oxygenated water.



RESULTS:

Fish in low oxygen move water over their gills more rapidly than those in oxygenated water. If the water is very low in oxygen, the only response you may see is the oxygen deprived fish going to the surface and gulping. Goldfish can get oxygen from the air if their gills are wet.

CONCLUSIONS:

In these experiments you have looked at two ways animals respond to water which is low in oxygen. One way is to increase the rate at which water moves over the gills. If you have ever watched a crab or shrimp in a small container, you may have noticed increased movement of the water across its gills. This reflects increased ventilation, just as the fish increased movement of water by "swallowing" faster.

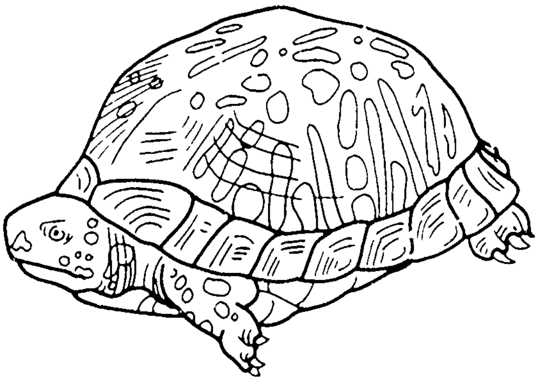
A second tactic is to move to an area of the water that has a higher oxygen concentration. Both responses use energy. Animals that can migrate within an environment are relatively lucky. Can your students name some animals that cannot move to an area with higher oxygen? Any aquatic animal that is sessile, that grows attached to a surface, cannot move. Oysters barnacles, mussels, worms that live in tubes . . . these are just a few. If they cannot move, they may die during periods of unusually low dissolved oxygen.

USING YOUR CLASSROOM AQUARIUM:

These fish can go in your aquarium. You can use fish from the aquarium with no ill effects if you use goldfish or guppies.

EXTENSION:

1. Can you identify a local problem caused by low oxygen? Have your students research this question by writing or calling one or more local organizations responsible for water quality. Try county government or a local conservation organization. You may already be aware of such a problem. Once a problem is identified, have your students try to find out when it occurred, the magnitude of the problem, the possible causes and any responses that were made. Common problems are related to cooling of power plants and the releasing of water with a high oxygen demand from sewage plants during warm weather. The point is to follow the process of the discovery of a problem and the responses to it.



ACTIVITY 14
WHEN THE OXYGEN IS GONE

Name Possible answers

Describe the experiment you are going to do. We are putting fish in water that does not have much oxygen to see how they react to low oxygen.

43
48
2|91
46

	number of times gill covers are opened per minute	
	water with oxygen	water without oxygen
Fish number one	43	56
Fish number two	48	71
average	45.5	63.5

56
71
2|127
63.5

What conclusions can you make from your experiment? If there isn't much oxygen in the water, the fish will pump more water over its gills to increase the amount of oxygen that passes over its gills.

Compare the behavior of the fish in low dissolved oxygen water with that of the fish in water with normal oxygen levels.

Low oxygen: This seemed to upset the fish, and it swam around fast. Then it went to the surface of the water and seemed to gulp air.

Normal oxygen: After getting used to the jar, these fish just sat there in the water.

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ACTIVITY 15

IN HOT WATER?

WHICH WEIGHS MORE: HOT OR COLD WATER?

SCIENCE SKILLS:

- observing
- measuring
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- Water is heaviest at temperatures near freezing. It weighs less when hot or when frozen.
- Water of different temperatures may form stratified systems.

MATH AND MECHANICAL SKILLS PRACTICED:

- measuring volume
- using a balance, spring scale or triple beam balance

SAMPLE OBJECTIVE:

- Students will be able to compare the relationship between water temperature and weight per unit volume (density).

INTRODUCTION:

This exercise examines the relationship of water temperature to weight per unit volume, or density. This relationship may have important consequences for aquatic habitats. Warm water floats above the cooler water without much mixing in the absence of wind, waves or tides. Under calm conditions a body of water may become layered or stratified with regard to the temperature of the water. The point at which the warm and cold water meet is called the THERMOCLINE. If you have gone swimming in a lake or pond, you may have experienced this sudden temperature change.

Animal distribution may be determined by the distribution of different temperatures of water. For instance, trout may concentrate in the lower water of a lake in the summer where it is cooler. Changes in water temperatures with the seasons may result in exchanges of surface and bottom water that affect distribution of nutrients and dissolved gases.

MATERIALS:

FOR THE CLASS:

- hot tap water (120° F maximum)
- ice cubes
- cold water (from refrigerator or ice water)
- unbreakable thermometers
- several colors of food coloring
- simple balance, spring scales or triple beam balance
- volume measuring devices (measuring cups or unbreakable graduated cylinders)

FOR EACH GROUP:

- four clear plastic cups
- a plastic spoon

LESSON PLAN:

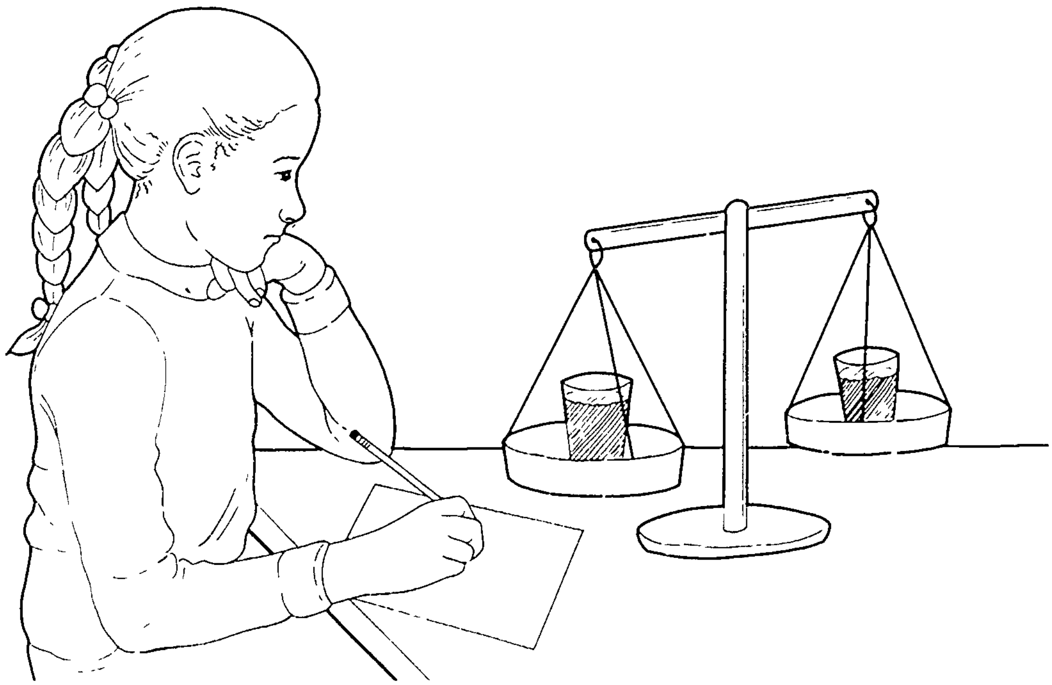
BEFORE CLASS:

Practice this experiment at home. If you do not lay the colored water into the uncolored water very gently, it will mix. If you are not able to do it, consider doing this as a demonstration and siphon the cold water under the warm water (as in Activity 4) to get two distinct layers.

Plan to do this experiment early in the morning if you do not have access to a refrigerator. Bring ice cubes from home. If you do not have an ice chest, put them into watertight plastic bags and wrap in newspaper, which is a wonderful insulator. You need hot tap water somewhere at school. The temperature should not be high enough to hurt if spilled. Plastic half gallon milk jugs are good water containers.

DURING CLASS:

METHODS: Tell the class they are going to ask some questions about whether warm or cold water is heavier. What are some ways they could test this question? They might suggest weighing the same volumes of warm and cold water. Try this. What about warm and cold water? If one is heavier than the other, what would happen when warm water and cold water meet? Have they done an experiment like this before? How did they address this kind of question with salinity? Some may predict cold water is lighter because ice floats.



To compare weights, exactly the same volume is needed. If the students do not use the exact same amount of water in each cup, it will not be a fair test. Fill one cup with very hot water (but NOT hot enough to burn a child's skin) and another with refrigerated (cold) water. Measure the water carefully before adding it to each cup. Either measure them separately if you have a spring scale or triple beam balance or put each on one of the two pans of a simple balance. The cold water should be heavier if they got the exact same amount of water in each cup.

Stop and discuss the results. What would happen if cold and warm water meet in a natural habitat? What would they predict? Would one float on the other? Would they mix? Here is a way to test this. Each group needs two cups of ice water and two of hot water. Add the same color of food coloring to one of the hot and one of the cold water cups. With a plastic spoon very carefully lay a sample of the cold colored water on the surface of the hot clear water cup What happens? Try the reverse, hot colored water on the surface of the cold clear water cup. What happens? For controls, try the colored water with water of the same temperature.

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RESULTS:

Cold water (down to 4° C) is more dense and should sink when added to the hot water. The hot water should float on the surface of the cold water because it is lighter.

CONCLUSIONS:

Warm water is lighter (less dense) than cold water. When warm and cold water come together and are not stirred, the warm water floats on the cold water. This stratification means that one body of water has two totally different kinds of places for animals to live in terms of temperature. Lack of mixing can also cause an unequal distribution of things in solution in the water such as oxygen, which diffuses in at the surface or comes from plants at the surface, and nutrients, which are released near the bottom as bacteria decompose dead plants and animals. Stirring mixes the water. What would "stir" water in a real habitat? Wind which also causes waves, currents, tides or running water would mix warm and cold layers.

USING YOUR CLASSROOM AQUARIUM:

Looking for a quick way to demonstrate the principles of this lab? Fill a small balloon with very cold water (stick a water balloon in the refrigerator) and drop it into the aquarium. Does it sink or float? Leave it and see what happens when it warms up.

EXTENSIONS:

1. What happens when a pond or lake freezes? Does it freeze from the bottom up? Where does the ice form? If you have a refrigerator in your classroom, you might investigate this question at school. Perhaps a better technique would be to have one or several students check this question at home

The students will need a model pond that is realistic. Ponds are surrounded by dirt which is an excellent insulator. A thin-walled plastic cup will not be a good model pond. Put several styrofoam coffee cups inside one another for insulation. Fill with cold water and place in the freezer. Check it every 15 min. Where does the ice form first? Record when the ice forms and where. If a pond works in the same way, where does the ice form first? Do not try to freeze the whole thing solid as it might break.

2. To demonstrate why ice floats, fill a clear plastic cup with cold water. Mark a line at the top of the water with a marker. Freeze the water and compare with the line. The water expands. If the same amount of water takes up more space, then it must be less dense than it was. Ice floats because water expands as it freezes. The water molecules get farther apart. For this reason water freezing in a crack can break a rock or concrete.

3. Water temperature has implications for the mixing or lack of mixing of human sewage from outfalls. If the waste has a temperature different from the receiving body of water, it will not mix unless there are winds or currents. Many times the engineers assume that waste products will be diluted enough that they are not harmful. Often this does not happen because of temperature differences.

The combined effect of warm, freshwater sewage entering cold salt water is that the sewage floats to the surface. This can be demonstrated. A cup of cold salt water is the ocean. Fill a straw with hot colored fresh water, the waste water. Lower the straw tip to the bottom of the cup and slowly release the water. The warm colored water does not mix, but comes to the surface. Do the waste products get diluted? No, they form a dangerous cloud floating in clean water.

ACTIVITY 15

Name Possible answers

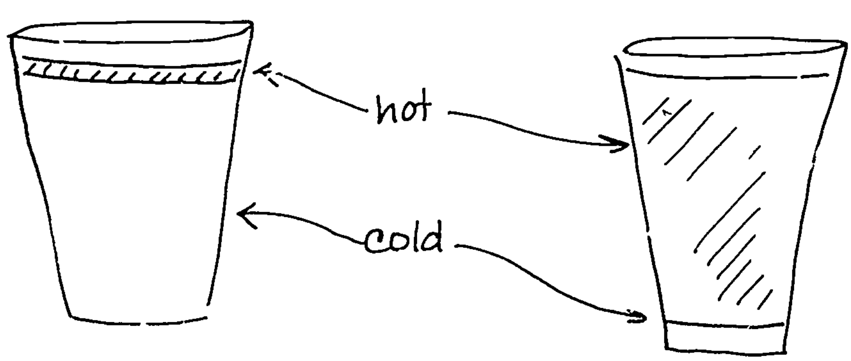
IN HOT WATER?

What question can be answered by doing these experiments? Which is heavier - hot or cold water?

What did you do for your first test? I tried to compare the weights of equal amounts of hot and cold water.

Compare the results of your first test with hot and cold water: I don't think I measured the volumes very well. I think hot water might be heavier

Draw the results of your second experiment:



added colored hot water to plain cold water and the hot water floated

added plain cold water to colored hot water and it sank.

Other groups used opposite colored water so food coloring can't be the cause of my results.

What conclusion can you make based on your experiments? Hot water is lighter than cold water, and hot water can float on cold water to make a layered system

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ACTIVITY 16

THE GREAT ANADROMOUS FISH GAME

WHAT ARE SOME OF THE FACTORS THAT DETERMINE THE REPRODUCTIVE SUCCESS OF FISH DURING THE SEASONAL MIGRATIONS OF RIVER-SPAWNING, OCEAN-LIVING SPECIES?

SCIENCE SKILLS:

- observing
- organizing
- communicating

CONCEPTS:

- Many fish species migrate seasonally for reproduction.
- While each fish is capable of producing large numbers of offspring, many factors reduce the chance that a fish will reproduce and that its offspring will survive.
- If the number of fish that die exceeds the number that are born, the total fish population will decline.

MATH AND MECHANICAL SKILLS PRACTICED:

- multiplication by fractions or decimals
- subtraction
- rounding off
- use of a calculator
- graphing

SAMPLE OBJECTIVES:

- Students will be able to describe the seasonal migration of anadromous fish.
- Students will be able to identify a variety of natural and human factors that affect the reproductive success of anadromous fish.
- Students will be able to apply mathematical skill to a biological problem.

INTRODUCTION:

MIGRATION is the movement of animals from one area to another. Many species do migrations during specific SEASONS of the year. In this game, blueback herring seasonally migrate from the open ocean through estuaries and into freshwater rivers and streams where they SPAWN (lay their eggs). The newly hatched young must then migrate back down the rivers to the sea. Fish that follow this pattern are said to be ANADROMOUS from the Greek for "running upward." Both the adults and the young face a number of hazards, some natural and some of human making. As the students play this game, they will learn about these hazards.

The math involved in calculating the reduction in numbers caused by these hazards requires advance practice for some age levels. One teacher with fourth graders "borrowed" some fifth graders to help her teach her class how to use calculators to do the math. After playing the game, students may wish to experiment with "what if" questions by removing some of the hazard cards, such as suspending all fishing, to see what effects these changes have.

MATERIALS:

FOR EACH GROUP OF 2-8 PLAYERS:

- game board *(see pages 266-284)*
- worksheets to keep score
- sets of cards
- a die
- 2-8 colored herring or other markers for players to move
- storage box such as a shirt box
- vocabulary sheets
- calculator if not doing math by hand

LESSON PLAN:

BEFORE CLASS:

This game requires time in its initial construction. Once made, it can be taken off the shelf and used. As with anything you plan to use repeatedly, lamination will make it last longer. Either xerox the cards onto different colors of paper or glue them to different colors of construction paper so they can be sorted easily. You might have your students add color to the illustrations. Xerox the worksheets. You will need to review fractions and rounding off with your students before playing the game. For example, you have 75,000 fish and one quarter of them are eaten by a school of striped bass. If one quarter are eaten, three quarters or .75 survive. Multiply 75,000 by .75 to get 56,250 fish still alive. If math is being done by hand, the numbers may be rounded off to the nearest thousand if this helps speed the calculations.

DURING CLASS:

METHODS: Start by asking the class if they think animals always stay in the same place or do they move. If so, why? MIGRATION should come up in the discussion. Have the students list some animals that migrate and suggest reasons why they might do seasonal migrations which are tied to climatic changes that affect food supply and reproductive potential. For example, humpback whales migrate to cold northern waters to feed in summer and move south to warmer water to calve during the winter. Canada geese migrate north each spring to breed in the northern U.S. and Canada and south each fall to winter feeding grounds in the southern regions of the United States.

What about fish? This is a game in which the students get to be herring which migrate to the ocean to feed as adults and into rivers and creeks to SPAWN, releasing eggs which are fertilized outside the female's body. These fish live along the eastern coast of the United States. Review the term ESTUARY as these fish will pass through an estuary both coming and going. Have the students predict some of the hazards they are likely to encounter during their migration: fishing, predators, bad weather, lack of food, manmade barriers like dams. pollution.

RESULTS:

The students will keep track of their populations' sizes on worksheets. Make the game more real by averaging all of the students' results and having a discussion about the role of chance in producing higher populations for some students than for others. Graph the decline in the fish school as the fish swim upriver and the decrease in offspring as they swim down to feeding grounds in the sea.

CONCLUSIONS:

These are among the things which may reduce the size of anadromous fish populations:

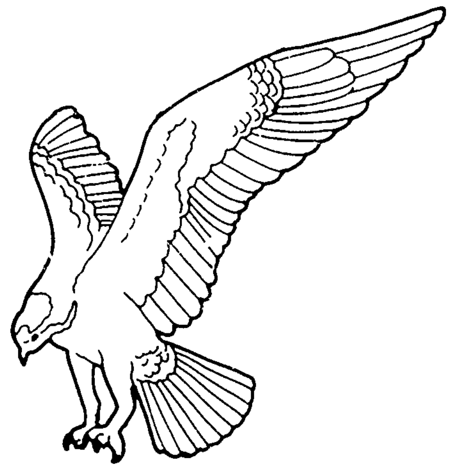
- predation by a wide variety of predators
- food supplies
- changes in salinity and water level from unusual rainfall
- abnormal temperatures
- unusually severe storms
- parasites and diseases
- waste products from humans that are directly toxic or kill by lowering oxygen level
- accidental entry of toxic compounds with runoff such as pesticides
- sediment from runoff
- obstructions to migration such as dams
- fishing by a wide variety of methods

With your students sort out which of these are the result of natural events over which humans have no control and which are things humans could alter to increase herring populations. Make sure they understand, however, that even if humans were totally out of the picture, far more herring are spawned than will ever survive to reproduce. Each species of animal or plant is capable of producing more offspring than are needed to just replace the individuals already alive. This allows species to survive predation and recover from natural changes or disasters. It also means that when natural controls such as predators are removed, populations may explode in size.

EXTENSIONS:

1. What would happen if human-caused fish deaths were reduced? Let the students choose one set of conditions to change such as no longer allowing any fishing. Replace these cards with blank cards and see what happens to the numbers. Would they continue to increase forever? No, because eventually the predator populations would increase and/or competition for food supplies would occur. These would set new limits for the numbers of herring. We do know from historical records that when European people first arrived in North America, there were far more herring than there are today. Many of the problems we have created are *not* new. Dams for power and the location of industries along rivers began more than two hundred years ago.

2. Have students choose an aquatic or marine species that migrates and make their own game that is based on that migration. When the games are done, trade them around and let other students play them.



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ACTIVITY 16 Name Possible answers

THE GREAT ANADROMOUS FISH GAME

You have a school of herring trying to reach the spawning grounds. There are 100,000 fish in your school. There are many dangers waiting for your school. Each time you meet a hazard, deduct the number of fish that died from your school. Use this chart to keep track of how many fish you have.
Round your numbers to the nearest thousand if it helps.

GOING TO THE SPAWNING GROUNDS No. of fish at start ____________

Ocean	Estuary and River	Streams
100,000	18,750	7,000
75,000	14,000	
37,500		

The number of adult fish that reached the spawning ground is 7,000.
Now how many baby (larval) fish did these adults produce? Here is how to find out:

1. Roll the die. Your number was 2.
2. Multiple tnis times 10 to get 20.
3. Multiple this number by the total number of adult fish to get the number of baby herring that start down stream 140,000.

Now the baby herring will head for the ocean. Keep track of the changes in the number of fish as they swim.

RETURNING TO THE OCEAN No. of baby herring headed for the ocean ______

Streams	Estuary and River	Ocean
140,000	26,000	
70,000	13,000	
35,000		

The number of young herring that reached the ocean is 13,000.

The average number of young herring that reached the ocean for the group I played the game with was 41,000. (Add all your total young together and then divide by the number of you that played.)

Are the total number of herring increasing each year or decreasing?
Decreasing, because there are fewer offspring than adults

If you were a fisheries biologist, what actions would you take which could increase the number of herring in future years?
I would remove stream obstructions, stop water pollution and reduce the amount humans catch.

ACTIVITY 17

A CHANGE IN THE WEATHER

PREDICTING SEASONAL CHANGES IN WATER ENVIRONMENTS.

SCIENCE SKILLS:
- observing

CONCEPTS:
- Seasonal changes take place in water habitats, many of which are related to temperature.
- These changes affect the plants and animals living in water environments, resulting in seasonal cycles in their life histories.

SAMPLE OBJECTIVE:
- Students will be able to describe the seasonal changes that take place in a pond.

INTRODUCTION:

Physical factors which change with the seasons have imposed seasonal changes in the LIFE CYCLES of the plants and animals that live in water environments. While you may be fortunate enough to have a pond or stream near your school that you can visit regularly, you may condense that whole year in the life of a water habitat by showing one of the excellent films available which focus on the changing seasons and their effect on the inhabitants of a body of water.

MATERIALS:

- film showing seasonal changes in a freshwater environment such as:
  Still Waters, 59 minutes, 1978, WGBH-TV (excellent; may be available on videotape; was shown on NOVA)
  Spring Comes to the Pond, 10 minutes, 1970, Coronet

LESSON PLAN:

BEFORE CLASS:

Order the film. Your county school film library may have a different film than those listed here. The film *Still Waters* is beautifully filmed, but may be too advanced for younger children. It is fine for middle school aged or gifted younger children. If you use a long film, show parts of it on several days; perhaps by season on four days. If you choose a short film, you may be restricted to a discussion of two seasons.

METHODS: Ask your students to observe carefully. Be able to describe the changes that take place in the yearly life of one plant or one animal that are caused by temperature changes in the water. They should be able to describe these changes in terms of what happens in each season. After the film, fill in the chart for the animal or plant.

Have the entire class share their observations with a large chart on the board. Compare the changes with the seasons for the animal and plants they picked.

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RESULTS:

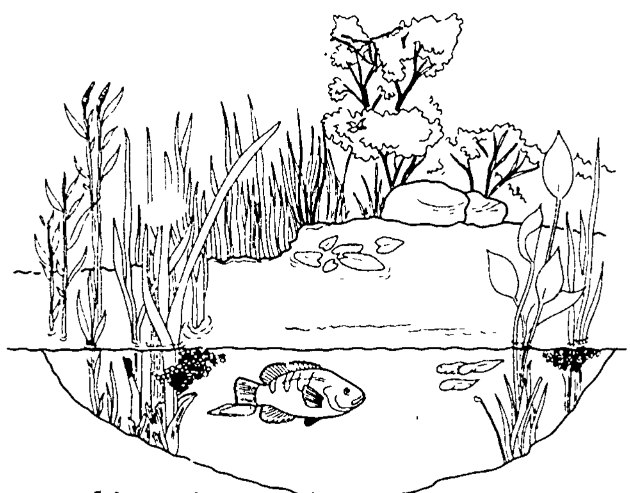
Seasonal changes which your students observe will vary, depending on which film you find.

CONCLUSIONS:

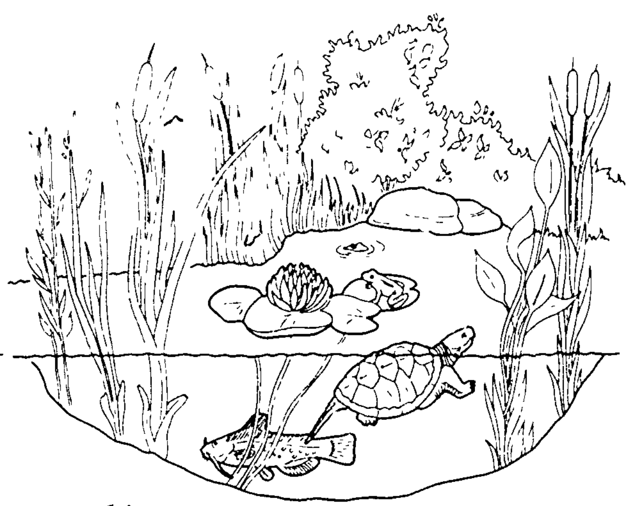
Animals and plants living in TEMPERATE regions do different things during different seasons of the year. They often have life cycles timed to suit the seasonal changes in their environment which range from freezing during winter and warm summer days.

USING YOUR CLASSROOM AQUARIUM:

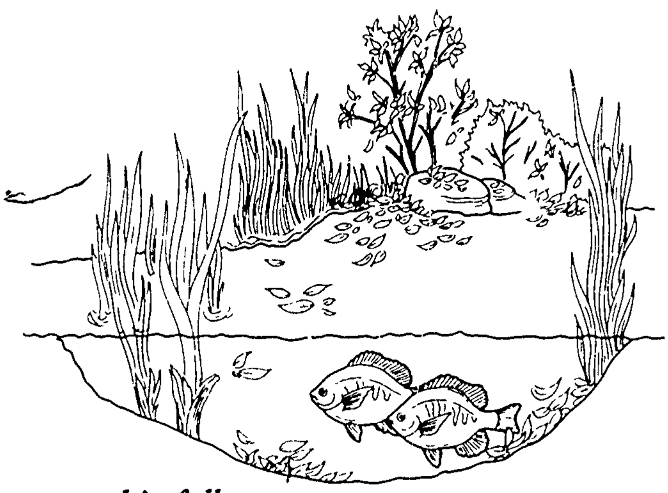
Did you choose to stock your aquarium with freshwater tropical fish? This is a good opportunity to contrast temperate with tropical. Tropical climates generally do not fall below freezing temperatures during any part of the year. The plants and animals in tropical climates are not able to survive freezing temperatures. How did you make sure your aquarium remained tropical? With heaters.



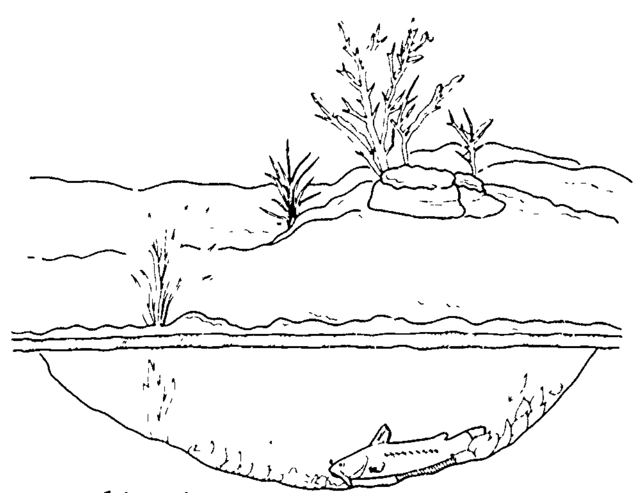
a pond in spring



a pond in summer



a pond in fall



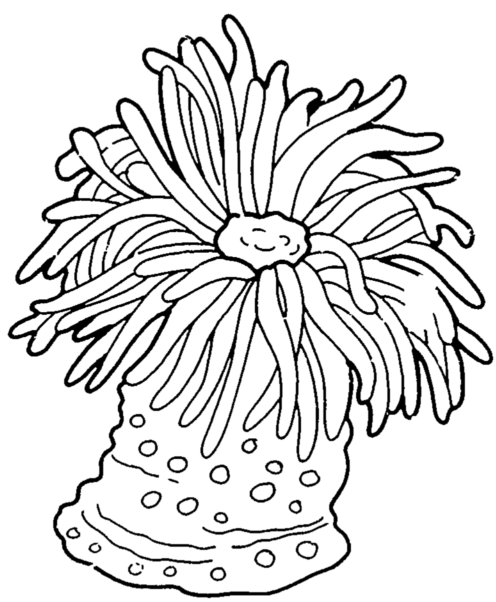
a pond in winter

EXTENSION:

1. If there is a stream with quiet pools or pond close to your school which can be visited on a weekly basis, start recording the temperature of the surface and bottom waters each week. If you have a water sampler, try recording surface and bottom oxygen as well. If you have a plankton net, take plankton samples each week and preserve them in alcohol in a baby food jar which is labeled with the week and location. Save these for your field study near the end of school. Remember water safety.

2. Have your students start a photo essay or video essay to document the change from one season to another.

3. Do you live in an area the coast where herring run? If you do, you might be able to arrange a field trip to observe the run. Check with the Fisheries section of your state department of natural resources or contact your local nature center to find out if this is possible. The run usually takes place in very late winter to very early spring, depending on where you live.



ACTIVITY 17 Name Answers vary with film

A CHANGE IN THE WEATHER

Observe the film carefully, paying particular attention to one animal or plant. When the film is over, write your observations about what the plant or animal is doing during each of the seasons.

The organism I chose to observe in the film is ____________________.
Draw a picture of it here:

This is what it was doing during each season:

Spring: ______________________________

Summer: ______________________________

Fall: ______________________________

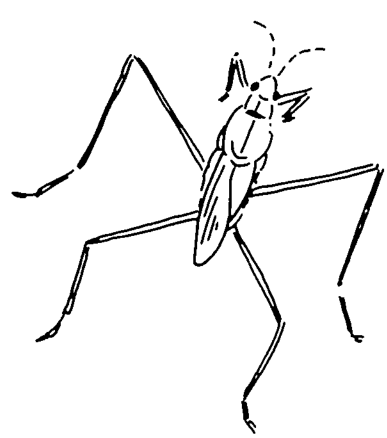
Winter: ______________________________

SECTION III
MOVING OR STAYING PUT: MAINTAINING POSITION WITHIN AQUATIC HABITATS

TEACHER'S INFORMATION

The physical characteristics of water have an effect on the nature of aquatic habitats and the kinds of places within those habitats where animals and plants may live. Water MOLECULES are the basic building blocks of this unique substance. Each molecule of water is composed of one ATOM of oxygen and two atoms of hydrogen. Due to the way in which these atoms are attached to each other, each water molecule has one positive end and two negative ends which are attracted when water molecules meet. This attraction is responsible for many of the characteristics of water. The weak positive and negative charges help make water the universal solvent that we studied in Section I. It is also involved in the changes in density with temperature which you saw in Section II.

The tendency of water molecules to stick to each other (COHESION) is also important in this section. This cohesive property of water is perhaps most obvious at the surface. The top layer of water molecules forms a film or "skin" which is very strong called SURFACE TENSION. Many animals and plants live directly on the surface of bodies of water. Some of them float and are lighter than water like duckweed, a tiny green seed plant which floats in large clusters on the surface of ponds with its rootlets dangling in the water. Others are heavier than water and do not float. They ride on the surface tension. Some kinds of beetles and bugs walk on water in search of prey. The



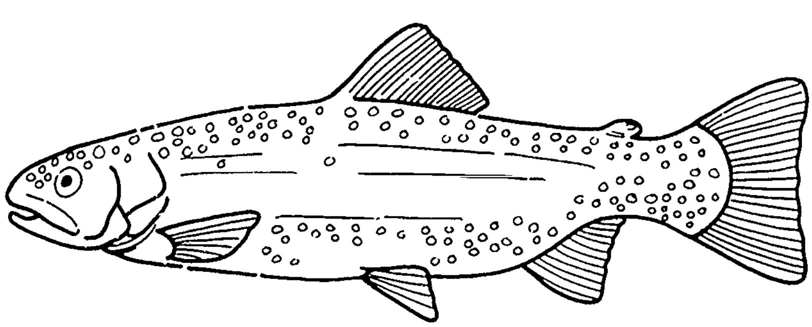
water strider, a familiar pond bug, has special hairs on its first and third pairs of legs which form dimples on the water surface. The strider's second pair of legs actually penetrate the surface tension and work like oars to propel the insect over the surface. There is a marine species of water strider as well. Other kinds of insects, like mosquito larvae, hang upside down from the surface film and poke a breathing tube up through it. A pond insect called a springtail has a spring-like appendage with which it jumps around on the surface of ponds and temporary water holes. Whirligig beetles are so well-adapted for life on the surface tension of ponds that each eye has two halves: the upper half can see above the surface while the lower half simultaneously views the underwater world! The addition of soap to the water interrupts the surface tension by breaking the weak attraction among the water molecules. Some insects that might otherwise be preyed upon by water striders are able to spit small amounts of detergent into the water and cause the strider to go under before grabbing its meal!

Another characteristic of water that is of importance in this section is its DENSITY. Some animals and plants are lighter than water of a volume equal to their own. These organisms float at the surface. The Portuguese man-of-war is a familiar marine invertebrate which floats. Other creatures are just barely heavier than water and sink slowly. Jellyfish periodically pulse their way back to the surface, only to start sinking again.

How do aquatic plants stay near the surface where light is available? PHYTOPLANKTON, the tiny algae that form the basis of the food chain in many bodies of water, are heavier than water. If they were not, they would all float in a single crowded layer at the surface. Different kinds have different tactics to achieve the same end: to sink very slowly. Phytoplankton are adapted to stay up in the water as long as possible. Some have oils which store food (energy). The oil helps keep their density near that of the warmer surface waters. Another tactic is to have lots of long projections from the surface. These create drag as the organism sinks, slowing its sinking. Also, many organisms we call plants that are phytoplankton have tiny "hairs" called FLAGELLA which may help them move when waved. Flagella are usually associated with animal cells in most people's minds, but many "plant" cells are also capable of movement. Yet another way to sink slowly is found among the diatoms, small flattened phytoplankton. As they sink, their shape causes them to make very wide swings from side to side.

ZOOPLANKTON, the tiny animals which drift with the currents, also have the problem of maintaining their position in the water. They not only need to keep from sinking to the bottom, but also move to find food and avoid predation. While some remain near the surface, many kinds of zooplankton make a daily VERTICAL MIGRATION up and down. They may move near the surface to feed at night on phytoplankton or on the zooplankton that feed on phytoplankton. During the day they migrate down to dark water where fish cannot see to eat them. In shallower areas the zooplankton may hide on or near the bottom and move up when feeding. Zooplankton also have adaptations that help them stay up. Many have long projections that slow the rate at which they sink. Some can "thrash" or pulse their way up, using antennae or limbs as oars. Zooplankton frequently have special organs which sense gravity so they know which way is "up."

The flesh of all fish has a higher specific gravity (is more dense) than water. Without special adaptations, fish would sink and indeed some live on the bottom. Bony fish that stay suspended in the water column have two ways to maintain their position. First, they may use their fins. A typical fish has 7 fins. The second thing that keeps bony fish from resting on the bottom is an air or SWIM BLADDER. This organ is a pouch located between the stomach and the backbone. In primitive fish it is connected to the throat by a tube while in most fish it is sealed and gases enter and leave it from the fish's blood. It can be inflated or deflated by the fish to adjust the fish's buoyancy to keep it weightless at whatever depth it is swimming. This system works much like the buoyancy compensation device used by scuba divers to help them maintain their position in the water.



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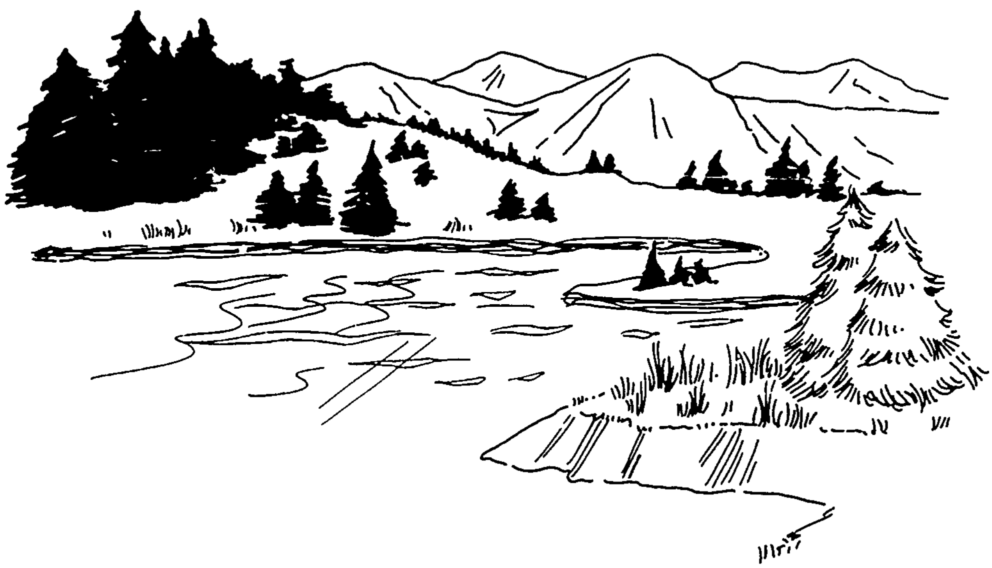
Most bony fish possess a swim bladder, but the CARTILAGINOUS fish (sharks, skates and rays which have a skeleton made of cartilage) do not. Sharks swim continuously lest they sink straight to the bottom. Sharks do have a huge, oily liver which helps make their density close to that of water since oil is lighter than water.

Water also has VISCOSITY, which is resistance to flow. It is not as viscous as gelatin or pancake syrup, but it is much harder to move through water than through air. Animals that move through water have special shapes that help them slip through the water to reduce the energy they must spend on swimming. Plants and animals that are heavier than water sink more slowly than might be expected if they have structures such as projections or hairs that take advantage of viscosity by increasing the organism's resistance to movement.

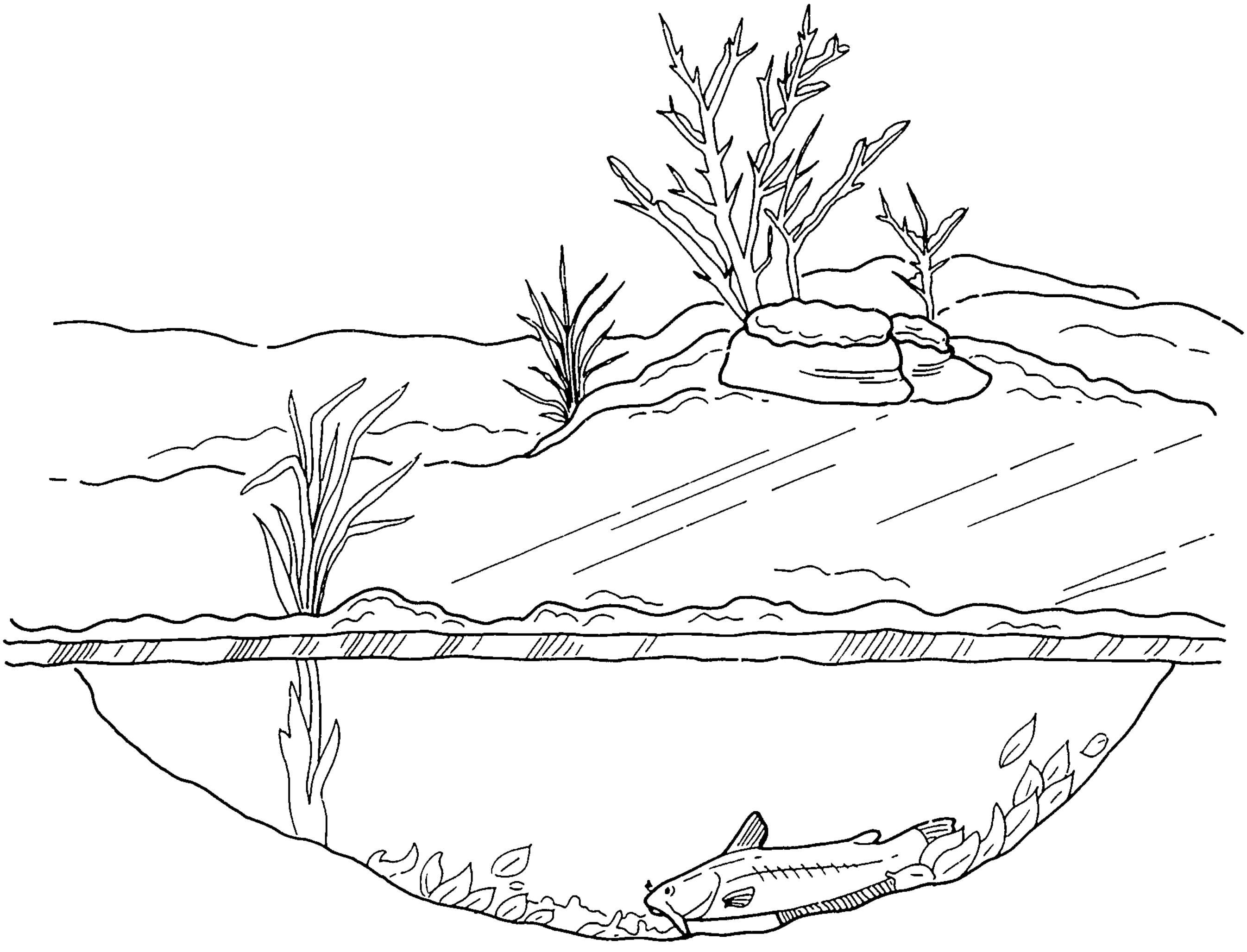


All of these characteristics of water result in there being many different ways of life in different aquatic environments or HABITATS. A habitat is the place where an animal or plant normally lives. Aquatic habitats can be divided into three broad areas or places: the BENTHOS, or bottom; the surface; and the WATER COLUMN, which is all the water in between. Within these major areas are subdivisions categorized by the amount of light, vegetation, closeness to shore, depth, food resources, and other plants and animals.

Animals and plants that live in aquatic habitats can be placed into COMMUNITIES that reflect where they live. Animals that live on the bottom sediment are BENTHIC. Rooted water plants are also benthic and may be submerged (completely under water) or emergent. Those plants and animals that float or move on, in or just under the surface film of water are called NEUSTON and have features that help them exploit the surface tension that interfaces air.

PLANKTON are the small plants and animals that live in the water column, either drifting or weakly swimming. PHYTOPLANKTON (phyto- = plant) are microscopic organisms that change inorganic nutrients into food and release oxygen when they do PHOTOSYNTHESIS. Like all plants, they can grow only in the EUPHOTIC ZONE, where enough light penetrates for the process of photosynthesis to occur. Phytoplankton are eaten by ZOOPLANKTON (zoo- = animal) and by filterfeeders ranging from clams and oysters to some small fishes both in the euphotic zone and as they drift below it toward the bottom.

The zooplankton community ranges in size from tiny, single-celled animals to larger creatures like jellyfish. It includes both temporary and permanent residents. Many freshwater and marine animals spend the early LARVAL stages of their lives as tiny animals and later may settle to become either slow-moving or SESSILE (anchored) adults or grow into free-swimming mobile animals, like fish. Strong swimmers that can move horizontally and vertically in the water column are called NEKTON. These animals can move against currents and tides to maintain their position.



ACTIVITY 18

TO EACH ITS HOME

WHERE DO ANIMALS AND PLANTS LIVE AND WHAT MAKES THEM SUITED TO THEIR HOMES?

SCIENCE SKILLS:

- classifying

CONCEPTS:

- Bodies of water can be divided into different kinds of places.
- The characteristics of these places determine the plants and animals that can live there.
- Not all aquatic animals swim; some float, sink, sit still, or even walk on the water's surface.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of a flow chart type key

SAMPLE OBJECTIVES:

- Students will be able to list the different kinds of places to live in an aquatic habitat.
- Students will be able to classify living things by the location in which they live in an aquatic habitat.

INFORMATION:

This activity introduces the concept of different places to live within a habitat and teaches vocabulary needed for the following activities in this section. It is done by individual students who trade animal and plant Identity Cards to complete their Aquatic Homes flow chart/key.

MATERIALS:

FOR EACH STUDENT:

- Aquatic Homes flow chart/key to animal or plant identities

FOR THE CLASS:

- Identity Cards set (enough for at least one per student)
- construction paper or poster board

OPTIONAL:

- pictures from magazines to decorate the cards

1:5

LESSON PLAN:
BEFORE CLASS:

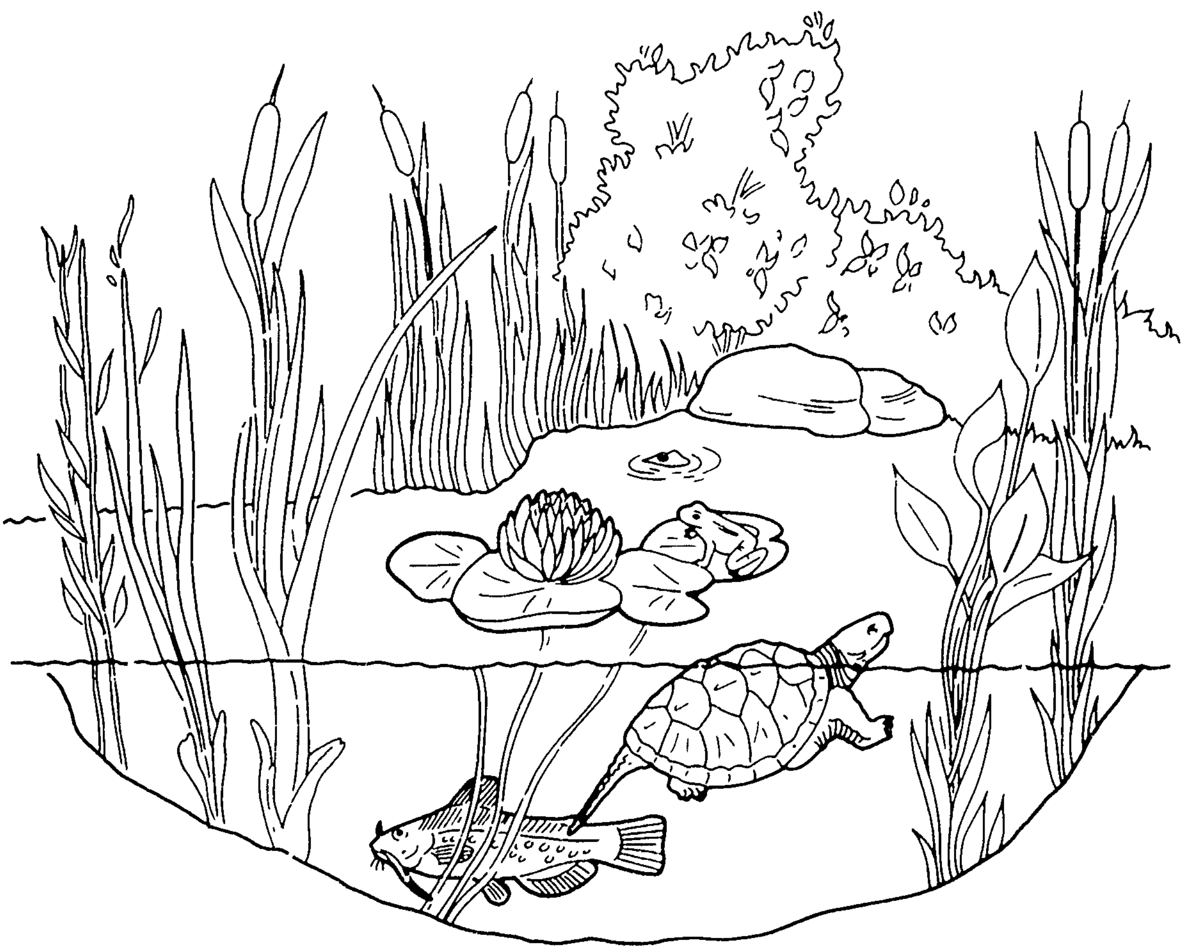
Review the lesson and collect the materials. There are 15 Identity Cards, so you may have to make a duplicate set. Cut out the Identity Cards. Glue them to poster board or construction paper. You may decorate the reverse side of the cards with pictures from old magazines like *National Geographic* or *Ranger Rick*. You may want to write the list of animals and plants found in each location on the back of your Identity Cards too. It is entirely possible to do this activity without pictures, but not as much fun. Laminate the cards or protect them with clear Contact paper for reuse.

DURING CLASS:

METHODS: Draw a cross-section of a pond (see below) or the ocean (see pages 288 & 289). Ask the students to suggest some different kinds of animals and plants that might live there and where they might live. Be sure to draw in some plants near the shore and some animals in the water and on the bottom. (Do not introduce any terms yet. Let the students discover them in the key.)

Explain that animals and plants live in different places in aquatic environments, whether they are in the pond you have drawn or the oceans or rivers. Each kind of animal and plant has its own home. Distribute the Aquatic Homes flow chart. Note that it starts with very broad divisions that get more precise with each level, so students must start at the left and go one step at a time, making a choice between two characters each time.

Pick one organism that you have drawn on your "pond" and use it as an example with the flow chart/key. Have your students work with you to identify what kind of place it lives in.



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Next, give each student an Identity Card. (Students may also work in groups at first.) Each is a plant or an animal that lives in a certain place or home. Read the card about the organisms that share this home and use the clues to figure out where they live. Fill in the card number in the space at the end of the key. There is enough space by the number for the students to write down a type of plant or animal that fits the description. Let them guess what kind of plant or animal this might be and write it down. Trade cards until each has inhabited all of the different places one can find within aquatic habitats. If you are short of time, do several cards and stop.

Do the worksheet for this exercise after working with the flow chart/key.

RESULTS:

Have your students name the different areas of the pond that may be occupied by the different groups of plants and animals they keyed out. Have them list the vocabulary words they learned which name the different places or aquatic homes.

CONCLUSIONS:

Environments are divided into many places that are used by different types of animals and plants. Affecting where an organism lives are the available food sources, light, depth and bottom characteristics as well as the mobility, weight, age and size of the animals and plants themselves.

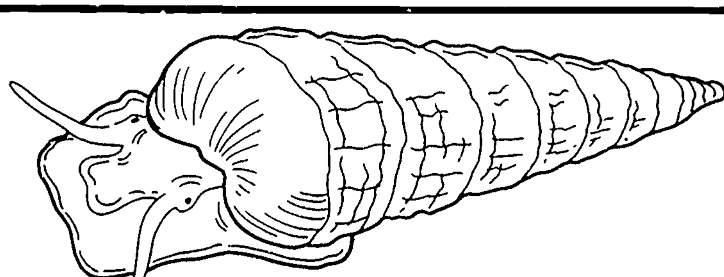
USING YOUR CLASSROOM AQUARIUM:

If you have several different kinds of animals and plants, the students can key them or make their own keys. Things to look for are: animals that stay near the bottom or clean the tank, such as catfish, *Plecostomus* and snails; fish that swim in the water column, such as goldfish, guppies and mollies; plants that float at the surface; plants that grow rooted to the bottom. If you have both small and large fish, find their preferred spots in relation to real or fake plants.

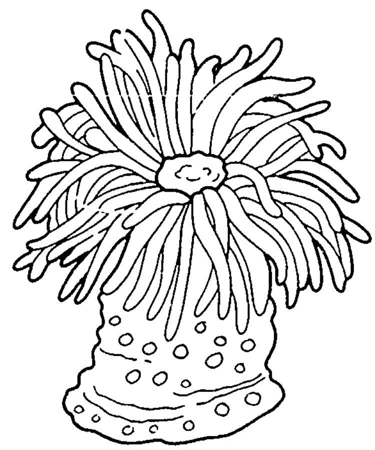
EXTENSIONS:

1. Included with the set of Identity Cards are short lists of typical animals or plants that have those identities. You can glue these to the reverse side of the Identity Cards. You may also send your students on a picture hunt. After they have finished their key, have them choose one identity and check the list to find some organisms that have this place for a home. Have your students research the plant or animal they choose from the list.

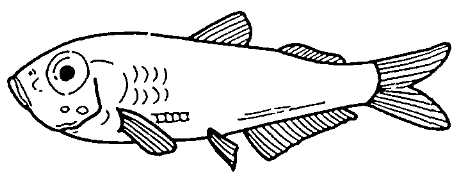
2. Do you have a dictionary that gives the Greek or Latin roots for words? Have your students research other words that use the parts in the worksheet. Find out what words they were derived from and what they mean. Most names which sound obscure to us are just the common names from ancient times.

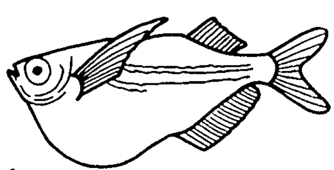


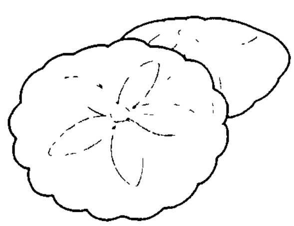
EXAMPLES OF PLANTS AND ANIMALS FROM DIFFERENT PLACES IN THE ENVIRONMENT

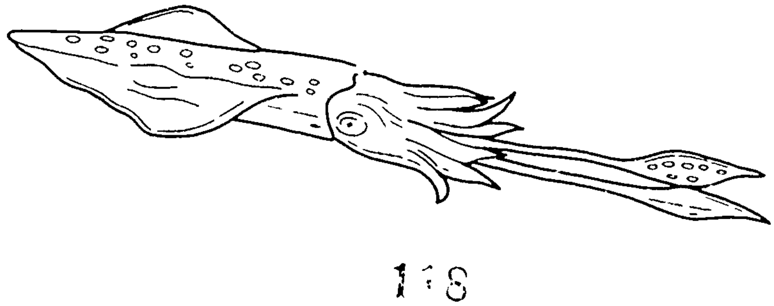


1. clams, tubeworms, some insect larvae, *Tubifex* worms
2. green algae, some seaweeds
3. most larvae (not fully developed forms) of fish, crustaceans, echinoderms, and tadpoles
4. horseshoe crabs, crayfish, flounder, anemones, *Hydra,* sea urchins
5. dinoflagellates, diatoms
6. mole crabs, sand dollars, quahogs and other clams
7. water striders and whirligig beetles
8. kelp, turtle grass, water milfoil, seaweed
9. deep sea anglerfish, flashlightfish, and hatchetfish
10. copepods, cladocerans, rotifers, and krill
11. bladderwort, water hyacinth, duckweed, and *Hydrilla*
12. Portuguese man-of-war, "silver beetle," fisher spider, and backswimmer
13. barnacles, coral, sponges, mussels, and oysters
14. cattails, water lilies, pickerel weed, and salt-marsh cordgrass
15. most adult fish, squid, some sharks, and all marine mammals









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ACTIVITY 18

TO EACH ITS HOME

Name Answers

Can you be a word detective? A scientific word often has the definition of the word hidden within it in the ancient languages of Greek or Latin which make up its parts. For example, the word *photosynthesis* may scare you unless you know that *photo* is Greek for light and *synthesis* means put together in Greek. Photosynthesis means put together with light and is a chemical process in which small chemicals are put together to make bigger ones using energy supplied by light. Here is a list of Greek and Latin roots which make up the scientific terms used in the Animal Homes flow chart or key. Parts written with a hyphen (for example: epi-) are prefixes and appear only at the beginning of a word. (Words with Gr are from Greek; those with L are from the language of the ancient Romans called Latin. A few are from old English and have roots in the languages of tribes that invaded England, the Anglo-Saxons. These are AS.)

benthos (benthic): Gr depth of sea or bottom

e-: L out of, from

epi-: Gr upon, on

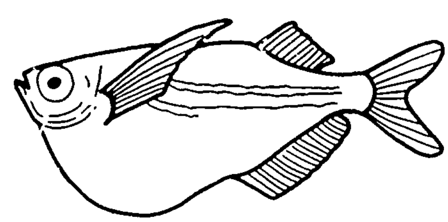
fauna: L groups of animals; Fauna was the sister of the god of agriculture

flora: L groups of plants; Flora was the goddess of flowers

in-: AS same as English word in

merge: L to plunge

mobile: L moves or movable



nekton: Gr swimmer or swimming

neuston: Gr swimmer or floater

photo-: Gr light

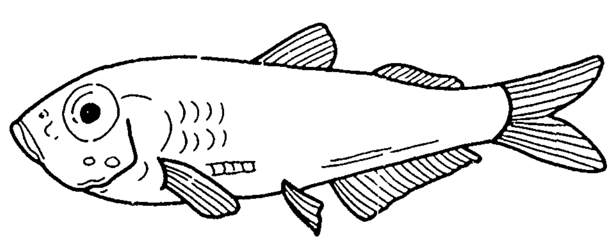
phyto-: Gr plant

plankton: Gr wandering or drifting

sessile: L sitting or sit

sub-: L under

zoo-: Gr animal



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Using these pieces, can you write the words whose definitions appear below?

plants that drift with the currents and waves phytoplankton

an organism that lives on the surface of the bottom benthic

an organism that lives attached and does not move is sessile

groups of animals that live in the sand or mud infauna

animals that drift with the currents and waves zooplankton

animals that swim actively in the water nekton

Can you think of some other words that use some of these Greek and Latin parts that you use?

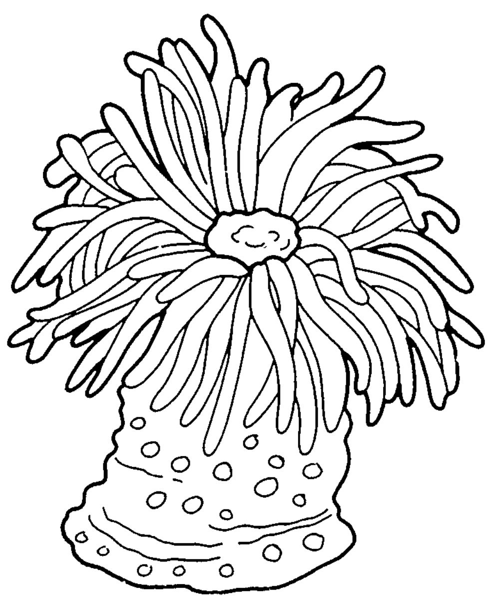
a boat that goes way down under salt water sub (under) marine (salt water)

a place where wild animals live that you can visit zoo

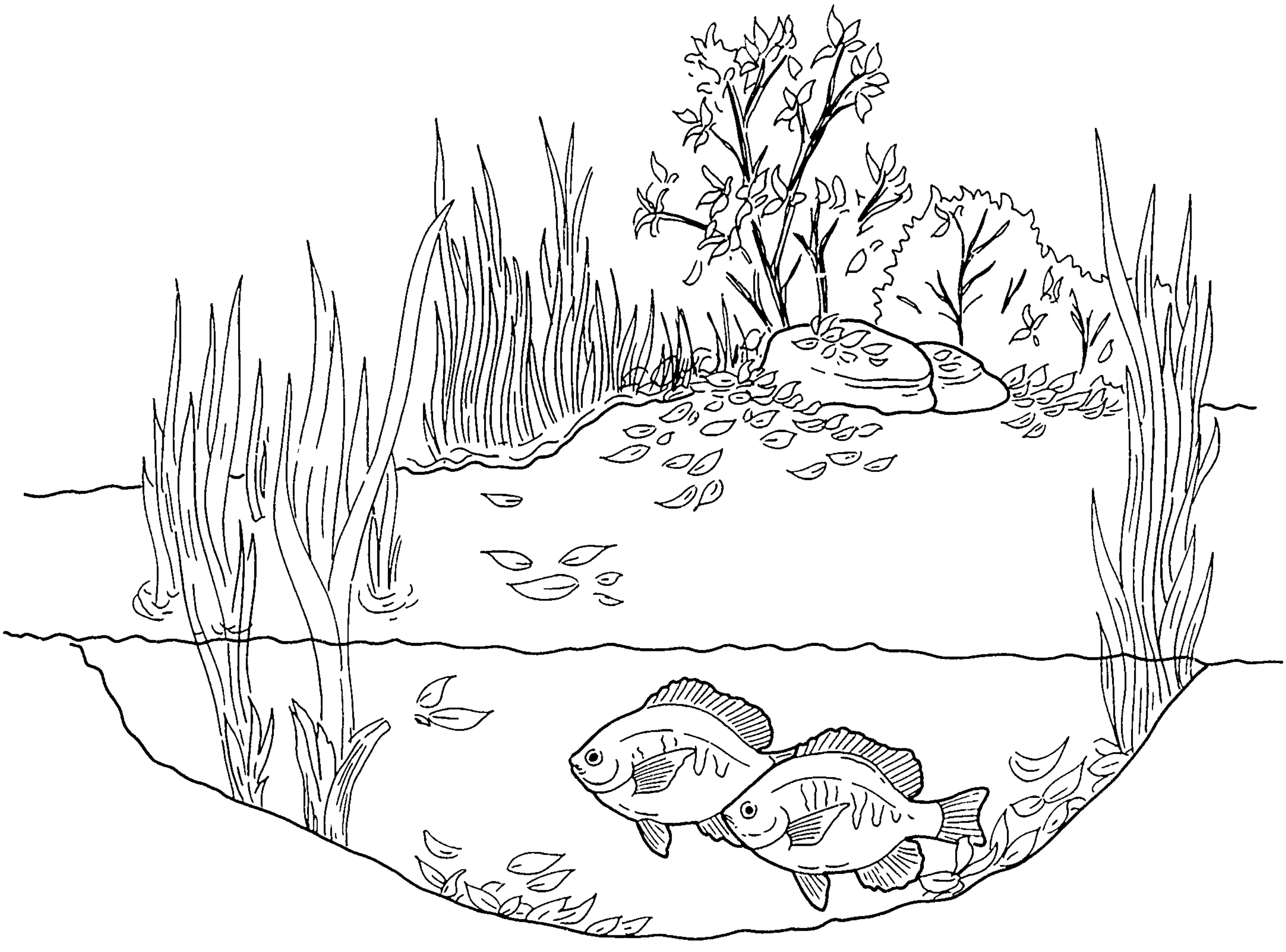
using light and film to make a record of a scene photo (light) graphy (drawing)

the things written on a tomb (Greek for tomb is taphos) epi-(on) taph (tomb)

a machine that you yourself can drive auto (self) mobile (moves)



- Plant
  - lives on or in the bottom (benthic) or on a surface
    - lives rooted in the mud or sand bottom
      - lives completely under water (submerged) ---------- 8
      - some part out of water (emergent) ---------- 14
    - lives attached to a hard place ---------- 2
  - drifting, not rooted in the bottom
    - tiny single-celled drifting plants (phytoplankton) ---------- 5
    - large drifting plants ---------- 11
- Animal
  - lives on or in the bottom (benthic)
    - lives in the mud or sand (infauna)
      - lives in sand bottom ---------- 6
      - lives in mud bottom ---------- 1
    - lives on surfaces or the bottom
      - lives permanently attached to bottom (sessile) ---------- 13
      - moves over surfaces or the bottom (mobile) ---------- 4
  - lives above the bottom
    - lives up in the water
      - strong swimmer (nekton) ---------- 9 15
      - weak swimmer drifting with currents (zooplankton) ---------- 3 10
    - lives at or on the surface (neuston)
      - lives at the surface ---------- 12
      - lives on the surface (epineuston) ---------- 7



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ACTIVITY 19

KEEPING YOUR HEAD ABOVE WATER

DO THINGS THAT FLOAT OR SINK BEHAVE DIFFERENTLY IN SALT AND FRESH WATER? WHAT LETS THEM FLOAT? WHEN DO THEY SINK?

SCIENCE SKILLS:

- observing
- measuring
- organizing
- predicting
- experimenting
- communicating

CONCEPTS:

- Because salt water weighs more than fresh water (is more dense), it buoys things up more than fresh water.
- Things that float displace a weight of water equal to their own weight.

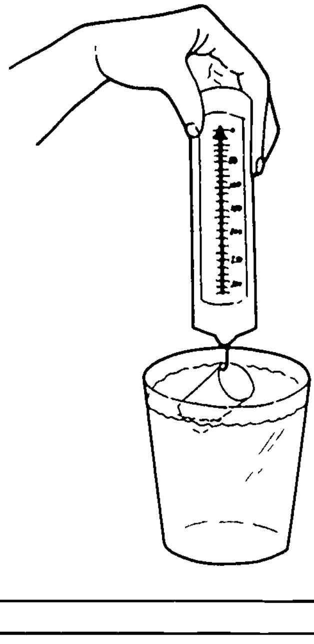
MATH AND MECHANICAL SKILLS PRACTICED:

- use of scale
- measuring liquid volume

SAMPLE OBJECTIVES:
- Students will be able to demonstrate why some objects float and others sink.
- Students will be able to compare the relative buoyancy of fresh and salt water.

INTRODUCTION:

BUOYANCY is a very difficult concept. The idea that some things sink and others float is straightforward, but the reasons behind th..e observations are not so easy to accept. This exercise is designed to demonstrate why things float differently in different solutions. It also allows you to introduce the idea of DISPLACEMENT versus floating or sinking. If you have younger students, do this as a demonstration or delete the part that measures displacement. If you delete some sections, some of the materials are not requir^d.



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MATERIALS:

FOR EACH GROUP:

- four 35 mm plastic film cans (of the same kind, *i.e.* all Kodak)
- 50 pennies
- rubber bands to hook to the scale
- small handheld spring scale with a pan (100 or 250 gram size)
- two clear plastic cups
- two small pans or trays from "TV" dinners or frozen meat pies
- 100 ml graduated cylinder calibrated in metric volume
- "plastic" modeling clay
- cafeteria tray or baking pan to catch spills
- plastic funnel

FOR THE CLASS:

- fresh water in plastic jugs at room temperature with 1 tbsp liquid detergent
- very salty water (1 cup table salt per quart) in plastic jugs at room temperature with 1 tbsp liquid detergent to break the surface tension

LESSON PLAN:

BEFORE CLASS:

Decide if this lesson is to be done by groups, learning centers or demonstration. Demonstration interspersed with discussion may be best for younger students. Mix the salt water the day before using hot tap water. Let it cool to room temperature. The detergent should help reduce surface tension which causes the water to round up on the cups.

DURING CLASS:

METHODS: Start with a discussion of your students' own perceptions of floating and sinking. Have they ever been swimming in salt water? Fresh water? Which was easier to float in? Have they ever been to the Great Salt Lake or seen people floating in it in pictures? How about the Dead Sea (really also a salt lake)? In your class you should be able to find at least one student who has made the observation that it is easier to float in salt water than in fresh water and that it is easiest to float in salt lakes that are even saltier than the sea.

What do they know about fresh and salt water from previous experiments? Salt water weighs more than an equal volume of fresh water. Can they design an experiment to test whether or not this might be important in floating and sinking? Consider the equipment and items available. Use pennies and film cans to make objects that are the same size, but have different weights. Film cans with 5, 10, 15, and 20 pennies make a nice series. Here are several tests they might try:

1. Put two clear plastic glasses in shallow pans to catch the overflow. Fill them absolutely full, one with salt and one with fresh water. Holding it by a wire or string, lower a heavy film can (20 pennies) into the fresh water. Observe what happens. The water that flows over into the pan is DISPLACED by the object. Try the same thing with salt water. Does it look like the same volume of water spilled over? Measure both and record the volume. The volumes should be the same. Do they weigh the same? Weigh the water samples. (The fresh water weighs about 40 gm and the salt, about 60 gm.) The same volume of salt water weighs more. Compare the weights of the water with that of the object that sank. It weighed more than either amount of water displaced. Record the results. From this they can conclude that objects displace water.

2. Try an object that is light and floats in both (8-10 pennies). Does it displace the same volume of water? Check to see. No, it will displace more fresh water than salt water. It floats higher in the salt water. Does it displace the same weight of water? Yes. What does the object weigh? It should weigh the same as the displaced water from both salt and fresh water.

Repeat this for several floating objects. Can the students formulate a rule based on their observations? An object that floats displaces a volume of water which weighs the same as the object.

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3. Attach the 10 penny can to the spring scale and lower it into the water. Can the students observe the water supporting the weight of the object? It should become "weightless" on the scale when supported by the water.

4. What about a film can weighted to float in salt water but sink in fresh water? Can the students make one? It should be in the range of 11 to 14 pennies for a Kodak can. Repeat the tests. Students should find that the volume of salt water displaced is equal to the weight of the object while the displaced fresh water weighs less tnan the object. Hence, it sinks in fresh water.

5. Now for a challenge! Does a ball (about 1½ in in diameter) of clay sink or float? It sinks. If the students change its shape, will it still sink? Try it flat or elongated. It still sinks. Compare its weight with that of the fresh water it displaces. Can the students figure out how to make it float? Forming it into a boat is the easy answer. Making it into a hollow ball is sneakier and much harder. (Clay might be shaped around a ping-pong ball to make a hollow clay ball.) It takes a great deal of trapped air to make the clay float. Has the weight changed? Measure it. No. What has changed? Its displacement or volume. Gently push the hollow ball under and compare its displacement with that of the original ball of clay. It displaces a greater volume, enough to more than equal its weight.

CONCLUSIONS:

If an object displaces a volume of water whose weight is equal to its own weight, it will float. If it does not, it will sink.

EXTENSIONS:

1. If you have older and/or gifted students, you may also introduce the concept of DENSITY by having the students calculate the weight per unit volume of the objects you have. You can find the volume of the objects by filling a measuring cup part way with water. Record the level. Then sink the object below the surface and record the new volume. Subtract the volume of the water from the volume of the water plus object to find the volume of the object. When all the objects' densities have been calculated, arrange them in order. What is the density of the fresh water? The salt water? Weigh a measured volume to find out. Where do they fit in the series of densities of the objects? Can you make a statement about density of an object versus density of a fluid with regard to whether it sinks or floats? If the object is less dense than the fluid, it will float. If it is more dense, it will sink.

2. If you have great students who like to think about space travel and planetary science, you may have your students calculate SPECIFIC GRAVITY for each object. Weight depends on gravity. Things weigh less on the moon where the gravity is less, but they have the same MASS. Specific gravity generally uses distilled water at 4° C as a standard and sets it equal to 1. Since water does not change, everything is compared to it. You could use cold tap water without being too far off. Divide the density of an object by the density of the fresh water to get the object's specific gravity. For example, if the object were 2 gm/cubic centimeter (milliliter) and water is 1 gm/cubic centimeter (milliliter), then the specific gravity of the object is 2. The units cancel out. Anywhere in the universe the specific gravity will always be 2 although the object's weight will change with gravity.

3. Specific gravity of liquids is measured with an instrument called a hydrometer. There are many activities which have the students make a hydrometer: a thumb tack in the end of a pencil; clay and sand in a soda straw. Once they have made one, students can compare the specific gravity of other liquids to water. They can also compare salt water or hot water. If liquids are used that are dangerous (ie. methyl alcohol), be sure that students are aware of the possible danger. Household products like cooking oil, pancake syrup and corn syrup should do.

ACTIVITY 19 Name Possible answers

KEEPING YOUR HEAD ABOVE WATER

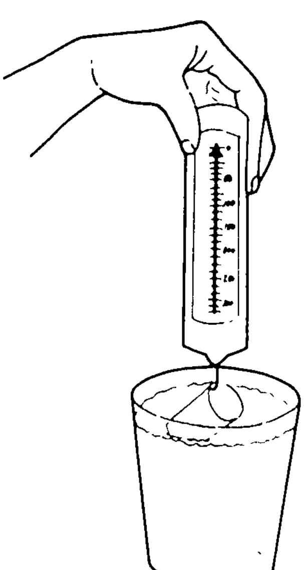
Use this sheet to record each test that you did and the results.

answers vary

Can you make a general conclusion about things that float based on your tests?

Things that float are less dense than water.

Things that sink weight more than the volume of water they displace.



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ACTIVITY 20

SINKING SLOWLY

HOW DO TINY PLANTS, WHICH NEED LIGHT, MAINTAIN THEIR POSITION IN THE WATER COLUMN IF THEY ARE HEAVIER THAN WATER? HOW DO TINY DRIFTING ANIMALS KEEP FROM SINKING TO THE BOTTOM?

SCIENCE SKILLS:

- observing
- measuring
- inferring
- predicting
- experimenting

CONCEPTS:

- Phytoplankton and zooplankton have a variety of adaptations which help them remain in position in the water column.

MATH AND MECHANICAL SKILLS PRACTICED:

- measuring time
- construction of models

SAMPLE OBJECTIVES:

- Students will be able to describe strategies plankton use to maintain their position in the water.
- Students will be able to apply an understanding of form and function to the construction of a model.

INTRODUCTION:

In this exercise, students will obser . pictures or a film about plankton and then apply what they have learned to the construction of a model. The goal in constructing a model of phyt plankton or zooplankton is to make one that sinks most slowly. This activity is best suited to warm weather when it can be done outside as both students and floor are likely to get wet. The construction phase may be done as a homework assignment with the contest taking place at school.

MATERIALS:

- pictures of phytoplankton and zooplankton
- movie or video on plankton if available
  Plankton and the Open Sea, 18 minutes, Encyclopedia Britannica
  Plankton of the Sea, 12 minutes, Fleetwood Films
  Plankton: Pastures of the Ocean, 10 minutes, Encyclopedia Britannica
  Plankton: the Endless Harvest. 18 minutes, Universal Education
- live or preserved plankton if available (see Recipes for easy ways to view plankton, even without a microscope, and for sources)
- clay, plastic vials, nuts, nails, toothpicks, wire, strings, styrofoam pieces, cooking oil, film cans, aluminum foil, coffee stirrers, straws, glue
- buckets of water
- one large aquarium or a trash can full of water
- stopwatches or digital watches which read in seconds (optional)
- small, inexpensive prizes

LESSON PLAN:

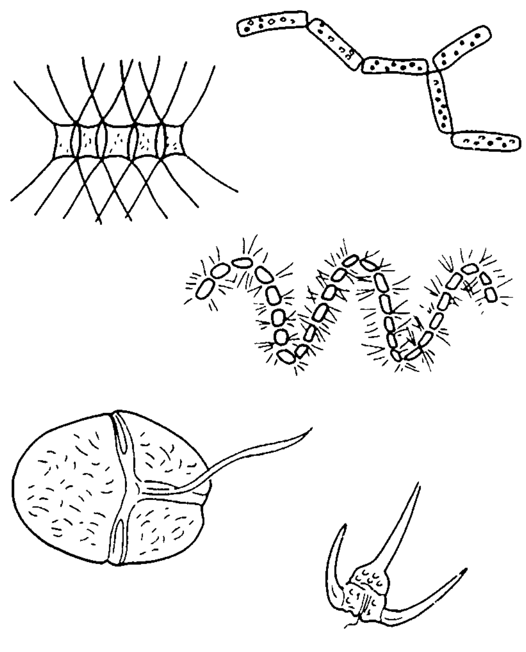
BEFORE CLASS:

This is a great, messy activity. It is particularly good for a warm day when the class may be naturally restless and ready for some excitement. The best way to finish this class is with a contest so you may want to think about some possible prizes.

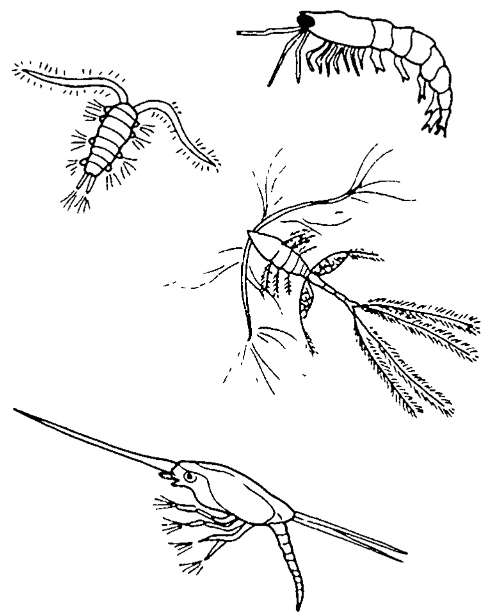
DURING CLASS:

METHODS: Start with observations of zooplankton and phytoplankton. Observe their shapes, projections and behaviors. Most plankton are heavier than water and tend to sink. Ask how they might stay up in the water. Make a list of the students' observations. Encourage thought about the discoveries on density from the preceeding lab.

Some of the students should notice that many plankton have long projections or antennae or hairs. Have them speculate on how these would affect movement through water. Could the students run through water faster with their own arms spread out or folded up?



phytoplankton



zooplankton

Now the students are going to see if they can make a model phytoplankton or zooplankton which will sink slowly. Since "thrashing" or swimming is not possible in a non-mechanical model, they must concentrate on designing a plant or animal that is just barely heavier than water and that slows its rate of sinking by increasing its resistance to movement through water with long projections or hairs or that sinks slowly because it swings back and forth as it goes down. Have selections of materials and buckets of water available around the room for design and testing. Use stopwatches to time the speed of sinking. Set a time limit for experimentation and announce a contest for the slowest sinking animal or plant at the end of that time.

The best way to have the contest is to gather around a large glass aquarium where everyone can see. A big trash can of water or a large bucket will work, but you cannot give everyone a good view. In that case have several students help you as judges. You can time each separately, but it will be more exciting if pairs of phytoplankton or zooplankton are released to "reverse race" their way down. Put both on a sheet of cardboard so they can be tipped in at the same time for a fair start. The SLOWEST from each pair goes into a second heat and so on until you get down to two.

Have the students analyze what they think made each of the last two models winners. Then have them vote on which they think will win the grand prize for slowest overall based on their analysis. Do the final test and distribute prizes.

Note: The plankton must SINK not float. They may not sink because they get wet slowly, but rather, because they are heavier than water from the start.

RESULTS:

Something just barely heavier than water with lots of projections should win unless a student can produce a flat, pie pan shaped object that makes big swings from side to side as it descends.

CONCLUSIONS:

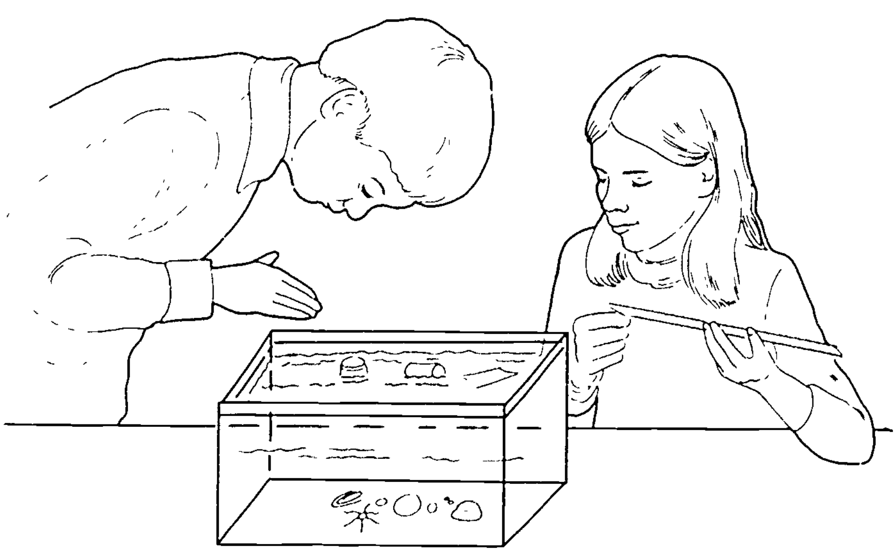
The strange looking shapes found on plankton have specific functions, including helping them stay in the lighted zone of the water where they can get enough light for photosynthesis (making food using light energy).

USING YOUR CLASSROOM AQUARIUM:

It is best not to do this activity in a functioning aquarium as the models may contain toxic materials, and the fish will not enjoy the activity. If you have live zooplankton for this class, try feeding it to the fish in your aquarium when you finish.

EXTENSION:

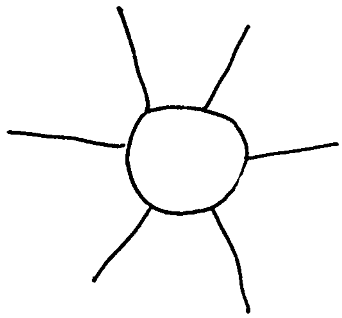
1. Have the students write a poem or paragraph about what it might feel like to be a phytoplankter or zooplankter, tending to sink. Remember that zooplankton can "swim" their way up.



ACTIVITY 20 Name Possible answers

SINKING SLOWLY

Draw a picture of the model plankton you designed.



If you did not have the slowest sinking model, compare how your model differed from the winner in terms of its shape. How would you change your design to make it sink more slowly?

No, mine was not the slowest. The winner had more projections to "catch" the water. It had more resistence or drag. Also, it was not so heavy.

ACTIVITY 21

SINK OR SWIM

WHAT ARE THE SPECIAL STRUCTURES THAT ALLOW FISH TO STAY UP IN AND MOVE THROUGH THE WATER?

SCIENCE SKILLS:

- observing

CONCEPTS:

- Most fish are well-adapted as swimmers.
- Fish have special structures such as fins which enable them to move through the water.
- Most fish have a swim bladder which regulates their buoyancy.

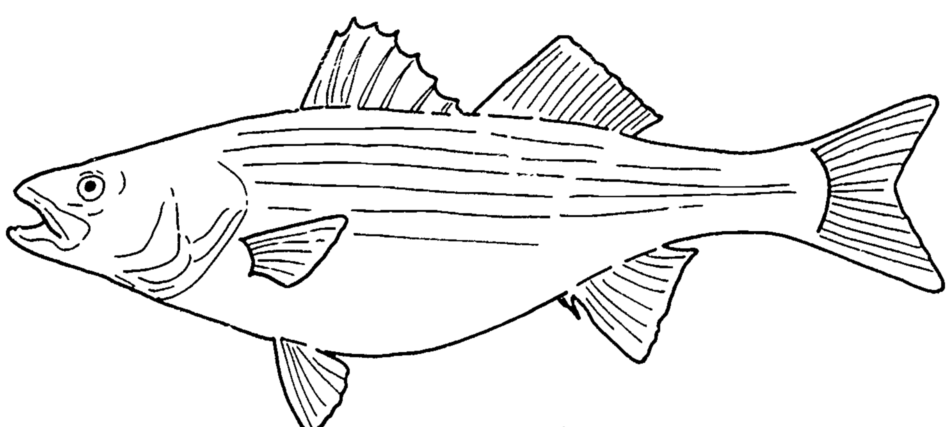
MATH AND MECHANICAL SKILLS PRACTICED:

- dissection

SAMPLE OBJECTIVES:
- Students will be able to do an orderly dissection to investigate a question.
- Students will be able to list and locate the fins of a typical fish.
- Students will be able to locate the internal organs of a fish.

INTRODUCTION:

Observing the external and internal anatomy of a BONY FISH is one way to answer the main questions that this lesson poses: how do fish move through the water and how do fish keep their vertical position within it? Your students will also learn about other fish adaptations and characteristics while observing and dissecting a fish. Contrary to what students may think, a dissection is a clean, neat and organized activity. It is not a cut, slice, hack and saw proposition; rather, each part must be carefully unwrapped from the other organs nearby. It should be thought of as uncovering the layers, one by one, so as not to harm the layer below. It is important to stress this with the students before beginning any dissection. Simple scissors with one sharp point and one rounded point are the only cutting tool needed.



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MATERIALS:

FOR EACH GROUP:

- a fish that has not been cleaned (seafood market or grocery store or caught during a vacation; keep on ice or frozen; thaw under cold running water ½ hr before use)
- newspapers or a dissecting tray
- one pair small sharp scissors (one point side pointed, one rounded)
- one probe (can be a coffee stirrer or round wooden stick)
- one pair of tweezers (useful but not required)
- paper towels
- work sheets

FOR THE CLASS:

- microscope (if available) or hand lens or magnifying glass
- one fish for demonstration (about 1 ft or so in length)
- small balloons
- a clear container of water into which one fish will easily fit
- safety pins or needle and thread

LESSON PLAN:

BEFORE CLASS:

The best fish for dissection are ones you catch and immediately freeze. You could put out a call among your students to save and freeze fish from a fishing trip with their parents. The insides turn to mush if the fish are allowed to sit around at room temperature. Thaw in cold running water shortly before class. Saltwater fish frequently have a larger swim bladder than freshwater fish. Practice dissection and prepare a fish to serve as a model for the students by dissecting it and labeling the internal organs in advance. If you plan to do the fish printing activity, remember to do it before the dissection.

DURING CLASS:

METHODS: Introduce this activity by reviewing the adaptations of other organisms for life in different places in the water. Some have special appendages to slow their rate of descent through the water; others have structures that allow them to live on the surface tension. But what about fish? What do they have that keeps them from sinking and enables them to occupy different levels in the water? Students will no doubt mention fins, but is there anything else? How about studying the external and internal anatomy of a fish to find out?

Discuss safe use of scissors and rules for behavior during dissection. Students tend to want to stick their fish in somebody's face to hear screams. Pass out the fish and work sheets and let teams proceed while you circulate to keep things going.

When the students have completed their dissections, find out if they found a swim bladder. Try this demonstration to see how it works. First ask students to predict what will happen when a dead fish, that has already been frozen and thawed, is placed in a tub of water. Try it! If it is not rotten, it will sink. Now, make a small cut with scissors in the underside of the fish (beginning at the vent opening). Insert a very small balloon, inflated just a little, into the opening. Use a needle and thread or safety pins to close the cut and hold the balloon in place. Does the fish sink or float when placed in a container of water now? This demonstration shows how a fish's swim bladder actually works to keep the animal suspended in the water, although its actual position will not be correct. You might also try taping a balloon to the fish's back for a demonstration of balance.

USING YOUR CLASSROOM AQUARIUM:

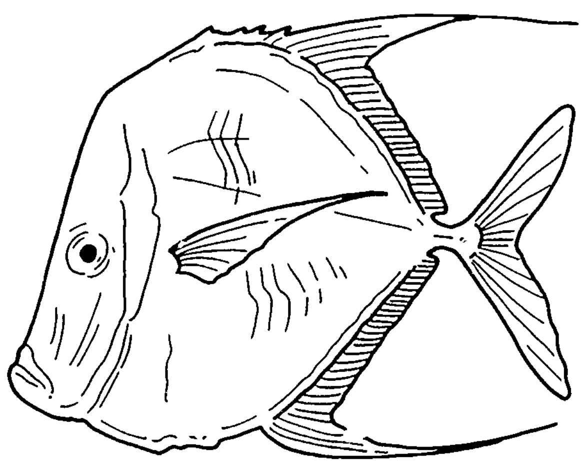
Observe live fish in an aquarium; note especially which fins are used, how they are used, and how easy or difficult it appears for different species of fish to remain suspended in the water. Do some remain motionless, hanging in the water? Which fins are used for swimming? Do all your fish swim in the same way?

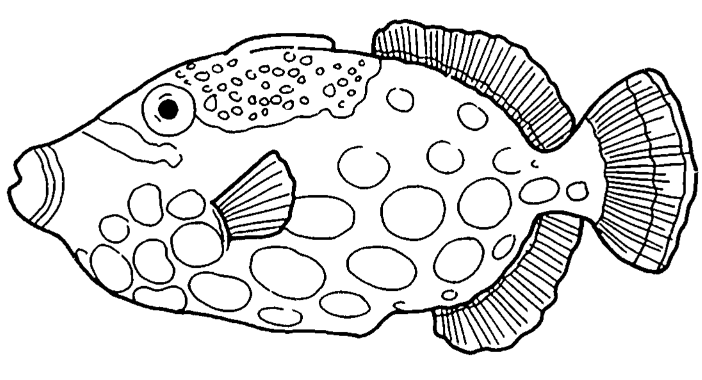
EXTENSIONS:

1. During dissection, have students remove sections of the backbone and/or the jaws and teeth. These can be cleaned, dried and preserved for later observation by removing as much of the flesh as possible, placing the bones in a jar of bleach for several days and then setting them somewhere safe to air dry.

2. Show the film *What is a Fish?* This 22 minute Encyclopedia Britannica film #2033 includes footage of a dissection as well as sections on adaptations. This is an excellent film.

3. Compare the differences, both internal and external, between sharks and bony fish by dissecting a shark with your students. Sharks can be obtained from biological supply companies, fishermen, and sometimes fish markets (especially if you let them know you're looking for one). Several manuals exist concerning shark anatomy and are available from biological supply houses. One major comparison would be the large oily liver of a shark, which provides buoyancy in place of the bony fish's swim bladder. Some sharks also swallow air at the surface for temporary buoyancy.





FISH PRINTING

A good follow-up to a fish anatomy lesson is an art activity called fish printing. This activity also fits into social studies if you are studying Asia.

The Jap. .se invented "gyotaku" (gyo = fish, taku = rubbing) as a means of recording their catch. (A fish print never lies!) Gyotaku (pronounced ghio-ta-koo) has since evolved into an art form and is a good way to gain appreciation for the beauty and variety of marine organisms. Fish printing may be done on paper or fabric; directions are similar and given for both.

MATERIALS FOR FISH PRINTING

- fish (any fish that is fairly flat and has obvious scales)
- newspaper
- paper towels
- newsprint (rice paper is traditional but expensive)
- water soluble paint or textile ink
- stiff-bristled paint brushes
- thumbtacks or tape

This can be rather messy and time-consuming, so plan accordingly. If you use textile paint, the students may make a T shirt or other item. Use cotton cloth for best results.

1. Before the class, wash the fish carefully and thoroughly with soap and water to remove the mucus. Plug the mouth and gills, and vent (if possible) with paper towels so the fish will not leak.

2. Paint the fish. Do not use too much ink. Thin the ink or paint if necessary. Stroke the brush from head to tail, but do not paint the eye. Paint fins and tail last, since they tend to dry out quickly. You may also brush the fish from *tail to head* to catch ink under the edges of scales and spines and improve the print if you use a thin coat of paint.

3. If the newsprint paper under your fish became wet with ink during the painting process, move the fish to a clean piece before printing. Otherwise your print will pick up leftover splotches of color.

4. Carefully lay a sheet of paper over the fish. Taking care not to move the paper, use your hands to press the paper over the fish. Press the paper gently over the fins and tail. Be careful not to wrinkle the paper or you will get a blurred or double image. If printing a shirt, put a layer of newspaper inside the shirt so that the paint does not seep through.

5. Slowly and carefully peel the paper off. Paint in the eye with a small brush. The prints tend to all look alike, so have students write their names on them and tack or tape them to dry.

6. Once a fish has been painted, it must be washed and dried before changing colors. If this is not feasible, use paper towels or a damp sponge to remove as much paint as possible.

7. Fabric items should be ironed (cotton setting) from t' reverse side for 30 seconds to set the color and washed in mild detergent.

ACTIVITY 21
SINK OR SWIM

Name Answers depend on the fish used.

I. THE OUTSIDE

A. What is your fish's general shape? ______________________________

____

Draw your fish in the space below and label all its fins and other parts as you do this worksheet:

B. Feel the surface of the SKIN. What does it feel like? ____________________

____

The skin is covered with MUCUS which helps protect from disease.

C. Most bony fish have tiny pieces of bone in their skin called SCALES. Scales help waterproof the fish's skin and also help protect the fish. Remove a scale and observe it under the microscope or a hand lens.
Draw the fish's scale:

Does the scale have rings? ______________________________

How many rings can you count? ____________________________

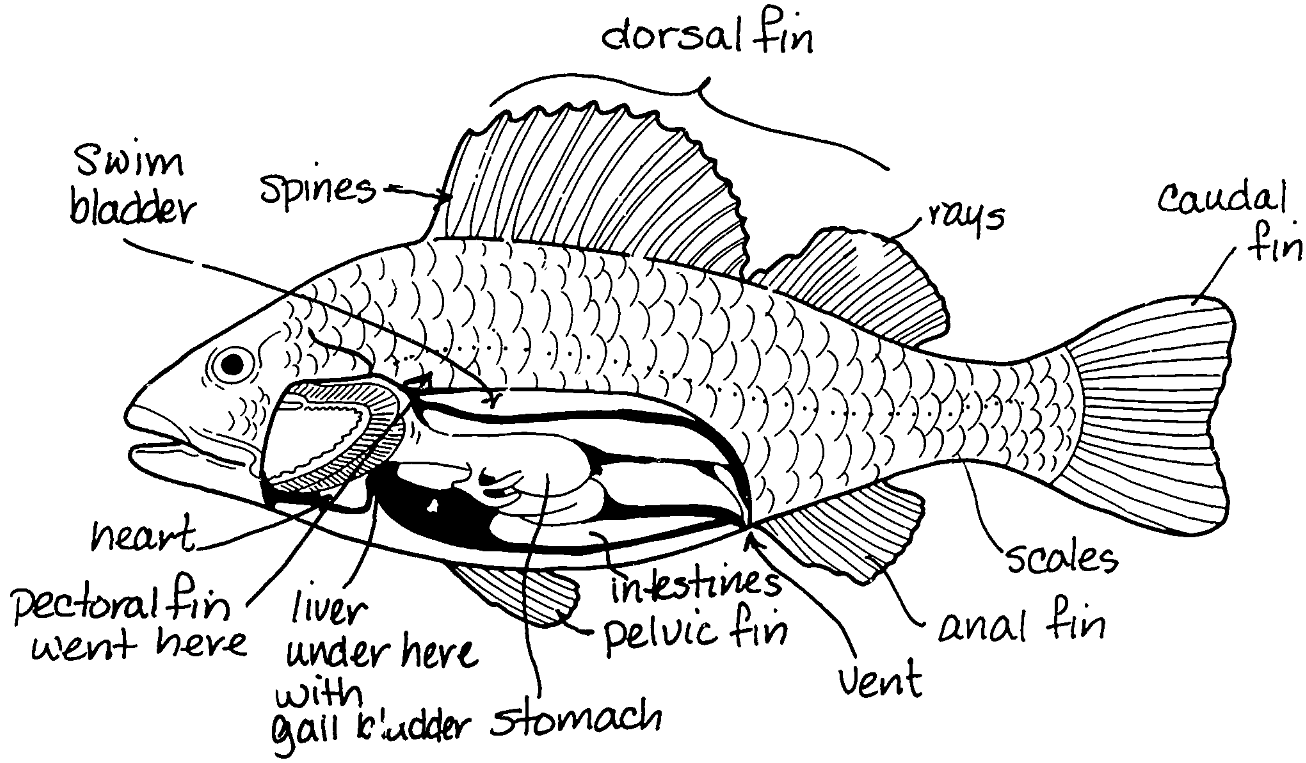
What might the rings tell you? ____________________________

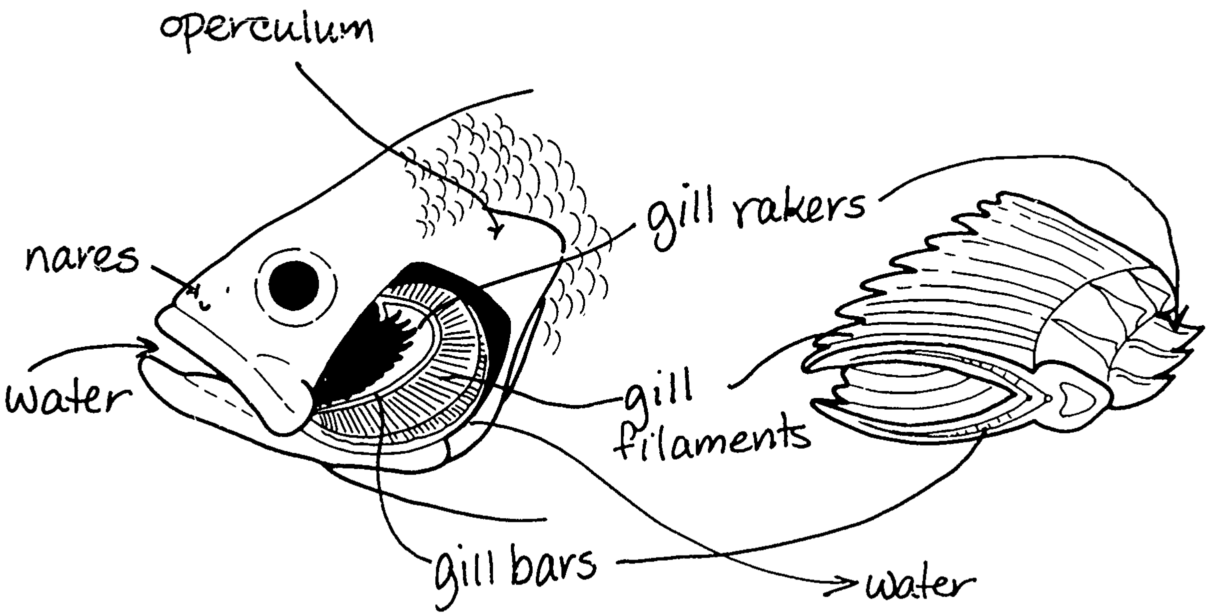
____

D. Is there a line down the side of your fish? ________ Most fish have a LATERAL LINE which senses movement in the water near the fish. Label the lateral line on your diagram if your fish has one that can be seen.

ACTIVITY 21
SINK OR SWIM

Name Fish anatomy does vary





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ACTIVITY 22

GRACE UNDER PRESSURE

DOES WATER PRESSURE VARY WITH DEPTH?

SCIENCE SKILLS:

- observing
- measuring
- experimenting
- communicating

CONCEPTS:

- Water pressure increases with water depth.
- Water pressure pushes in all directions on objects in the water.
- Air is compressed into a smaller volume in deep water due to water pressure.

MATH AND MECHANICAL SKILLS PRACTICED:

- averaging
- graphing

SAMPLE OBJECTIVES:

- Students will be able to give evidence that pressure increases with water depth.

INTRODUCTION:

The difference between this exercise and many similar activities on water pressure and depth is that your students will collect data rather than just observe. The most interesting feature is to compare the differences in results for different groups and try to identify the variables that may give rise to these differences. The use of balloons to observe the effect of increasing pressure on gases is a wet activity and should be done outside in warm weather.

MATERIALS:

FOR THE CLASS:

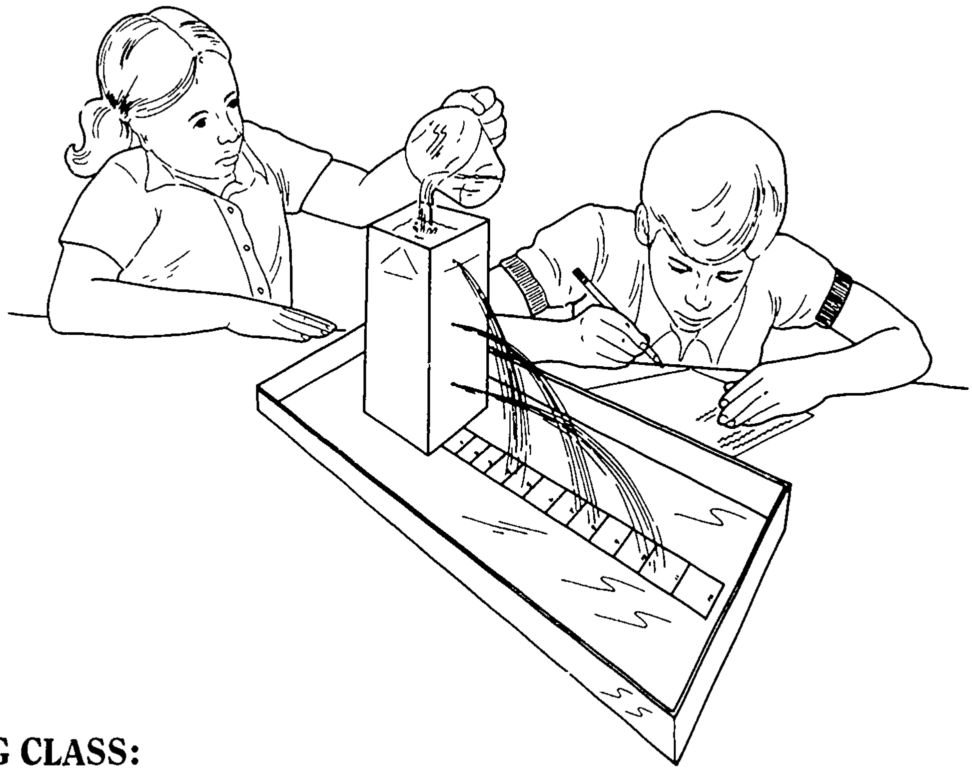
- a large trash can (at least 2 ft deep) filled with water, such as custodial can with wheels
- several small balloons (slightly inflated)
- water source

FOR EACH GROUP:

- enamel tray or 9" × 13" baking pan
- empty cardboard milk carton (some quart size and some half gallon) or quart and half gallon plastic soda bottles
- plastic ruler
- 3 nails of same size (finishing nails best; use two different diameters for different groups but all the nails within a group are the same)
- tape

LESSON PLAN:
BEFORE CLASS:

Organize the materials. If you have only two groups working, use only one size of nails. If you have four or more groups, divide the materials in this combination: half gallon with large nails, half gallon with small nails, quart with large nails, quart with small nails. Large nails would be more than 1½ in long.



DURING CLASS:

METHODS: Introduce the idea of water pressure by asking what happens to your ears when you dive to the deepest part of a swimming pool? Hold up a milk carton and ask the students if they think the greatest water pressure would be near the top or the bottom. How could they test this? One way to test their hypothesis is by measuring the differences in streams of water flowing simultaneously from the top, center, and bottom of the milk carton. Would they expect the lengths of their water streams to remain constant or to change with time? Let them experiment to find the answer to this question, but collect their data with a constant water level which is achieved by gently pouring water in the side away from the holes as it drains out. The set up looks like this: If holes are punched very low on the milk carton, you will need to elevate it above the tray slightly. Use the ruler to punch all the holes at the same distances from the top of the containers for each group. Leave the nails in the holes until after the carton is filled.

Tape the ruler to the pan to keep the ruler from floating away. When ready to begin measuring, remove all nails at the same time. Measure the distance from the container that the water flows.

A separate question is how water pressure affects gases trapped in animals that descend into the water. Introduce a challenge, to be attempted in teams of no more than two at a time: can the students observe (feel) a difference in the volume of air in the balloon as it descends to the bottom of a trash can full of water? This is a wet activity! Students should roll up their sleeves and reach down only as far as they comfortably can. They should try to keep their hand in the same position around the balloon as they move down into the barrel. They should be able to feel the balloon shrink in their hand. Another method is to squeeze the balloon at the surface and then observe how much they can ease up on their squeeze as the balloon descends. Establish rules in advance concerning the whereabouts of the water and the balloons.

RESULTS:

Compile the data on the blackboard. Compare the results from the different groups. Students should be surprised to learn that hole height (depth) and hole diameter are important, but that the volume of the container is not. Smaller holes have greater resistence to flow and will reduce the force of the water moving through them. Average the data and draw a bar graph to show the length of the water stream from each different hole.

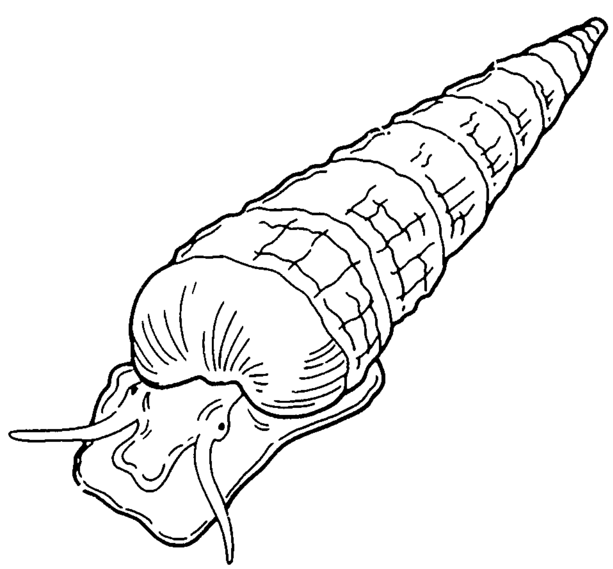
CONCLUSIONS:

Water pressure is greater with depth. That is why the stream of water flows farther out at the bottom of the milk carton than at the top. The water pressure provides the push. As trapped gases descend in depth, they are compressed by the water pressure until the internal pressure of the gases is equal to the external water pressure.

EXTENSIONS:

1. Invite someone who is a scuba diver to speak to the class and expand on the pressure/depth relationship and its importance to people using self contained underwater breathing apparatus (SCUBA). If you do not happen to know a diver, you might be able to enlist the help of someone who works at a local dive shop or YMCA.

2. If you did Activity 2', have the students predict what might happen to the swim bladder of a fish that was caught in deep water and brought to the surface. The swim bladder is full of trapped gases. It quickly expands as the pressure decreases. Sometimes it inflates until it pops out the fish's mouth. It may also "blow up."



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ACTIVITY 22

Name Possible answers

GRACE UNDER PRESSURE

What question are you going to answer with this experiment? What are some of the variables that affect water pressure?

What size container do you have? 2 quart (1/2 gallon) milk carton

How far below the water surface was each of your holes?

Top 7" Middle 4.5" Bottom 2"

Did you have large or small nails? small

How far from the base of the container did the water flow from each hole?

Top 1" Middle 4" Bottom 7"

Compare your data with others in the class by filling in this chart. Write the distance from the carton, using the same units for all measurements.

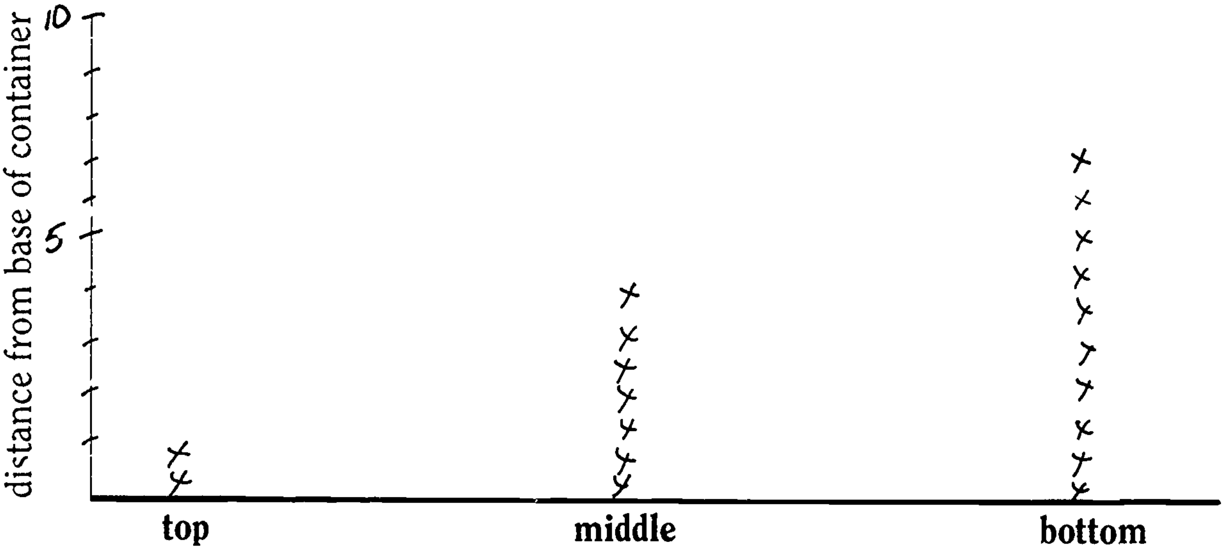
1
0.5
2
3)3.5
1.2

distance from container

hole position	groups								average
	1	2	3	4	5	6	7	8	
top	1"	1/2"	2"						1.2"
middle	4"	4.5"	3.5"						4"
bottom	7"	8"	6"						7"

4
4.5
3.5
12.0

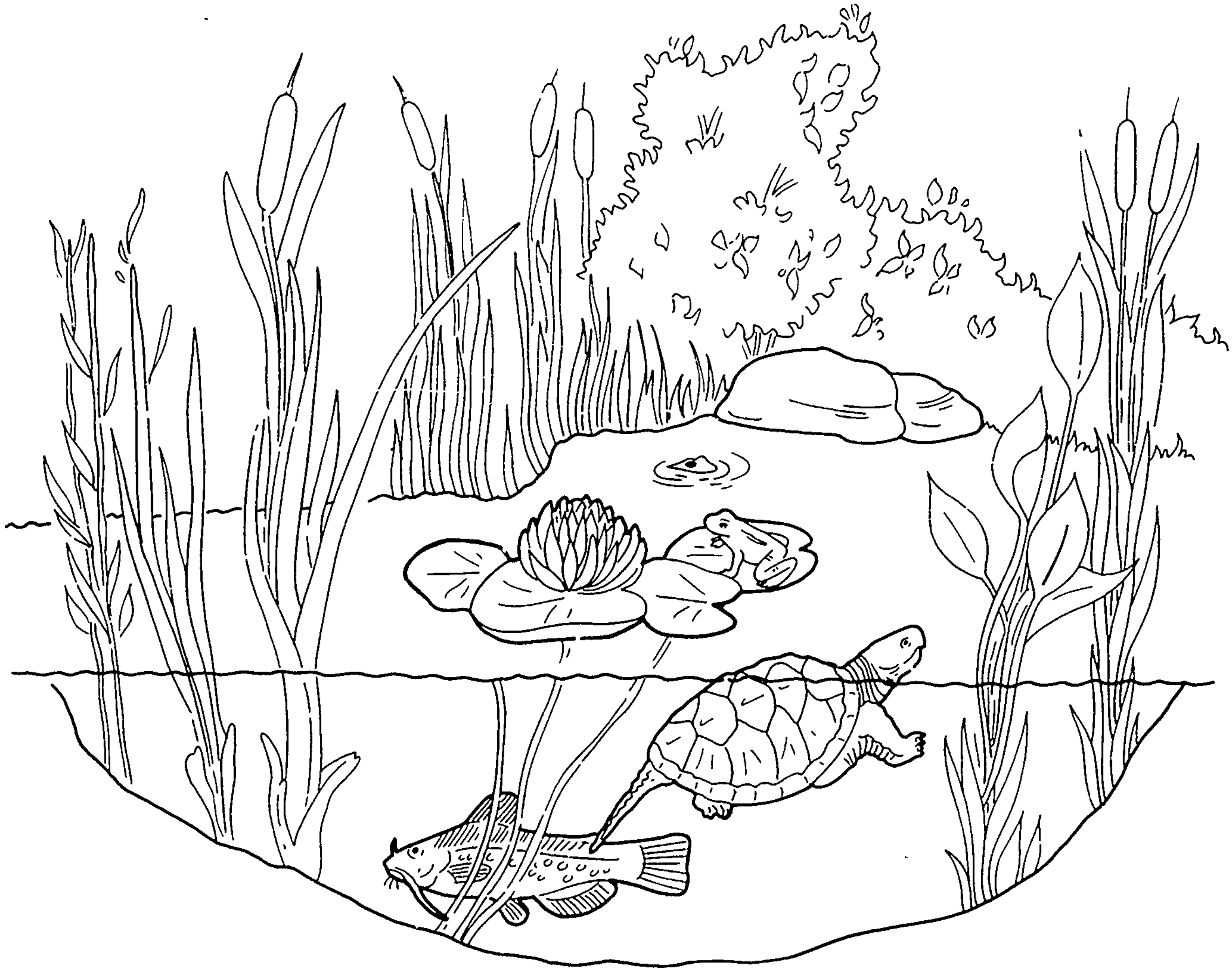
Make a bar graph to compare these results:



What conclusion can you make based on the results of this experiment?

Water pressure increases with depth. The size of the diameter of the container made no difference.

1 3 2



ACTIVITY 23

LIFE AT THE SURFACE

WHAT IS THE SURFACE OF THE WATER LIKE? CAN ANIMALS TAKE ADVANTAGE OF THE WATER SURFACE AS A PLACE TO LIVE?

SCIENCE SKILLS:

- observing
- predicting
- experimenting

CONCEPTS:

- Water has a strong, elastic "skin" on its surface which forms surface tension.
- Some animals ride on the surface tension.

MATH AND MECHANICAL SKILLS PRACTICED:

- careful hand/eye coordination
- graphing
- averaging

SAMPLE OBJECTIVES:

- Students will be able to demonstrate the existence of surface tension.
- Students will be able to create a model of a living organism from simple materials.

INTRODUCTION:

These exercises examine the tendency of water to stick to itself. This cohesive property of water is perhaps most obvious at the surface. The top layer of water molecules forms a film or "skin" which is relatively strong which we refer to as SURFACE TENSION. Many animals and plants live directly on the surface of bodies of water. Even though they are heavier than water and cannot float, they stay at the surface by "riding" on the surface tension. In these activities students will experiment with surface tension and then try to design an animal that is heavier than water, but stays at the surface because of surface tension.

MATERIALS:

FOR EACH STUDENT:

- cup of water
- 2 paper clips

FOR EACH TEAM:

- small pie tin
- 50 pennies or 20 marbles (the whole class should use the same item)
- eyedropper
- dish pan or bucket of water
- dishwashing detergent

FOR THE CLASS:

- materials for the model animals which might include: toothpicks, thin wire, string, straight pins, clay, staples, wooden or plastic coffee stirrers, wire screen, plastic strawberry basket

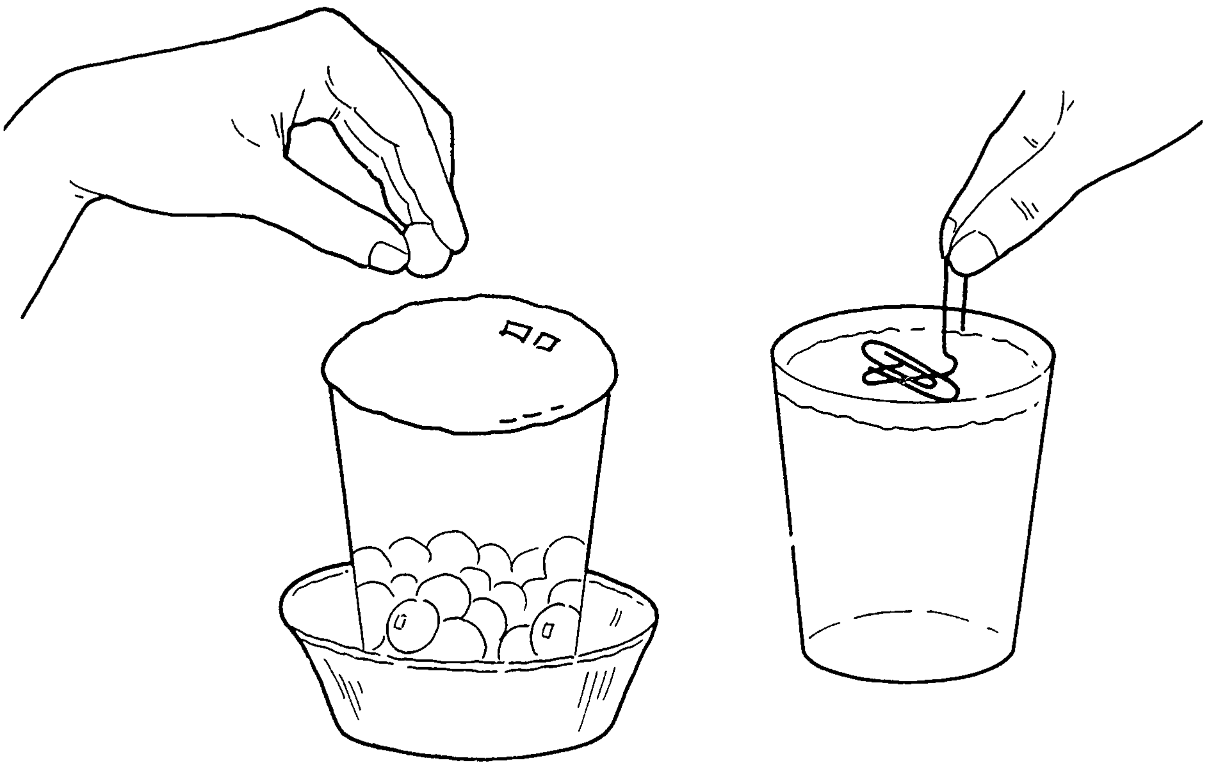
LESSON PLAN:

BEFORE CLASS:

Try making the model yourself. Simple thin wire makes a nice "water strider." This is not easy. The students will learn more if they are allowed to work through trial and error rather than by copying your design. Note: be careful not to refer to things that are supported by surface tension as floating. They are heavier than water and DO NOT FLOAT. If you demonstrate parts of this, try using the overhead projector to enable all the students to see.

DURING CLASS:

METHODS: Introduce the activity by referring back to earlier activities in which students used spoons to remove water from a container. Ask students if they noticed how the water in the spoon formed a nice, rounded top. What causes this? Have each group put a clear plastic glass in a small pie pan and fill it until the water is exactly level with the top of the glass. Would they say the glass was full? Yes.



How many marbles (pennies) could they put in before the glass runs over? Have them estimate the number. Now drop pennies or marbles into the cup one at a time, counting as they go. What happens? The water piles up into a rounded bulge until it finally appears to break. How many marbles (or pennies) did it take? Have each group write their numbers on the board and then plot the results. Then add the numbers and calculate the average number of marbles dropped in before the rounded top was "stretched" too far.

Now discuss what happened. The water molecules are attracted to each other: they stick together. At the surface this produces a "film" that covers the surface and holds it. Eventually so much water was pushing against the film, called SURFACE TENSION, that it broke and the water fell over the sides of the glass.

How strong is this film? Would the students predict that a paper clip would float or sink? Try it. The illustration shows how a paper clip can be lowered onto the surface so it rides on surface tension. After they have tried, if none of the students are successful, demonstrate this method and let them try it. Can you prove that the paper clip is not floating, that it is not lighter than water? Touch it gently and it sinks. Try adding a drop of dilute detergent to the water. It should also sink as detergent destroys the surface tension.

Have any of the students ever seen animals that use surface tension? Some kinds of beetles and bugs walk on water in search of prey. The water strider, a familiar pond bug, has special hairs on its first and third pairs of legs which form dimples on the water surface. The strider's second pair of legs actually penetrate the surface tension and work like oars to propel the insect over the surface. There is a marine species of water strider as well. Other kinds of insects, like mosquito larvae, hang upside down from the surface film and poke a breathing tube up through it. A pond insect called a springtail has a spring-like appendage with which it jumps around on the surface of ponds and temporary water holes. Whirligig beetles are so well-adapted for life on the surface tension of ponds that each eye has two halves: the upper half can see above the surface while the lower half simultaneously views the underwater world! Some insects that might otherwise be preyed upon by water striders are able to spit small amounts of detergent into the water and cause the strider to go under before grabbing its meal!

Can your students design an animal that uses surface tension? The winner is the student who designs the heaviest model organism that can ride on the surface tension. Provide them with a box of little "model parts" (see list of ideas in MATERIALS section) with which to build their "creatures." Remind them that the model must sink when detergent is added to the water, yet must ride on surface tension when placed gently on the surface. You might want to turn this exercise into an elaborate contest. If so, have the students with viable entries bring their creatures to the front of the room. Allow them to place their models, one at a time, on the surface tension of a large, clear container of water in full view of the class. Weigh the ones that are successful and determine the heaviest. Award a prize to the winner.

RESULTS:

The students generally make very low predictions for the number of objects that can be added to a full container. Why did different groups get different results? They may have started with slightly different amounts of water; the way they dropped the objects may have been different; or the glasses may have been a bit dirty which changed the surface tension. It is normal for there to be variability in results which is why experiments must be repeated over and over to be sure. The use of statistics enables us to compare variable results.

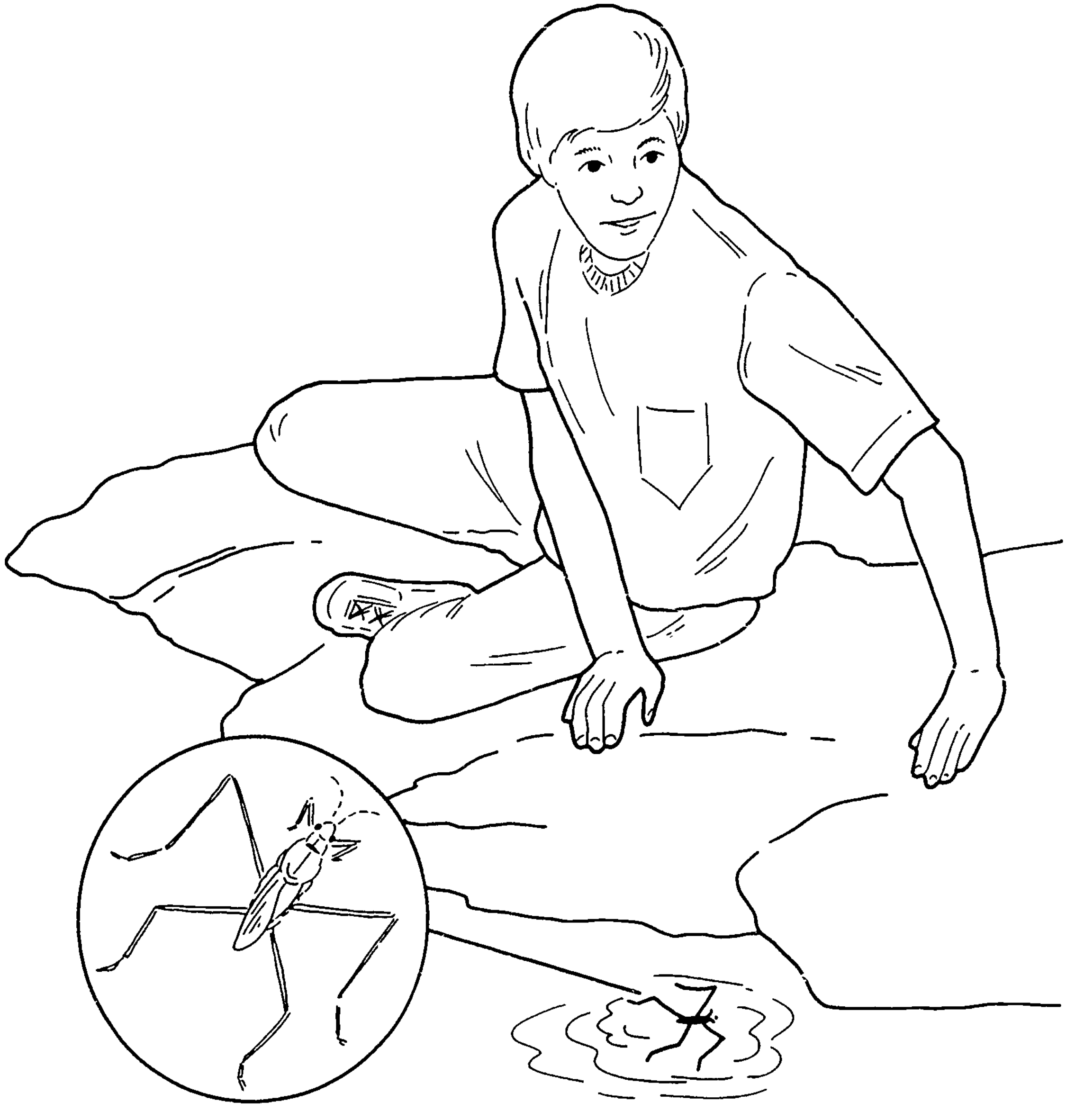
Initiate a follow-up discussion concerning which model shapes and parts worked best. It will probably be clear that the models with their weight evenly distributed over the surface area, not all in one spot, work best.

CONCLUSIONS:

While water has surface tension which can be exploited by some animals, only a few designs work. It is very hard to "ride" on surface tension. Only designs that spread the animal's weight over a very wide area work. This can be likened to what happens when people try to walk on the thin ice of a pond. They break through. To save themselves they may crawl to shore by spreading their arms and legs while lying flat and inching along carefully. They do not weigh less, but have spread their weight over more of the ice surface.

USING YOUR CLASSROOM AQUARIUM:

If any of your students live near a pond, ask if they can safely collect some water striders. Add them to your aquarium while all the students are watching. In addition to seeing animals ride on surface tension, they may get to see how the water striders deal with hungry fish.



EXTENSIONS:

1. Begin a discussion of the creatures that live on the surface tension and their special adaptations for this environment. Have students research the animals mentioned in this exercise and look for other examples of animals that "walk on water." They might be surprised to learn about spiders that live on the surface of the ocean. Use pictures the students draw along with descriptive paragraphs for a bulletin board.

2. Discuss strategies for reducing the local mosquito population. Since the larvae develop while hanging upside down on the surface tension and use a snorkel-like breathing tube, spreading oil on the water's surface to block their air supply can act as a "natural" pesticide. What harmful effects to other plants and animals may be the result of this practice? Oil can prevent oxygen from diffusing into the water.

ACTIVITY 23

LIFE AT THE SURFACE

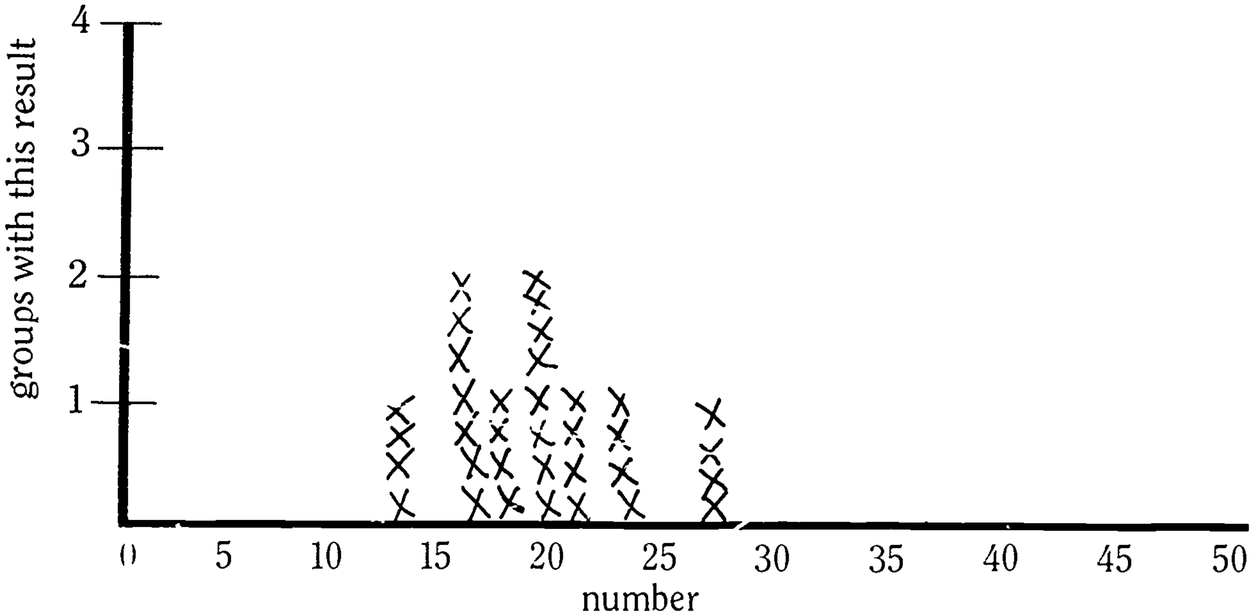
Name Possible answers

How many objects do you predict that you will be able to add to the glass before the water runs over? 2

How many did you actually add? 19

What happened when you added objects to a full glass of water? The top of the water bulged up. Finally, it overflowed.

Plot the number of objects each group added before their water ran over:



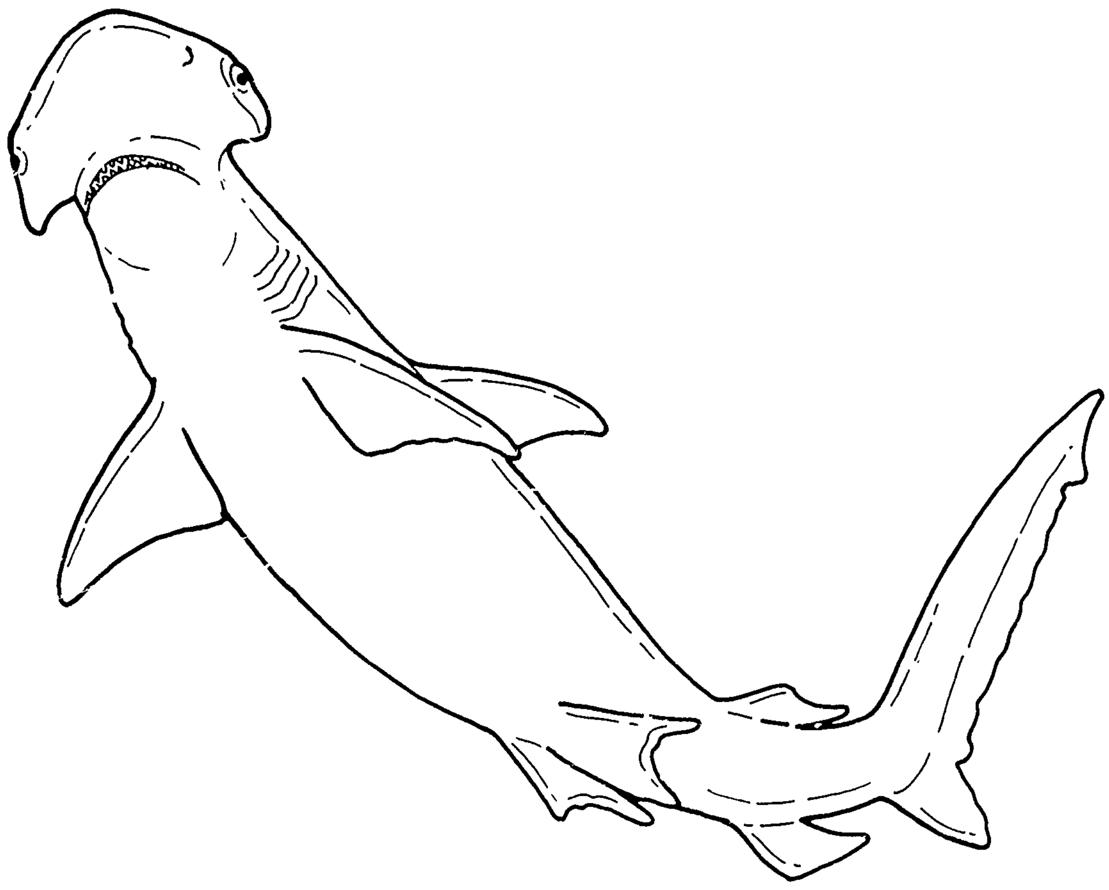
What is the average of all these numbers? 19

How did it compare with your estimate? My estimate was way too low.

Did you succeed in making the paper clip ride on surface tension? after demonstration

What happened when detergent was added? The paper clip sank!

Draw a picture of your model of an animal that rides on surface tension. If it did not stay up, what could you change that might make it work better?



ACTIVITY 24

AT THE RACES!

HOW DO FISH SWIM? WHAT ARE THE CORRELATIONS BETWEEN BODY SHAPE, SWIMMING TECHNIQUE AND SPEED?

SCIENCE SKILLS:
- observing
- measuring
- organizing
- inferring

CONCEPTS:
- Fish are adapted to movement in water in many different ways.
- There is a correlation between the body shape and swimming speed of different fish.

MATH AND MECHANICAL SKILLS PRACTICED:
- measuring time and distance
- calculating average speeds

SAMPLE OBJECTIVES:
- Students will be able to calculate rate of movement (speed).
- Students will be able to correlate fish body shape and swimming technique with swimming speed.

INTRODUCTION:

In this activity, students are introduced to some of the physical adaptations for movement found in fish. They will measure differences in terms of speed. This activity is designed to be done at an aquarium, science center or zoo which displays a variety of fish species. It works particularly well with sharks if they are exhibited in such a way that they can swim continuously in one direction. Unlike most activities done at such sites, At the Races collects numerical data.

Fish must overcome drag and have a means of propulsion and maneuverability in order to move through water efficiently. A variety of body shapes and structures meet this goal. Not all fish are swift and agile, however. Losses in swimming efficiency in certain species are offset by other adaptations. All adaptations for movement reflect an animal's "lifestyle" which is in turn influenced by the physical factors of its particular environment.

MATERIALS:

FOR EACH TEAM OF TWO:
- clipboard with pencil tied on
- data sheet
- stopwatch or watch that measures seconds
- Moving through water handout

FOR THE CLASS:
- tape measure or carpenter's rule

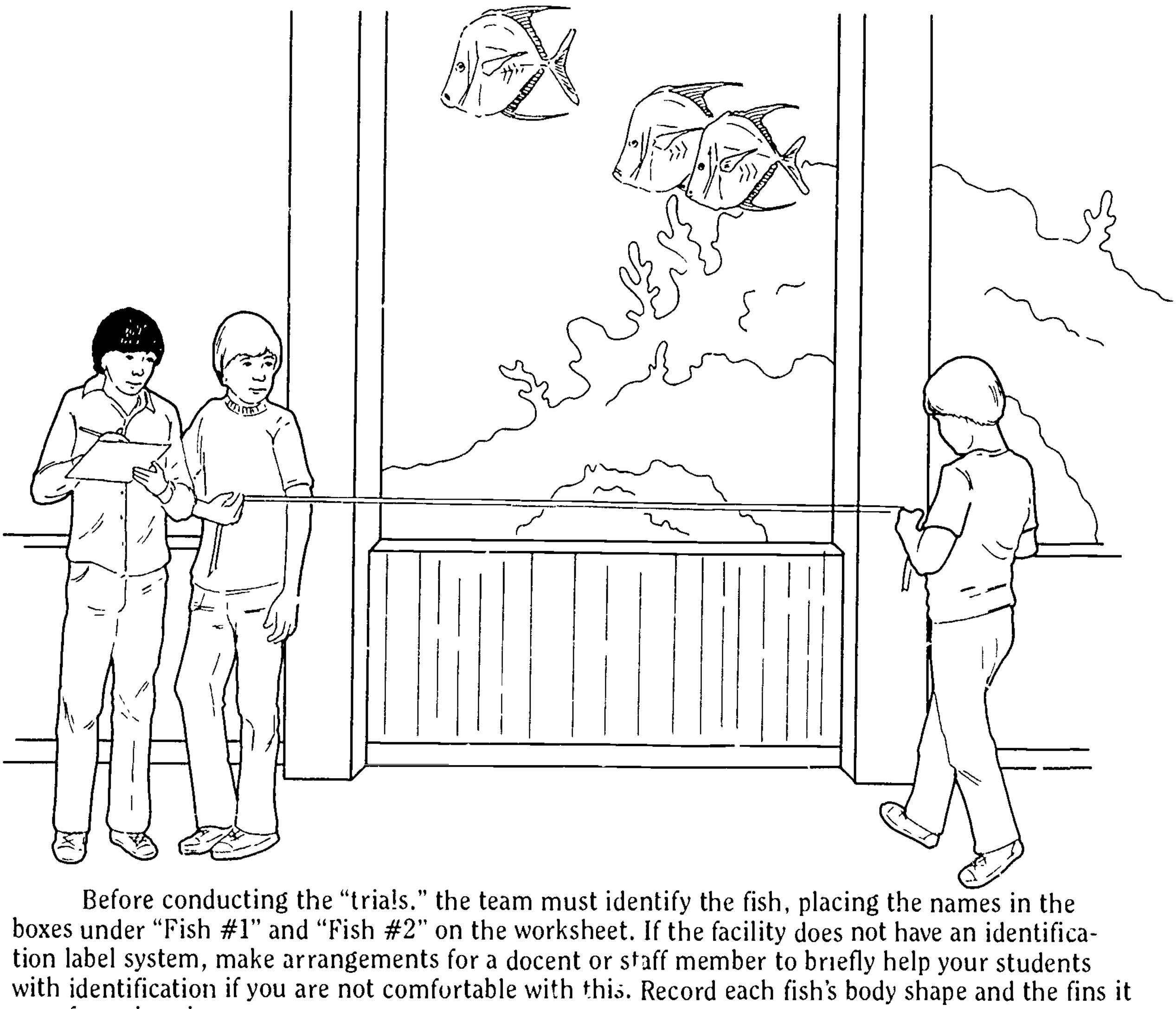
LESSON PLAN:

BEFORE THE TRIP:

Have students read *Moving through Water* which is in the worksheet section of this curriculum. Review the terms used in it. Discuss the research project for the field trip so that students know what they are going to be doing ahead of time. Pick the exhibit in which you will be working. It should have fish which swim freely and be large enough for the students to work in it. For example, at the National Aquarium in Baltimore, both the Open Ocean (sharks) and Western Atlantic Coral Reef are large exhibits which allow the fish to swim in giant circles.

ON THE FIELD TRIP:

Hand each team of two students one clipboard, data sheet, pencil, and a stop watch. Determine the "race course" and measure and record its distance. The race course might extend from one end of the tank to another, or if it's a very large exhibit, the width of one or two viewing panels. Each team should choose two species of fish to time. Try to get a variety among the teams. Have them watch the fish for several minutes to make sure the fish they choose swim relatively straight.



Before conducting the "trials," the team must identify the fish, placing the names in the boxes under "Fish #1" and "Fish #2" on the worksheet. If the facility does not have an identification label system, make arrangements for a docent or staff member to briefly help your students with identification if you are not comfortable with this. Record each fish's body shape and the fins it uses for swimming.

Now for the races! Let the students look at each others' fish and "bet" or predict which they might think is faster. Next the students will time each fish as it swims its "course," recording three trial times.

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BACK IN THE CLASSROOM:

Compute the average swimming speed for each of the two species for each team. Rank the fish in terms of fastest to slowest on the board.

RESULTS:

Which was the fastest fish? Fish that are streamlined and swim using their caudal fins are the fastest fish. However, some species with these characteristics will be observed to move very slowly, such as the tarpon. These fish do not move quickly unless they have to. Then they are capable of short bursts of very fast speed. These fish have a broad base on their tail.

Which are the slowest fish? Depressed fish and those that move with their dorsal and anal or pectoral fins are not extremely fast in terms of forward movement, but can dart and turn swiftly, and maneuver in tight spaces.

As you determine the relative speeds of the fish tested, look for other adaptations that may offset an animal's deficiencies of speed. How does it protect itself? Where in the habitat does it live? What food might it be adapted for catching if it can't go after swiftly moving prey?

CONCLUSIONS:

Fish have different methods for moving through water. Some methods are better than others. Speed is not all important in terms of survival. A fish that is not speedy has other adaptations for survival.

USING YOUR CLASSROOM AQUARIUM:

You can hold fish races in your own tank if it is a big one. Most likely the aquarium fish you have chosen will not be fast swimmers. Have the students analyze ways that your fish move and which fins they use. If you have any invertebrates in your aquarium, compare their swimming habits with those of fish. There are not too many invertebrates which have mastered swimming. The jet-propelled squid is one. Most move over surfaces or drift with the currents.

EXTENSIONS:

1. Build a Fish. After visiting the aquarium or science center, have the students construct a fish. Have the student write a label describing the fish's habitat and its behavior and build a fish whose body shape and structures would enable it to survive in the habitat described in the card. Some suggestions for materials to be used include:

fruits	buttons	sequins
vegetables	wire	papier mache
clay	ping pong balls	aluminum foil
pine cones	construction paper	styrofoam
toothpicks	rocks	tissue paper
wood scraps		pipe cleaners

ACTIVITY 24 Name Answers vary with species

AT THE RACES!

Length of the race course is 11 feet (two windows).

FISH NUMBER ONE is a yellowtail snapper.

It uses its tail (forked tail) fin(s) to swim.

Its body shape is fusiform.

Time it took this fish to swim the race course in seconds:

1. 3 sec 2. 4 sec 3. 2 sec

Average speed 3.67 ft/sec (remember this is distance per unit time)

FISH NUMBER TWO is a triggerfish.

It uses its dorsal and anal fin(s) to swim.

Its body shape is laterally compressed.

Time it took this fish to swim the race course in seconds:

1. 9 sec 2. 11 sec 3. 12 sec

Average speed 1.03 ft/sec (remember this is distance per unit time)

What body shape and swimming method did the fastest fish in the class use?

The fusiform fish with the forked tails were fastest. The fusiform fish that swim are the fastest.

What was the shape and swimming method of the slowest fish anyone found?

The fusiform tarpon with a broad, flat tail just hung there. The porcupine fish was the slowest swimmer.

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SECTION IV
LIGHT IN WATER

TEACHER'S INFORMATION

Water absorbs light. Since light is essential to plant growth and almost all living things depend on plants either directly or indirectly for their food, light is very important in aquatic habitats. As water gets deeper, it gets darker. Even in very clear water that does not have sediment r phytoplankton to block light penetration, it is almost dark at 150 m although a few photons penetrate to 600 m. This lack of light in deeper water has two consequences. The first is that plants in the ocean or in lakes can grow well only within 100–200 m of the surface in very clear water. In water that is murky, they must be much closer to the surface. Second, rooted plants or seaweed that must grow from the bottom up do not live in very deep water.

Light is also necessary for vision, an important sense for many animals. Animals that depend on vision as a sense are restricted to relatively shallow water when one considers that ocean depths are measured in thousands of meters. Animals that are bioluminescent, making their own light, have one interesting solution to this lack of light in deep water. Many animals that must search for prey or that need to find others of their own species in shallow murky water or in deeper dark water make use of senses other than vision. These include senses that pick up sound (vibrations), chemical information, or electrical fields.

In addition to the general lack of light, there is a differential absorption of different colors (wavelengths) of light by water. Red and orange are absorbed most effectively while blue penetrates best. Underwater movies or photographs which are made with natural light look blue while those that show bright colors are made with artificial lights carried by the photographer. The brilliant colors we associate with some kinds of marine animals like sponges are invisible in their natural habitat! Other marine organisms like the colorful coral reef fish live in shallow water where their colors show. Color vision is common in some fish that live in shallow water, but not in those that live in deeper water or way out at sea.

With the exception of some very unique aquatic habitats such as the deep ocean vents, organisms that use light for PHOTOSYNTHESIS produce the food that sustains all other living things, either directly or indirectly. Things that do photosynthesis may be lumped into the category "plants," but include organisms that range from the familiar higher green plants to mosses to single-celled ALGAE to multicelled algae (seaweeds) to many kinds of bacteria. All of these things produce FOOD (stored energy) from inorganic elements and are lumped into a group called PRODUCERS. Plants use sunlight to provide the energy for the chemical process that takes place within their cells called PHOTOSYNTHESIS. As the name implies, light (photo) energy is used to make (synthesize) some of the compounds the plant needs. The raw materials for this process are carbon dioxide and water. The oxygen that is produced is a waste product. The food energy they produce is stored in themselves—their bodies, stems, leaves or seeds.

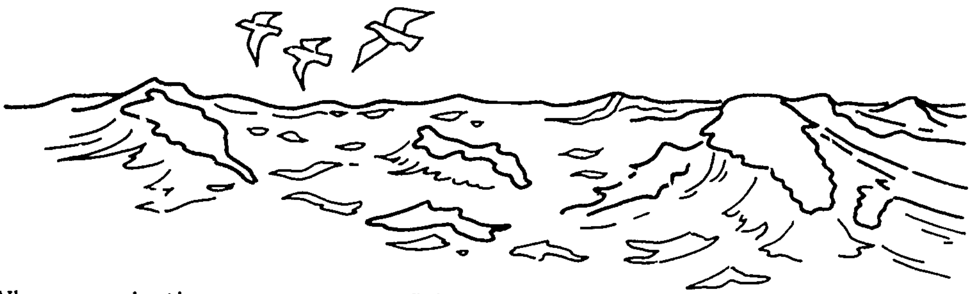
The producers form the base or bottom of the FOOD CHAIN, also called a FOOD WEB because it is not as simple as a straight chain. Animals that eat the producers or other animals are called CONSUMERS. Consumers that eat plants are called HERBIVORES which comes from Latin roots meaning "grass-eating." Animals that eat other animals are called CARNIVORES from Latin for "meat-eating." Some kinds of animals eat both plants and animals and are called OMNIVORES from the Latin for "all." The general term PREDATOR applies to an animal that eats another. The word PREY refers to the animal that is eaten. A given animal might be a predator on one species and the prey of another.

At each stage of the transfer of food energy, it is used for many different things. Some is used for growth or as stored food (fat or oil). Some is used for reproduction. Some is wasted as undigested material lost in feces or the bodies of dead organisms. Much of the food that an animal eats is broken down in a process called RESPIRATION that takes place inside cells. In this process, oxygen combines with the carbon and hydrogen atoms in the food to make carbon dioxide(CO_2) and water(H_2O). Energy is released which the cells capture and use to do work such as movement, making new molecules or moving molecules around. Since no energy transfer is perfect, some energy is also lost as heat. Food that is broken down is said to be "burnt" since the end products, carbon dioxide and water, are the same as those of combustion. Food energy is measured in calories, so animals are referred to as burning calories when they do cellular respiration.

Food that is burnt or broken down is gone from the food chain and not available to the animals at the next level. Consequently, each level of the food chain above the level of the producers has less available food than the level below it. The food available to the next level of the food chain is in the bodies of the plants or animals at the lower level and is called the STANDING CROP. The amount of food available at each level may be expressed as total weight or as calories.

What determines the length of a food chain? Why do some habitats have longer chains than others? First, the amount and quality of food stored in the producers has an effect. Since energy is lost at each stage, if you start with a great deal there will be some left at the higher levels. Second, efficient use and transfer of energy makes for longer food chains. If the animals at one level are very inefficient and burn most of the energy they consume, they will not be making much of themselves for the next level to eat. In general, food chains in aquatic habitats are often rather long when compared with those on land.

Human activities may affect food chains in many ways. Pollution and habitat destruction cause obvious changes that are easy to see. Dead fish are hard to ignore. It is also easy to understand the consequences of filling a pond or marsh in order to build a shopping center or add another field to a farm. The whole habitat goes away. Much more subtle changes may result from the extensive harvesting or removal of specific levels of the food chain.



When we selectively remove some fish, we are making changes that may have a significant impact on the other animals and on the plants in the pond, lake or ocean. Very careful planning of fishery regulations are necessary to be able to remove animals from a system on a long term basis without destroying the ECOLOGICAL BALANCE of the entire system. The result of this careful planning is a calculation of how many fish can be taken year after year without upsetting this balance and is called the SUSTAINED YIELD. The people who study these problems are in a field called FISHERIES MANAGEMENT. They set fishing limits for both sportfishing and commercial fishing and enforce them.

The concepts of food webs can be communicated to students by letting them be the animals in a simple food chain and playing a game to see who survives. The rules of the game are the rules that govern the survival of plants and animals in the wild. When they have mastered the basic rules that govern food chains, then the students can experiment with the system by changing one rule at a time (remind them — only one variable per experiment). They can ask "what if" questions, predict the answers and then run an experiment to see what happens. This kind of SIMULATION of natural systems is a form of MODELING. Sophisticated modeling can be done with computers. Educational computer software that will allow students to continue to ask "what if" questions about food chains are available (see Recipes and Resources). Because the computer runs the simulation much faster, students can collect a great deal of "data" using a computer simulation. Such experiments might make a very nice science fair project.

ACTIVITY 25

LIGHT TO SEA BY

WHAT HAPPENS TO LIGHT WHEN IT MOVES THROUGH WATER?

SCIENCE SKILLS:

- observing

CONCEPTS:

- Water absorbs light.
- Water absorbs different wavelengths at different rates.
- Things suspended in the water absorb light.

SAMPLE OBJECTIVES:

- Students will be able to observe the effect of water on light transmitted through it.

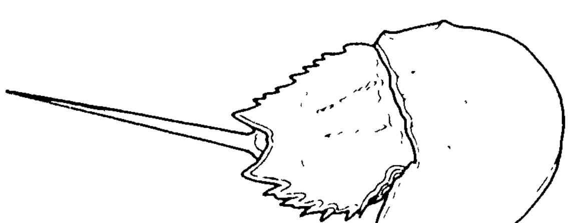
INTRODUCTION:

This teacher demonstration asks questions about changes in light INTENSITY (the quantity) and QUALITY (the colors present) when light shines through water. The results are not clear-cut measurements, but value judgments (observations) made by students who may have different sensitivity to colors. This is a nice place to discuss the use of instruments to make measurements that are standardized and do not include as great a possibility for error as simple observations do. Variability in their own perceptions and slight differences in responses means that there will be more than one "right" answer. That is why scientists repeat their work. It is also why they go to great lengths to avoid value judgments and to use instrumentation which is standardized.

Different amounts of preparation for this exercise are appropriate depending on the background of your students. Have they ever looked at a spectrum? Do they understand that light bouncing off of an object is reflected to their eyes? Do they know that the colors of objects are determined by which colors (wavelengths) of light they reflect?

MATERIALS:

- aquarium tank 20 gallons or more (may be your classroom aquarium with sides that are clean and do not have algae
- air-cooled 35mm slide or filmstrip projector
- glass jar of clear water
- glass jar of dirty water (about ½ cup dirt added)
- underwater pictures from a scuba magazine or *National Geographic*
- prism
- two sheets of stiff white paper
- cardboard slide with thin slit to fit projector



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LESSON PLAN:

BEFORE CLASS:

The aquarium will need to be accessible. Remember to fill it after it is in its correct location and to siphon the water out before moving it after class. Never move an aquarium with water in it. If using your classroom aquarium, make sure the sides of the tank are clean. Make a cardboard square the size of a slide or part of a filmstrip and cut a thin slit about 1 in long and 1/16 in wide with a mat knife or razor blade. Find two or more underwater photographs that show the contrast between shots made under natural light (very blue colors) and those made with artifical light (will show bright colors such as red and yellow). Glue these to cardboard and laminate them to make them last. One old scuba magazine should be enough.

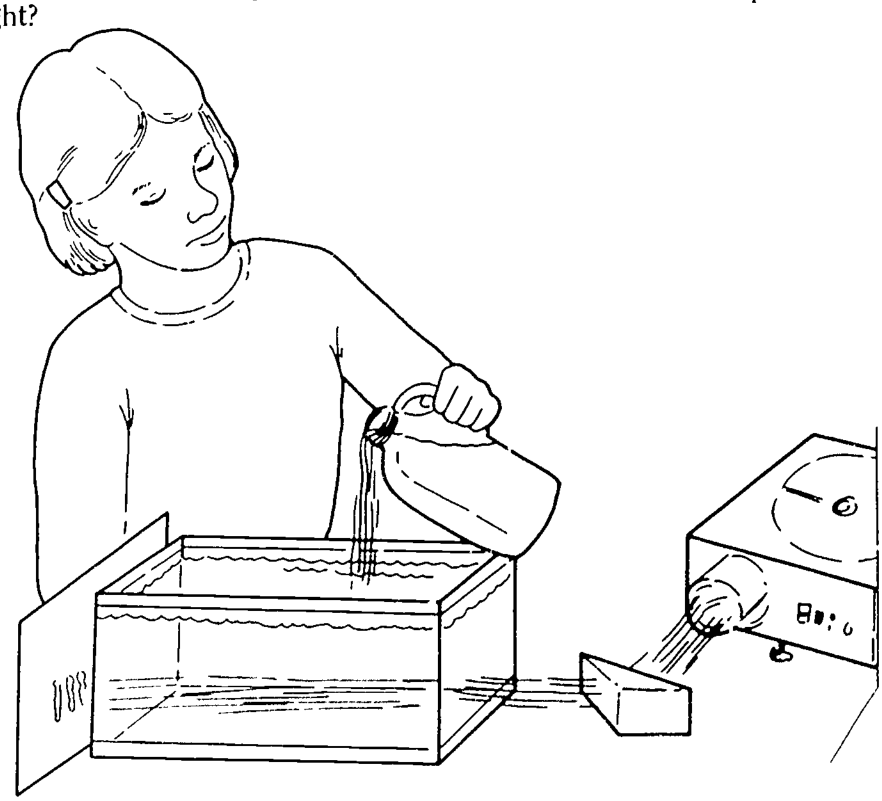
DURING CLASS:

METHODS: Begin with a discussion of what your students know about light. Make sure they remember the difference between quantity or brightness (INTENSITY) and QUALITY or color. Use a prism and the slide projector to show the colors that make up white light. Make your classroom dark so the students can see this clearly. Now for questions about how water affects light quantity and quality available to plants and animals living in water.

Demonstration 1: Does water absorb light? Have the students make predictions on the basis of their experiences before trying this. Compare the brightness of lights shining through the short and long dimensions of an aquarium onto a plain white paper. Which is brighter?

Demonstration 2: Does water absorb some colors of light more than others? Again, ask for predictions. Put the cardboard slide into the projector. Shine light through the prism, then through water onto white paper. Are some colors brighter than others? Compare with the relationship of colors not passing through water by putting the white paper in front of the aquarium in the spectrum and then behind it.

Demonstration 3: What is the effect of material suspended in water on the light available to plants and animals living in water? Again, ask for prediction. Shine a bright light through a jar of clear water. Then shake a jar with dirt in it and shine the light through it. Compare the brightness of the light shining through the dirty water versus the light shining through clear water. Does the suspended material absorb light? What problems could this cause for animals or plants living in the water that need light?



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RESULTS:

The results from these exercises may be subject to debate because they are based on human perceptions. Generally, the students should see that light is absorbed as it passes through water. Some wavelengths (colors) are absorbed more than others. Blues are absorbed least. Particles suspended in water really block the light.

CONCLUSIONS:

How do these results relate to marine and aquatic environments? Students should be able to conclude that the deeper you go in a big lake or in the ocean, the darker it gets. They should also be able to understand that suspended sediment or particles in water will block light, even in very shallow water. It is a bit harder to understand that as you go deeper, things have different colors than they do in shallow water or when a diving light is used. Illustrate your conclusions with photographs taken under water. Those that are taken with natural light look very blue. Those taken with a flash show the true colors of things, colors that are never seen under natural conditions. In subsequent exercises, you can explore the implications of these conclusions for the plants and animals that live in aquatic and marine systems.

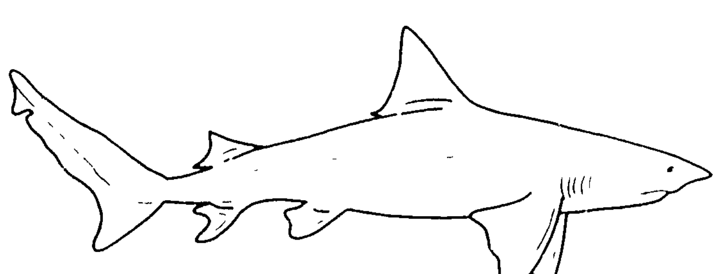
USING YOUR CLASSROOM AQUARIUM:

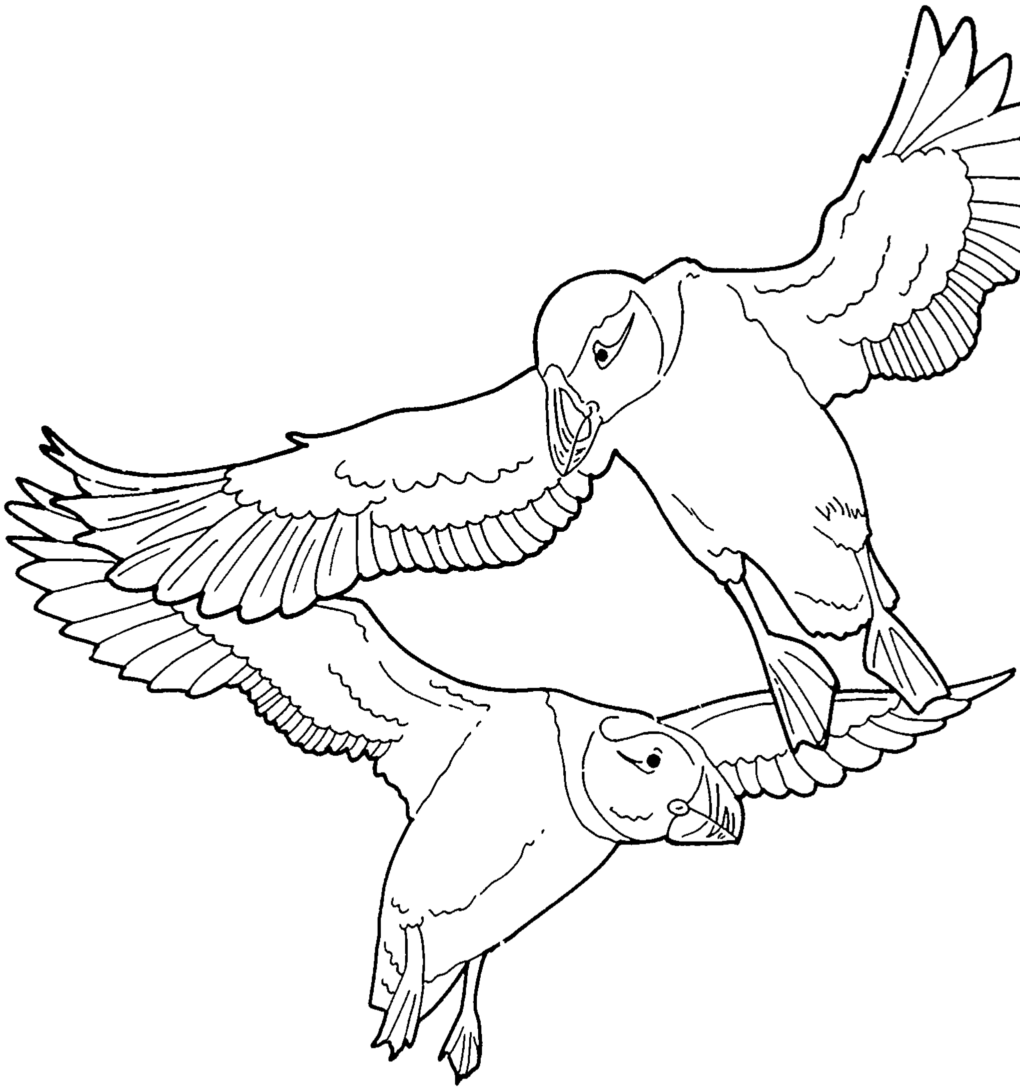
If these activities are done one at a time, the first two can be done with your classroom aquarium. Try not to scare your fish to death with movement and noise.

EXTENSIONS:

1. Some animals that live in the deep ocean communicate with light they make themselves since there is not any natural light. This light is referred to as bioluminescense because it is light made by a living thing. Fireflies are another example of the use of "living light." If you have a flashlight for each student, divide them into "species" pairs and see if they can figure out how to find their mate in a dark room. They will have to work out coded sequences to go with their "species." In the wild, different patterns of many lights on one animal would also work to distinguish different species in the dark.

2. Sediment in runoff may be a problem for vegetation that grows rooted to the bottom. If you know of an example of this kind of problem in your area, discuss it with your students. In the Chesapeake Bay suspended material may have contributed to the decline of underwater vegetation essential to many animals for food or refuge.





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ACTIVITY 26

HIDE AND SEEK

WHAT DOES IT LOOK LIKE UNDER WATER? WHAT DO ANIMALS SEE? IS CAMOUFLAGE THE SAME BELOW WATER AS ABOVE?

SCIENCE SKILLS:

- observing

CONCEPTS:

- Color patterns that are easy to see in air may be very well camouflaged under water.

MATH AND MECHANICAL SKILLS PRACTICED:

- drawing
- cutting with scissors

SAMPLE OBJECTIVES:

- Students will be able to explain why color patterns that are easy to see in air may be hard to see under water.
- Students will experience the problems predators face when searching for camouflaged prey and develop foraging strategies for these prey.

INTRODUCTION:

Some colors of light (wavelengths) are absorbed faster than others when passing through water, particularly red and yellow. Blues are transmitted best. These facts have interesting consequences for color and color patterns and their distribution among animals that live in water. Fish that live in shallow, well-lighted water may have color vision. But what do most fish see? Fish that live in murky or muddy water may be almost blind and depend on touch or electrical fields to sense their surroundings.

In this exercise your students will experience what the world looks like to fish that live far enough below the surface that the world looks blue, the only color to effectively penetrate very deep.

MATERIALS:

FOR CLASS:

- blue cellophane from school art supply store
- stapler
- clear tape
- string
- underwater photographs cut from magazines that show bright colors and others that are of wide views that are predominantly blue; SCUBA magazines or *National Geographic* are good sources

FOR EACH STUDENT:

- red construction paper 4" x 8"
- other contruction paper or poster stock 4" x 11"
- scissors
- pencil
- template for goggles (see p. 152)

LESSON PLAN:

BEFORE CLASS:

Have the students review their knowledge of fish anatomy in drawing and cutting out a fish made of red construction paper. Did they remember paired pectoral and pelvic fins, the tail (caudal), dorsal and anal fins? Explain that the red color is typical of some California saltwater fish that hang out around rocks in 10 m (33 ft) or more of water. Many shallow water nocturnal fish are also red, and red is a very common color for deep sea animals generally.

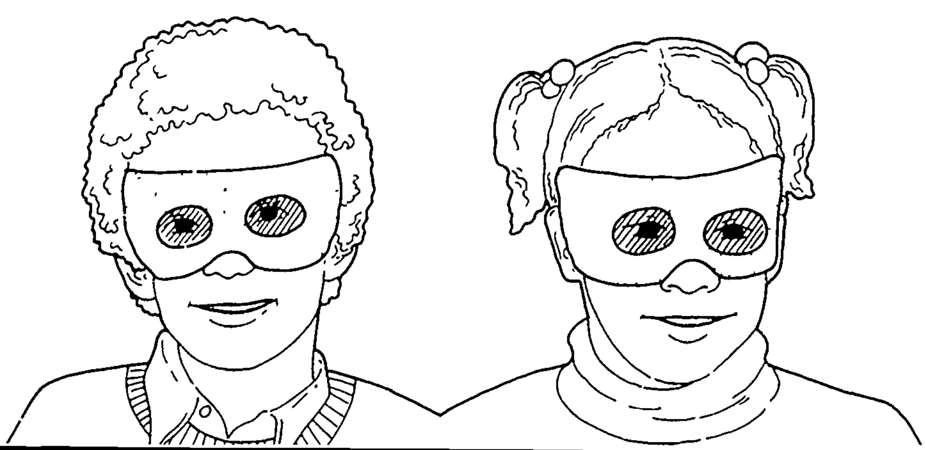
Have each student construct a pair of goggles using the provided pattern or an aide or parent might make a permanent set for your use. Inexpensive blue cellophane available in rolls from school art supply stores is folded to make **four** layers over the eye holes. Tape the celophane in place. Staple, tape or tie strings to hold the goggles in place. Explain they will use the goggles to see as fish see. Do not allow students to wear the blue goggles for more than five minutes. To do so longer may bleach (temporarily) some of their visual pigments.

DURING CLASS:

METHODS: When the students are not in the classroom, distribute all the red fish around the room against *dark* backgrounds. Turn the classroom lights off and create dim light. It is dark in 10 m of water. Pin or tape the fish to bulletin boards, prop on shelves, put them in corners on the floor. Hold a pair of goggles up to check that you are placing the fish against backgrounds with the same value.

Meet the class outside the room with the goggles. When the goggles are in place, have the students enter the room and sit down. Tell them they are predators searching for red fish in 10 m of water. They are wearing the goggles because blue is the primary color of light that penetrates very far into water. Have them start searching for the fish at the same time. Time them if you want to repeat the exercise without the goggles.

Stop them before all the fish are found and have them sit back down. Remove their goggles. Now can they see the fish they missed? Why were the fish hard to see? The filter allowed only blue light through. The fish reflect only red. Under water there would be no red to see. If you wish, repeat the exercise without the goggles to compare the time it takes to find the fish when red is visible.



RESULTS:

A fish that appears very colorful to us (red) may, in fact, be very well CAMOUFLAGED from predators. The fish is hard to see because red light is missing as it is being absorbed by the water and, therefore, cannot be reflected to the fish's predator's eyes.

Use the color photographs to illustrate. Any colorful underwater photograph was shot with a flash which provided all the wavlengths of light. Any photo in which the predominant color is blue shows what it really looks like under water.

CONCLUSIONS:

You cannot make judgments about animals based on human perceptions. Fish in shallow, clear water may see things in a way that is similar to us, but fish that live in dark, murky water or deep water probably do not have color vision and may use vision very little, depending on other senses.

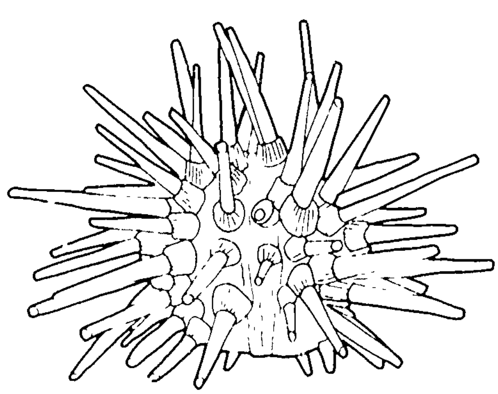
EXTENSIONS:

1. What about other senses? Can your students think of another sense that water animals might depend on? Sound is one good choice. Have them try an experiment using sound. Call it "Swamp." You should do Swamp outside. You will need blindfolds for the class because Swamp happens at night. Designate all but one of your students as frogs. How do frogs find mates? The males call and the females find them by the sounds. Have your students ever heard frogs calling? Students can do their own interpretation of this sound. It may range from the peep of spring peepers to the bonk of a bull frog. Half the frogs are female and half are male. Assign half to be male callers and half to be female searchers. The male frogs will call and the females will find them by following the sound. A male frog may call as many females as he can. When the female finds a male, she should hang on to him and stay put. The male can stop calling after finding one female or keep calling, it is up to the individual to choose.

The remaining student is the alligator. It will find frogs to eat by following the frogs' calls, but it can also eat frogs it bumps into accidently. Any frog touched by the alligator is considered eaten and removes its blindfold and leaves the pond. The teacher can keep other animals from leaving the pond by telling them to turn back when they get too far apart.

Let Swamp run until some of the males have more than one mate and some of the frogs have been eaten. Have the students sit down and talk about their strategies for searching. How did it feel to be in the dark with the possibility of being eaten? Would it have been better or worse if the females had been calling too? Would even more frogs have gotten eaten? Did more males get eaten than females? Consider that calling made the frogs more vulnerable. The males are more expendable than the females since one male can mate with more than one female.

2. What about fish that live in very murky water and depend on touch and taste (or smell) to decide what to eat? Could you put together a variety of food items, some desirable and some not, which your students could find while blindfolded? Would they be willing to decide whether or not to eat something they could not see? Many animals must do so. Catfish use whiskers to feel their food and sense its chemical composition. This activity might make a great Halloween party with spaghetti for worms, etc. Just make sure that everything is edible, if not good to eat by kids' standards.



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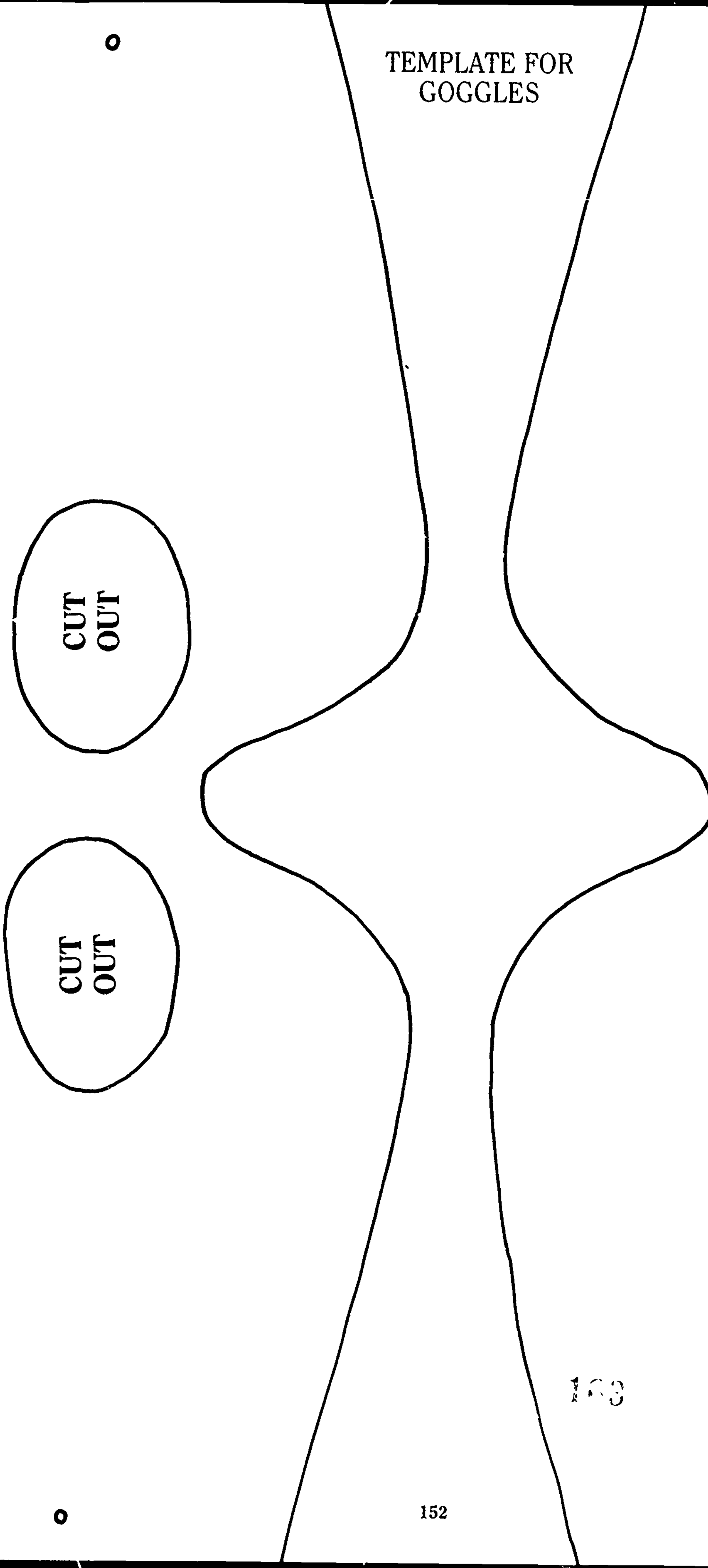
TEMPLATE FOR GOGGLES



ACTIVITY 27

A LIGHT SNACK

WHAT IS THE RELATIONSHIP BETWEEN LIGHT AVAILABILITY AND PHOTOSYNTHESIS IN AQUATIC PLANTS?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- If sufficient light is available, plants will produce more oxygen in photosynthesis than they use in respiration.
- The amount of oxygen produced is proportional to the available light.

MATH AND MECHANICAL SKILLS PRACTICED:

- use of dissolved oxygen test kit
- averaging

SAMPLE OBJECTIVES:

- Students will be able to design and complete an experiment to test how the amount of light available affects photosynthesis rates in aquatic plants.

INFORMATION:

This experiment tests the effect of two different light conditions on the amount of photosynthesis done by aquatic plants. It proves that the amount of light available may limit photosynthesis. This concept is important for an understanding of several ecological conditions. The first is that the production of food by plants and phytoplankton is limited to the surface waters of lakes and oceans because light is absorbed by water. Although vast in size, oceans and large lakes are more limited in their ability to produce food than it might seem because photosynthesis requires light. Only the top layers of these bodies of water have enough light for photosynthesis. A second consideration is the effect of human actions that increase the TURBIDITY or cloudiness of water. These actions cut down on the light needed by plants to make food using photosynthesis.

MATERIALS:

FOR EACH GROUP:

- two quart or pint fruit jars with screw tops
- one large bunch of freshwater plants such as *Elodea* (use six 6 inch strands per quart)
- two sources of light, one low and one higher (should not be a strong heat source)
- aged water

FOR THE CLASS:

- dissolved oxygen test kits
- boiled tap water cooled and sealed in a jar
- turkey basters or syringes for sampling jars

LESSON PLAN:

BEFORE CLASS:

The experiment covers three days. Have the students start the experiment one day, putting the jars in the dark overnight. On the second day, they will test each for dissolved oxygen and then put the jars in two different light intensities. On the third day, they will again test for dissolved oxygen to see what the effect of the two different light intensities was. You may shorten the activity by setting it up yourself. This is written in a way that assumes you do the first day's preparation yourself.

Day One: Pour aged tap water into each jar. Add the *Elodea* or other aquatic plant. Try to get the same total length of plant in each jar. Make sure the jars are full to overflowing and seal. Place at room temperature in the dark overnight. This will remove almost all of the oxygen from the water and saturate it with carbon dioxide because the plants are using the oxygen in respiration and producing carbon dioxide as a waste product. If you started this experiment with the amount of oxygen normally found in room temperature water, oxygen (which is a waste product of photosynthesis) would build up and slow down photosynthesis. If you used boiled water which is low in oxygen, it would also be low in carbon dioxide which is required for photosynthesis.

DURING CLASS:

METHODS: Day Two: Review the results of student observations with regard to light and its absorbance by water. What is the most likely effect of low light availability on the plants that live in water? What do the students know about plants and how they use light? Review photosynthesis. Can they think of a way to test the effect of low light?

Bring out the jars and explain what you have done to prepare for this activity. Ask the students what they might use as a measure of how much photosynthesis takes place. Oxygen is produced as a waste product, and they are good at dissolved oxygen measurements. What do they need to do first? Measure the amount of oxygen at the beginning of the experiment. Replace the lost water from the sample with cool boiled tap water.

How will they test the effect of low light on photosynthesis? Put one jar of each pair in high or low light after testing for dissolved oxygen. One location might be full sunlight and the other, indirect light. Incandescent lights may be used also. Either put the jars two different distances from lights of the same intensity or put them all the same distance from bulbs of two different intensities such as 75 and 150 watts. Avoid intense heat, but make sure the jars stay between 65 and 80° F.

Day Three: Test the dissolved oxygen in the two jars. Calculate the results as the difference between Day Two and Day Three. Have students put their results on the board so that all the students can share.

RESULTS:

The dissolved oxygen produced should be greater in the jars that received more light. How did the results compare with the results from plants left in the dark in Activity II? Considering that respiration happens all the time, the amount of actual oxygen produced is really higher than you measured because it is constantly being used in respiration as it is being produced by photosynthesis. All that can be measured in this activity is the amount left over.

If the student were an aquatic plant, where would he/she want to live and why? Near the surface or in shallow where there would be enough light to make enough food to survive. It would be important that the water be clear so that light could get through.

CONCLUSIONS:

The amount of photosynthesis done by water plants is directly related to the available light. Where light does not reach in deep water, no photosynthesis takes place. Only the light surface waters produce food.

USING YOUR CLASSROOM AQUARIUM:

If your classroom aquarium receives good light and you have a good algal population or many underwater plants, you might try turning off the aeration system on two successive days. The first day leave it uncovered and test the dissolved oxygen level after several hours. Turn the aeration back on. If the animals did not show signs of stress, the following day turn off the aeration system and cover the tank with a dark cloth for two hours. Again test the dissolved oxygen. It should be much lower if your plants or algae are healthy.

Discuss why plants and animals both belong in an aquarium. What is the role of the aeration system? If you carefully planned the amount of plants and animals in your aquarium, could you do without an aeration system? Theoretically, in a properly balanced aquarium with the right amount of light, the amount of excess oxygen produced in photosynthesis could balance that used by plants and animals in respiration.

EXTENSIONS:

1. Have your students design and draw a balanced aquarium in which aeration of the water by a pump is not required. It is possible to find the right combination of plants and animals, but most people put too many animals in their system.

2. Have your students list all the things they can think of that make water more turbid. Some things are sediment from farms or housing developments, sewage, and industrial wastes. They might not realize that things like plant nutrients that come from fertilizer, animal manure or sewage can make the water more turbid by encouraging phytoplankton to grow too fast. The phytoplankton can actually get so dense that they keep light from reaching aquatic plants growing on the bottom.

ACTIVITY 27 Name Possible answers

A LIGHT SNACK

What question might you answer by doing this experiment? Do plants make oxygen in the light? If so, does the amount of light have an effect on how much oxygen is made?

Record your results here:

	dissolved oxygen at beginning in ppm	dissolved oxygen after 24 hr in ppm	difference
low light	0.6	5.3	4.7
high light	1.2	8.8	7.6

Average the differences from all of the high light samples and low light samples for the class. The averages are:

High light: 9.1 ppm

Low light: 5.4 ppm

4.7 8.8
6.1 9.2
5.3 9.4
16.1 27.4

Based on these results, what statement can you make about the importance of light in producing oxygen during photosynthesis?

The amount of light is directly related to the amount of dissolved oxygen the plant produced during photosynthesis.

If you were an aquatic plant, where would you want to live and why?

I would want to live in clear, shallow water where there was lots of light so I could photosynthesize lots of food.

ACTIVITY 28

COMPETING FOR FOOD

WHAT IS THE RELATIONSHIP OF FOOD AVAILABILITY TO THE NUMBER OF HERBIVORES AN AREA CAN SUPPORT?

SCIENCE SKILLS:

- organizing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- Plant (food) availability may limit how many herbivores live in an area.
- When plants are limiting, herbivores compete with each other for their food.
- Predators may balance the lack of food by keeping the herbivore numbers low enough to prevent competition for food.

MATH AND MECHANICAL SKILLS PRACTICED:

- averaging
- graphing

SAMPLE OBJECTIVES:

- Students will be able to use a model of a simple food chain.
- Students will be able to explain how the availability of food ca. limit the population which depends on that food.

INFORMATION:

This game is a SIMULATION of how food availability can limit the numbers of the animals that feed on that source. In this game or MODEL your students are the animals that are COMPETING for food. They will be zooplankton searching for phytoplankton in a small pond so they are HERBIVORES. The limits may be expressed in several ways. In extreme cases, the herbivores may starve to death. In the wild animals that are suffering from lack of food frequently fall prey to predators or disease before they starve. Predators prefer weak animals as they are less effort to catch. Where there are no predators, however, food availability frequently limits the number of herbivores in a population.

Another result of insufficient food supply is that the number of offspring an animal has decreases when it does not get enough food. The result of the combination of increased MORTALITY (death) and decreased BIRTH RATE caused by low food supply is a decline in the number of animals COMPETING for the food which means there will be more to go around for the next generation. The number of animals that an area can support on a permanent basis is called the CARRYING CAPACITY.

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MATERIALS:

FOR EACH STUDENT:
- 10 markers (poker chips, beans, pennies or other non-destructible small items)
- small plastic bag

FOR THE TEACHER:
- data sheets and a clipboard
- pencil
- whistle

LESSON PLAN:

BEFORE CLASS:

Plan the location for the activity, including an alternate site in case of rain if you are planning to do it outside. While working around furniture is interesting, children get very enthusiastic and can get hurt. This exercise works best in an open space.

DURING CLASS:

METHODS: Ask the students questions which review Activity 18 in which they learned the words ZOOPLANKTON and PHYTOPLANKTON. If you did not do this lesson, review these words. Make it clear that many zooplankton feed on the tiny phytoplankton that drift through the surface water. Explain that the students are now going to pretend that they are zooplankton that eat phytoplankton and see what happens when herbivores have to compete for food. Have them predict what might happen to them if they do not get enough to eat. They might starve and die or they might not have any offspring.

Start with a pond that produces a limited number of phytoplankton and has only a few zooplankton. There will be the same food supply from one period (generation) to the next. The phytoplankton are the beans or poker chips. Start by designating about ⅔ of the class as zooplankton and give each student a plastic bag to collect phytoplankton. The rest of the class are the reserves.

Scatter 10 food items per student (for the ⅔ of your class playing) around the area. Tell the students that each will try to eat as much as they can without taking any away from another zooplankton. Say "go" and let them pick up all the food. It will be over pretty fast. Use the whistle to stop the action, if it gets out of hand.

Have everyone sit down. Did they all get the same amount of food? No, some individuals are more efficient searchers than others. Record the results on the data sheet. Some of the zooplankton did not get enough food to reproduce while others did. Those that got more food left more offspring. Herbivores that got fewer than nine phytoplankton starved to death. Those that got nine to eleven left one offspring. With twelve or thirteen phytoplankton, they make two offspring. More than thirteen, they leave three offspring.

Repeat the game. After reproducing, the parents die, leaving behind the number of offspring indicated on the data sheet which are the zooplankton of the next generation. Change the number of players to match the number of offspring. Recruit from the reserve and allow substitutions for tired "zooplankton." Scatter the same number of food items that you did in the first game regardless of whether the number of players went up or down. Assume the same number of phytoplankton will be produced. The amount of food is limited. Run the game again and calculate the results. Repeat. If possible, do four or five generations. You should find that as long as the food supply remains the same, approximately the same number of animals are produced in each generation.

RESULTS:

Back at their desks, have the students discuss what happened. Put the results of the simulation on the board. Ask them to give you some answers to the following questions. Did all the zooplankton get enough to eat? No; even though there were food items enough for everyone to survive, some were better at competing for food than others. What happened to those that got more food? They used their extra food to reproduce. The best competitors had the most offspring. Did anyone find a particular trick to help them compete more successfully for food? If this trick or adaptation was one that was inherited, would their offspring also be better at finding food? Would more animals in the next generation be better at catching food? Yes, because those that got the most food left the most offspring. Have the students complete the worksheet and answer the questions.

Once you have your data, you might allow the students to change the rules, one rule at a time, and see what happens to the population. Some suggested rule changes (new experiments) are listed with the extensions. The next two activities build on this activity also.

CONCLUSION:

Animals compete for food. Those that do not get enough to eat die or are caught by predators because they are weak or diseased. Those that compete most successfully leave more offspring. If the limit to the number of herbivores in an area is the food supply, their number remains more or less the same from one reproductive period to the next if the food supply remains constant. This average number of animals is the CARRYING CAPACITY for that habitat. If predators are added to this system, the number of herbivores may be reduced so that food is no longer the thing that limits the population. Under these circumstances fewer animals starve.

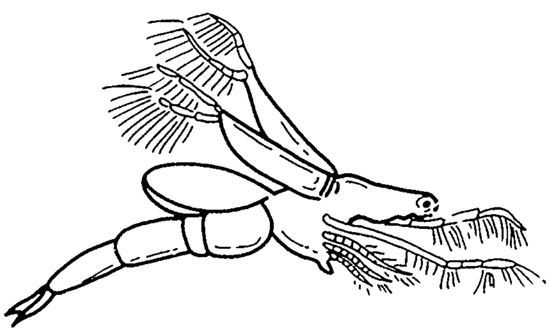
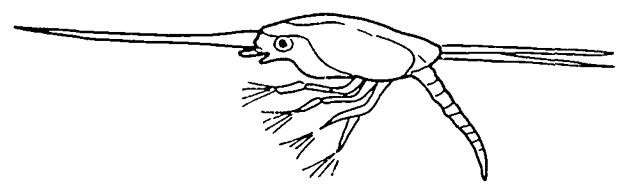
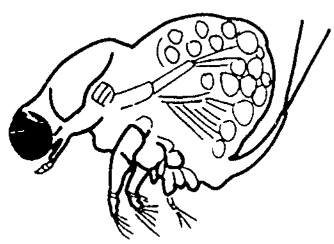
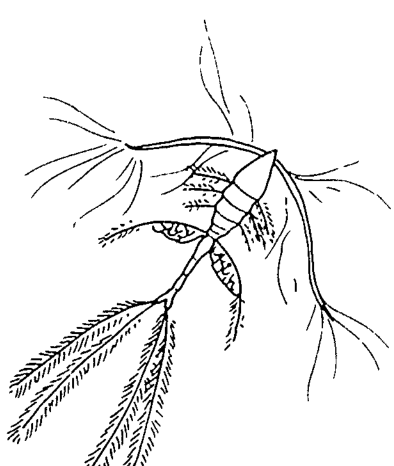
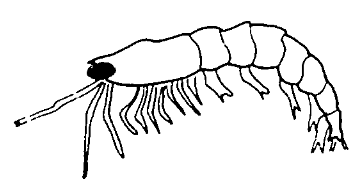
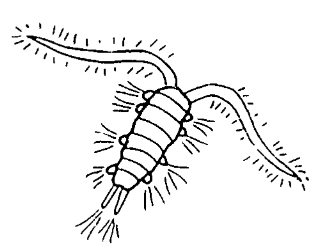
USING YOUR CLASSROOM AQUARIUM:

Do you have any plants in your classroom aquarium? Any planteaters? If so, how well does the balance work between the two? Does one ever "win?" Sometimes algae in the tank may threaten to take over and look like the creature that ate New York. How do you control it? Add herbivores.

EXTENSIONS:

1. Ask the students to think of one change that would increase the number of zooplankton that survive. An immediate answer would be to increase the amount of food. Multiply the amount of food by 1.5 and run the game several times. Eventually a new limit is reached, although at a higher level.

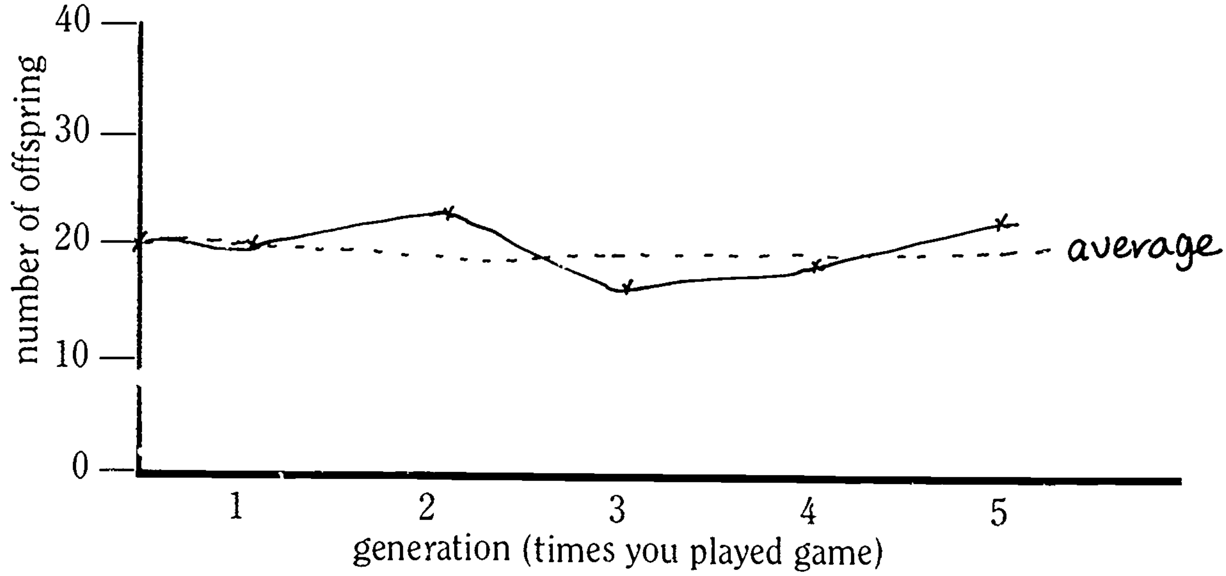
2. Once the students have gotten the basic idea of this simulation, they should be able to continue it on their own. Several children living near each other could recruit friends to play this game repeatedly to test new variables or to check if the number of herbivores remains relatively constant over many generations when they are limited by food. This could make a good science fair project. Have the students go over the questions that they plan to test with you ahead of time and discuss what they plan to do to make sure that they are testing only one variable at a time and that they are going to be keeping good records.

ACTIVITY 28 Name ______________________

COMPETING FOR FOOD

Graph the number of zooplankton offspring you got each time you repeated the game.



Calculate the average number of offspring in the population by adding the numbers from each generation together and then dividing by the number of generations you had.

20
22
17
19
22
100

$5 \overline{)100}$ = 20

The average number of offspring was 20.

Draw a line across the graph to show the average. How do the actual numbers compare to the average?

They vary around the average.

What change could you make in the game that would make the number of offspring go up?

I would add more food.

DATA SHEET FOR ACTIVITY 28

Generation number 1

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
8	fewer than 9	none	0
7	9, 10 or 11	1	7
2	12 or 13	2	4
3	more than 13	3	9

Number of parents 20 number of offspring in next generation 20

Generation number ______

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
______	fewer than 9	none	0
______	9, 10 or 11	1	______
______	12 or 13	2	______
______	more than 13	3	______

Number of parents ______ number of offspring in next generation ______

Generation number ______

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
______	fewer than 9	none	0
______	9, 10 or 11	1	______
______	12 or 13	2	______
______	more than 13	3	______

Number of parents ______ number of offspring in next generation ______

ACTIVITY 29

EATING AND BEING EATEN

WHAT ARE SOME OF THE FEEDING RELATIONSHIPS AMONG THE PLANTS AND ANIMALS THAT LIVE IN A POND?

SCIENCE SKILLS:

- organizing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:

- The numbers of predators and of prey have a direct relationship which is a result of the way in which energy passes through the food chain.
- Predators and prey have specific ways of dealing with each other.

SAMPLE OBJECTIVES:

- Students will be able to produce a model of the way energy passes through a food chain.
- Students will be able to develop feeding strategies appropriate to different levels of the food chain.
- Students will be able to suggest changes in the rules of the simulation which test new ideas about feeding strategies.

INTRODUCTION:

This simulation builds on Activity 28 by adding the next levels of the food chain, those animals which feed on other animals, the PREDATORS. The activity may be broken down and taught on several days, starting with the introduction to the concept of food webs. There are a number of possible variations which the students may want to try once they have begun to play the game.

MATERIALS:

FOR EACH STUDENT:

- 15 markers (poker chips, beans, pennies or other non-destructible small items)
- small plastic bag

FOR THE TEACHER:

- plastic or crepe paper flagging or cloth strips in three colors
- whistle
- pad or chalk board and pen or chalk
- copies of the data sheet
- Pond Food chain (p. 312)

OPTIONAL:

- pictures of pond animals (the Golden Guide *Pond Life* by George Reid is a good source)

LESSON PLAN:

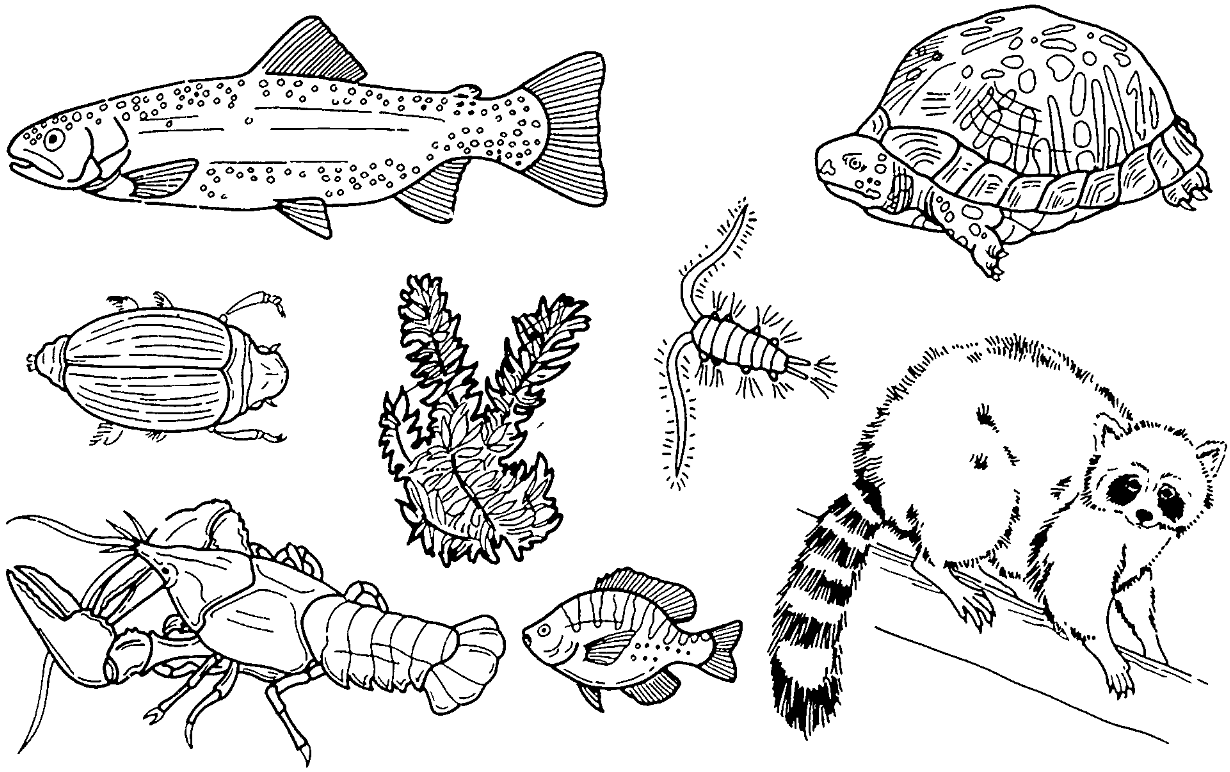
BEFORE CLASS:

Pick a location to do the exercise with alternate plans for bad weather if you are going to be outside.

DURING CLASS:

METHODS: Get settled either indoors or outdoors and explain that the class is going to pretend to be the animals in a pond. Ask them to name some animals they might find in a pond. Big and little fish, frogs, crayfish, tiny zooplankton, insects, beavers and raccoons are some answers that are possible. Have pictures of as many pond animals and plants as you have handy to illustrate. Explain that in our pond we are going to have groups of kinds of animals that represent levels based on who eats whom.

Where does the food comes from? From plants which use light to do photosynthesis. Some of these plants are tiny phytoplankton while others are rooted green plants that grow under the water or along the edge of the pond. Write the words phytoplankton and green plants at the bottom of the board. Show pictures of pond plants and phytoplankton. Introduce the word PRODUCERS for those things that make food. Who might eat these plants? The tiny animals called zooplankton eat phytoplankton as the students learned in Activity 28. Many insects and the crayfish feed on the plants as do the beavers. Write insects, crayfish, beavers and zooplankton above the plants on the board and draw an arrow up to them. Explain you are drawing a diagram of the path food takes in the pond. Those animals that eat plants are called HERBIVORES.



Who eats the herbivores? The little fish and frogs as well as some bigger fish. Add them to the next level along with an arrow. Animals that eat other animals are called CARNIVORES. The animals that get eaten are called PREY. Finally, who eats the carnivores? The big fish and the raccoon who are the TOP CARNIVORES. Do they just eat the level below them? No, they also eat the crayfish from the lower level. Can the students see the FOOD WEB or FOOD CHAIN forming as you draw the lines between the levels? (One way to illustrate the web is to pass out cards with the names of different animals and have the students pass a ball of yarn from the persons with the lowest levels of the food chain or web to those higher up.)

Now for the game. The students are going to play a game which is really doing an experiment. Just like an experiment, there are rules. They are going to be the animals in a pond food chain and are going to feed on each other.

The food plants or phytoplankton (poker chips or large white beans) are scattered over a wide area. Unlike Activity 28, in this game they are going to assume that there are more plants than the herbivores can eat: that food is not limiting.

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Assign ⅓ of the class to be zooplankton, crayfish and insects. Give them the same colored strip of cloth to wear and a plastic bag. They are all HERBIVORES. Scatter 20 food items for each herbivore. That means 20 × one third the number of students in your class. These are the plants in the pond. The herbivores must get their food by picking it up. To live, they must get 10 pieces of plant food before the end of the game. If they do not get 10 pieces before the game is done, they have died of starvation.

Give another ⅓ of the class a second color arm band or sash and a plastic bag. They are the CARNIVORES, the frogs and small fish. To eat, they must tag a herbivore. The herbivore gives up his food bag and sits down as he has been "eaten" by the predator and is out of the game. The predators must collect 20 pieces of food from the herbivore food bags to be alive at the end of the game. They must stop eating when they have passed the 20 item mark. If they do not get 20 pieces before time is called, they have died of starvation.

The remaining students are the TOP CARNIVORES. They get the third color of cloth and a plastic bag. They feed by tagging either the herbivores or the carnivores who must give up their bags and sit down when tagged as they have been "eaten." The top carnivores need 40 pieces of food to be alive at the end of the game. They should stop eating when they have passed 40 food items.

Caution the students about rowdy behavior and running into each other. Give them 5 minutes following the above rules and then stop them.

RESULTS:

It is time to sit down and analyze what has happened. Use the board and data sheet to record what happened. Do the students think this model worked like a real pond food chain? What was the cause of death in most cases for the herbivores? For the carnivores? Were the proportions the same at the end as the beginning? What levels of the food web do they think should have the most animals?

The original proportions are *intentionally* wrong. They were chosen because they do not work. The students should be able to see the lack of balance. The top carnivores are going to eat all their prey. With none left to reproduce, the top carnivores will starve to death. The numbers at each level should be more like a standard pyramid. If all the herbivores get eaten, they will not leave any offspring, and the rest of the levels will starve to death in the future.

Let your students discuss these questions. Then let them pick *one* thing to change about the *original* rules, other than changing the amount of phytoplankton. Continue to scatter 20 pieces for each herbivore. Run the game (the experiment) again from the beginning. Would it be a "fair test" if they changed more than one thing at a time? No. In order to compare the first with the second experiment there can be only one difference (variable). Otherwise they cannot tell which difference caused the different result. Here are some changes that they might make:

1. Change the number of herbivores or top carnivores. If the proportions are changed by deleting some students, you can keep within the rules of changing only one thing at a time. If you delete some in one run, they can be added in the next run. For example, most of the top carnivores can be removed. After seeing what the result is, they might be added as herbivores in a subsequent test.

2. Give the herbivores some places where they can hide or are safe from the carnivores. Draw a safe zone with string or rope or use something like a hula hoop. They can run out to grab a bite to eat and then hide. But remember, they have to get 10 pieces of food or they die of starvation. An example might be the burrows in which crayfish hide.

3. The carnivores may also be given a refuge in which they are safe from the top carnivores. Have the students give you some guesses as to how frogs or small fish might hide from predators. Both might be able to hide in vegetation. The food might be in the open while tagging a tree or pole is "safe." Another possibility which protects the herbivores is that some feed when the predators are not active such as at night. Have 30 second safe times periodically when the top carnivores rest and stop eating. In actual fact, many predators catch their prey at dawn and dusk.

Have the students discuss the strategies they used to catch prey while not being caught. The smart top carnivore will let his prey alone until they have eaten enough to be of value when caught.

CONCLUSIONS:

In order for the food web or chain to be realistic, the students must have some individuals from each level alive at the end of the model. These animals will be the ones that reproduce, making the next generation. Make adjustments until this happens. It requires very few top carnivores (perhaps one), a few carnivores and lots of herbivores. This exercise illustrates that there are fewer animals in each succeeding level of the food chain. It also introduces the concepts of predator-prey interactions and the strategies that predators and prey use in feeding and hiding from predators.

USING YOUR CLASSROOM AQUARIUM:

Have your students identify the feeding level of each of the different kinds of animals in your classroom aquarium. Is your aquarium a balanced ecosystem with regard to predator-prey relationships? If you have more predators than prey, what do you do to enable the predators to survive? You feed them food produced outside the tank. What changes would have to be made to create a balance in your aquarium?

EXTENSIONS:

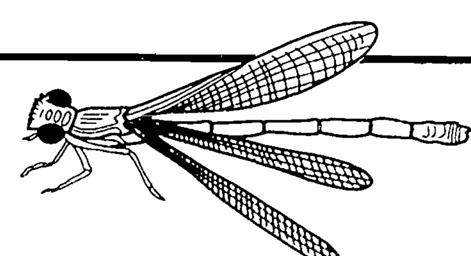
1. Have the students write several paragraphs about how it made them feel to be "eaten" or to not get enough to eat and to "starve." Most wild animals must face these problems routinely.

2. If your school has computer software that includes food chain simulations, set one up so that the students may experiment with it. Have them compare their model used in class with that of the computer. Identify which animals were producers, consumers, etc. Did the computer model give similar results?

3. Have students do an analysis of common domestic farm animals with regard to their place in the food chain. It becomes apparent rapidly that most of the major animals we depend on for meat, milk or eggs feed low on the food chain. Why? Each animal uses food to produce heat and movement as well as for growth. Energy spent on heat, movement, digestion and chemical work inside its body is lost. Only energy which is used for growth is available to the next level of the food chain. Less food would be available if we fed on carnivores rather than herbivores. Examples: cows, sheep, horses, rabbits, geese, and goats eat plant material; chickens and pigs are feed primarily plant material, although they may also get fish meal or other animal products. The two carnivores that are common on farms are kept for behaviors that relate to their feeding habits. Cats kill rodents that would steal grain from the farmer. Dogs hunt by chasing things, making them naturals at herding cows or sheep. They also bark at the sign of intruders.

4. Have the students analyze their own diets to see where they feed on the food chain. Western diets are much higher in animal protein than those of many underdeveloped countries where people cannot afford to waste the food energy that would be lost from grain by feeding it to animals and then eating the animals. Research the diets of other countries and compare how much plant food versus animal food is eaten.

5. Have a food tasting session to sample nutritious foods that are all plant material. Since plants do not have the complete protein that animal products do, combinations of plants are needed to provide balance. A good vegetarian cookbook from the library will explain how to plan a vegetarian diet for good nutrition.



DATA SHEET FOR ACTIVITIES 29 AND 30

First run

feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores	12	12	–	0
carnivores	6	–	2	4
top carnivores	2	2	–	0

results ______________________________

Second run

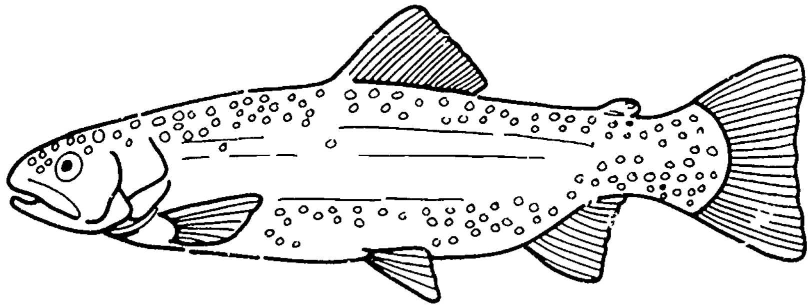
feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores				
carnivores				
top carnivores				

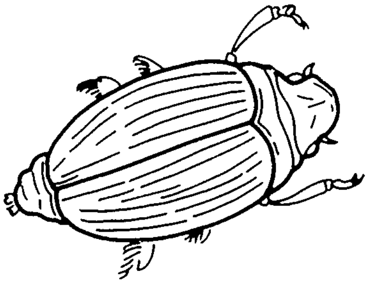
results ______________________________

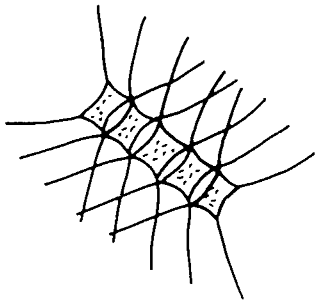
Third run

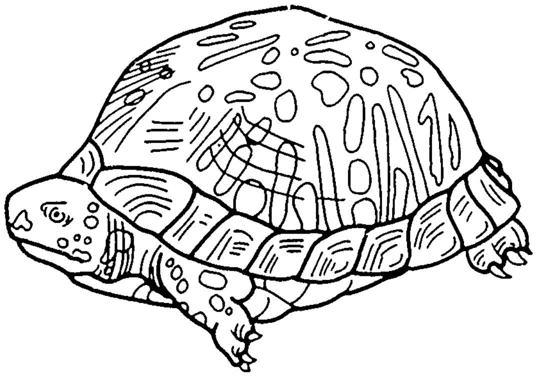
feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores				
carnivores				
top carnivores				

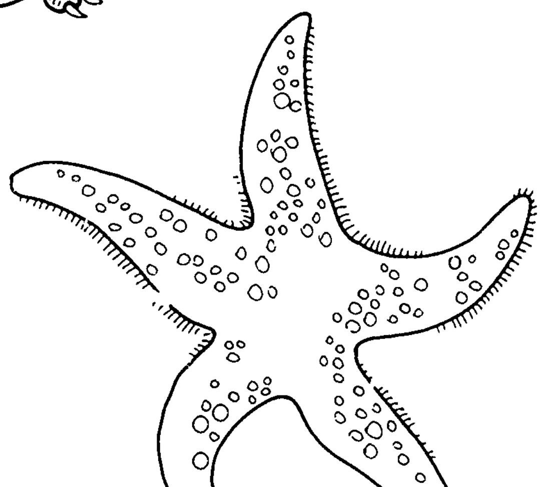
results ______________________________

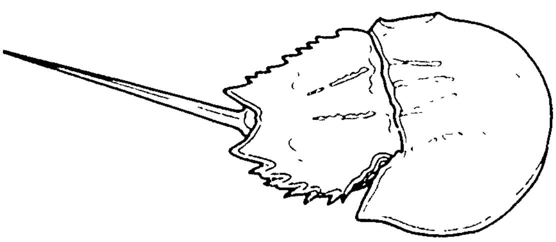












ACTIVITY 30

GETTING CAUGHT

DO SOME HUMAN ACTIVITIES CHANGE THE FEEDING RELATIONSHIPS, AND THUS THE ECOLOGICAL BALANCE, OF A FOOD WEB?

SCIENCE SKILLS:

- organizing
- inferring
- predicting
- experimenting

CONCEPTS:

- Removing the top carnivores from a habitat can change the feeding relationships at other levels of the food chain.
- Human management of natural areas requires an understanding of the importance of a balanced food web.

SAMPLE OBJECTIVES:

- Students will be able to identify human activities which affect feeding relationships in an aquatic environment.
- Students will be able to identify correct fisheries management practices.

INFORMATION:

In this simulation activity your students will learn how the basic ecological principals relating to food chains, which they have experimented with in Activities 28 and 29, can be applied to the management of aquatic habitats. Human activities may affect food chains in many ways. Pollution and habitat destruction cause obvious changes that are easy to see. Dead fish are hard to ignore. It is also easy to understand the consequences of filling a pond or marsh in order to build a shopping center or add another field to a farm. The whole habitat goes away. Much more subtle changes may result from the extensive harvesting or removal of selective levels of the food chain.

When we selectively remove some fish, we are making changes that may have a significant impact on the other animals and on the plants in the pond, lake or ocean. Very careful planning of fishery regulations is necessary to be able to remove animals from a system on a long term basis without destroying the ECOLOGICAL BALANCE of the entire system. The result of this careful planning is a calculation of how many fish can be taken year after year without upsetting this balance, the SUSTAINED YIELD. The people who study these problems are in a field called FISHERIES or WILDLIFE MANAGEMENT. They set fishing limits for both sportfishing and commercial fishing and enforce them. They make use of practical applications of the kinds of ecological principles learned in this exercise.

MATERIALS:

FOR EACH STUDENT:

- 10 markers (poker chips, beans, pennies or other non-destructible small items)
- small plastic bag

FOR THE TEACHER:

- plastic or crepe paper flagging or cloth strips in three colors
- whistle
- pad or chalk board and pen or chalk
- data sheets to record results (p.313)

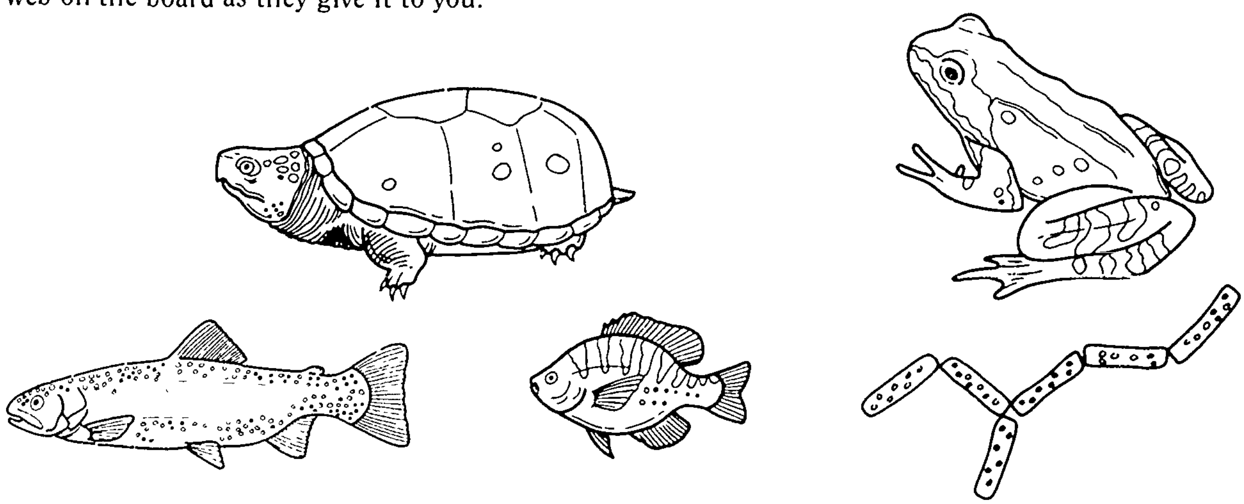
LESSON PLAN:

BEFORE CLASS:

Use Activities 28 and 29 prior to this activity. This experiment combines the effects of COMPETITION from Activity 28 and PREDATION from Activity 29. The two taken together establish the idea of a balanced food chain and the way that feeding regulates reproduction rates. The materials and location for this activity are the same as those two exercises.

DURING CLASS:

METHODS: Explain that the class is going to continue to experiment with food chains, but this time the students are going to ask questions about the impact that humans can have on the balance of a food chain. Ask for some ways that some people might affect the animals in the pond food chain that they have been using as a model. While the students are most likely to think of things relating to pollution, someone will probably come up with fishing. Ask them to tell you what the feeding levels were in the pond model and what kinds of animals lived at each. Draw the food web on the board as they give it to you.



Which level is the most likely to be taken by humans? Since people like to catch big fish rather than tiny minnows, big fish are the likely candidates for human removal. The children are less likely to think of hunting for sport or trapping for fur. Another top carnivore, the raccoon, is frequently hunted with dogs as a sport. During the winter, raccoons are trapped for their fur which is used in fur coats. Ask if anyone has seen a coat made of or trimmed with raccoon fur. (It has long hairs and is a mix of tans or browns.) Therefore, in our model pond, we are going to assume that people come to the pond and catch all the big fish while other folks hunt all the local raccoons. We now have decided how humans are going to disturb the pond food chain in our model.

Run the first experiment. The first time around see what happens before humans are involved. People will be added to the system in a later run. Start by designating ¾ of the students as herbivores—the zooplankton, insects, and crayfish. Make 2 students top carnivores—the big fish and raccoons. The remaining students will be carnivores that feed on the herbivores—the frogs and small fish. Hand out the colored flags which show their feeding level and the plastic bags to hold the food they eat.

Scatter 10 food items per herbivore. Each herbivore needs 10 to survive and reproduce. Each carnivore needs 20 pieces and each top carnivore needs 40 to survive and reproduce. When any animal has enough food, it can go to hide in a safe place. When any animal has been tagged by its predator, it has been "eaten" and must give up its food and sit down. Allow the students to play the game until everyone has either gotten enough to eat, run out of food to eat or been eaten. Was this in reasonable balance? That is, did some members of each level survive? Record the results.

Now repeat the experiment with one big change. A trapper came and caught the raccoon and a fisherman or woman got the big fish. Have the same children take each role, but the two top carnivores sit out. Have the students predict the outcome. Run the game again.

RESULTS:

What happened to the balance? Did the herbivores get eaten much worse? What would the children predict would happen in the next generation? Ask the students if they can see the direct consequence of removing the top carnivores on the structure of the food chain. Even in one generation, there should be the obvious result that there is no longer a balance. The secondary consumers are now able to eat almost all the herbivores, leaving few to reproduce in the following year. With the herbivores gone, the carnivores will starve in the following years.

CONCLUSIONS:

Natural food chains are generally balanced over a period of years. When all of one level is removed, the other levels will be affected. Any human harvesting of natural populations must take into account the effect on the other levels of the food chain. Top carnivores are an important part of the balance of the food chain, not bad things that should be killed.

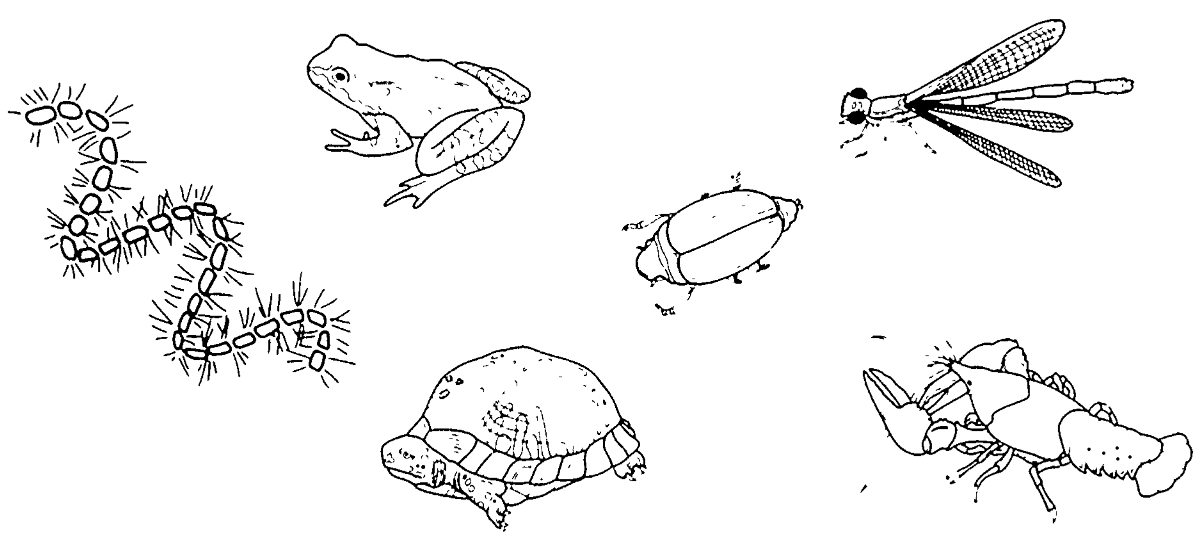
EXTENSIONS:

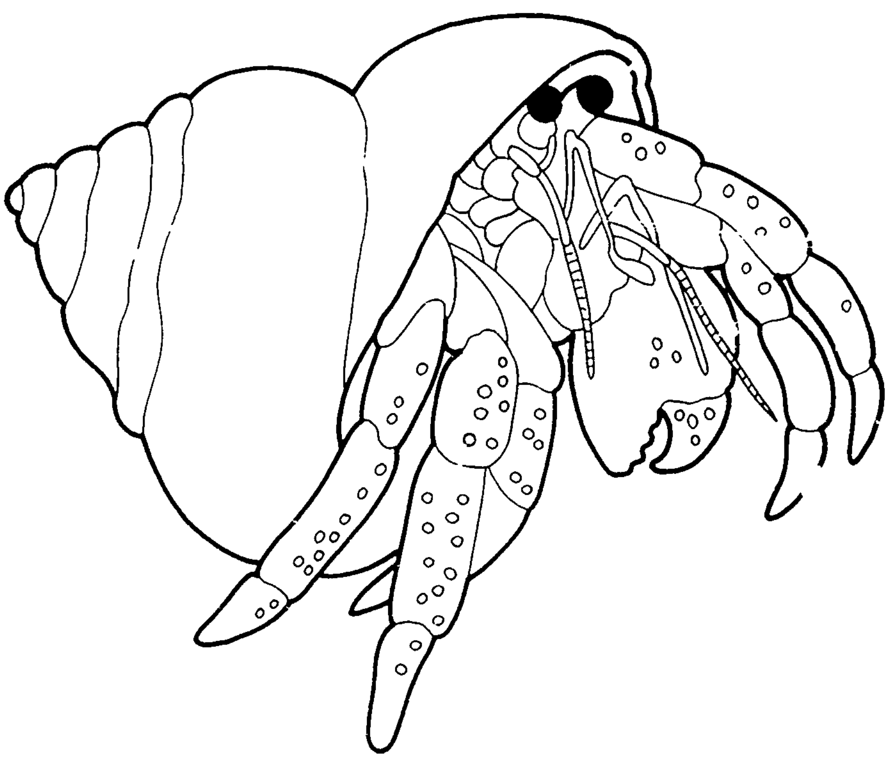
1. For a comparison of what has happened in cases where people have actually selectively removed whole levels of a food chain, consider the following:

a. In the early part of this century, extensive hunting of mountain lions in northern Arizona effectively removed predation from the deer herds. In the years that followed, the deer herds grew because their predators were gone. Eventually there were so many deer that they ate all the vegetation. Then the deer started starving during the winters. They had virtually destroyed the vegetation on which they depended. During succeeding years the deer population declined dramatically due to starvation. In this case removing the top carnivore resulted in starvation of its prey and such extensive damage to the plants that neither the vegetation nor the deer have ever recovered properly.

b. Recently extensive fishing for small fish called capelin has so reduced the numbers of these animals that the sea birds such as puffins that depend upon capelin for food are experiencing reproductive failure as their young starve. It is possible to overfish capelin because they swim in tight schools. By hunting for the schools with planes and surrounding them with large nets from boats, humans can catch so many that there are not even enough fish left to reproduce.

2. Have students research your state fishing and hunting regulations. These are management practices that should be based on an understanding of food chains and ecological balances.

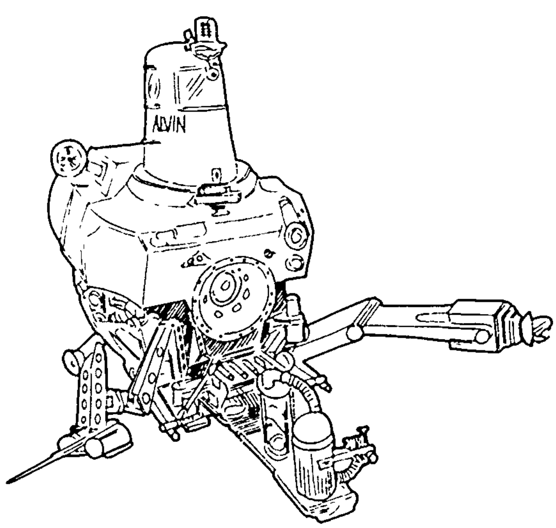




SECTION V
EXPLORATION, RESEARCH AND COMMUNICATION

TEACHER'S INFORMATION

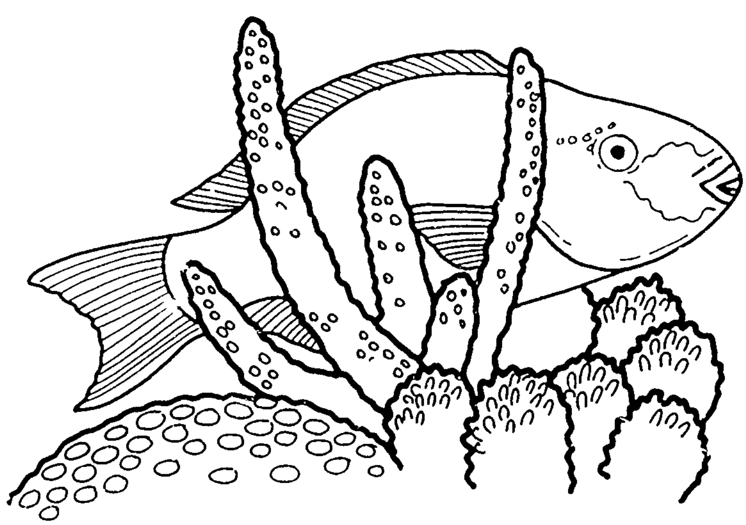
Exploration of aquatic habitats, particularly the oceans, has changed radically in the last several decades. Although humans have looked beneath the water by jumping in or with a variety of somewhat crude diving machines through the centuries, recent technological advances making both firsthand exploration and remote sensing possible are opening up a vast new frontier. People had been collecting information on tides, depths and currents for many years, but the first major oceanographic expedition, the four year voyage of the *H. M. S. Challenger,* occurred in the 1870's, only a little more than one hundred years ago. The *Challenger* used nets, lead lines and water samplers to collect information just as scientists still do today in both marine and freshwater environments. In recent years, new technological advances have made possible several other means of gathering data. Sophisticated sonar has presented us with accurate pictures of bottom contours, taught us about the grooves gray whales make when they feed, and even located the *Titanic.* Submersibles like *Alvin* have taken humans to the bottom of the sea floor to make discoveries like the deep vents. Remote cameras send back pictures of strange creatures thousands of feet beneath the ocean surface. Current meters scattered throughout the world periodically surface and radio back information about water movements at various depths. Satellites send back information on phytoplankton abundance, surface temperatures and weather patterns.



How is all this information shared among scientists? Researchers write papers which are read by other scientists. Some of the really exciting findings also appear on the evening news or in magazine articles. The National Geographic Society funded part of the expedition which explored the deep vents of the Galapagos Rift. Many of the incredible discoveries of the expedition were reported in *National Geographic* before they appeared in scientific journals because journals require a lengthy review process by other scientists before they will publish papers. While the scientific literature is not accessible to children, magazines like *Oceans, Sea Frontiers* and *National Geographic* are good places for them to do library research on marine and aquatic science.

The best way for children to really appreciate how scientists study aquatic habitats is to go on a field trip which enables them to do the real thing and be scientists themselves. Where they go is not so important as what they do. Children need to understand the process a scientist would use. First, they should read whatever they can about the kind of habitat they will visit. A scientist starts a project with a literature review to find out what is already known. Second, they should plan exactly what kind of information they want to collect and how they are going to collect it. A scientist would plan the trip, collect needed gear, and make data sheets to organize the information collected. On the trip the students should work cooperatively to accomplish the goals they established in their planning. A scientist frequently works with others and supervises the work of graduate students or research associates. The samples collected on the trip should be brought back to the classroom for analysis. A scientist may spend a week in the field and a year studying the collected materials back in her/his laboratory. When the data are assembled and analyzed, the students should write reports and/or give papers which share their findings with others. A scientist's work is not finished until it is shared with other scientists.

Communication is the final part of the scientific process. If a scientist does not share his or her results with others, then a field of study cannot advance. Communication may take the form of words, graphs, charts and pictures. Scientists write papers for scientific journals, give talks at meetings, share their knowledge with politicians and public interest groups, write articles for magazines, publish books and textbooks, and make movies and videos for television and schools. All are forms of communication and are important.



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ACTIVITY 31

GETTING TO THE BOTTOM OF THINGS

CAN SCIENTISTS MAP THE BOTTOM OF AN OCEAN OR A LAKE WHEN THEY CANNOT SEE IT?

SCIENCE SKILLS:

- measuring
- organizing
- inferring
- predicting
- communicating

CONCEPTS:

- Students can describe something they cannot see by measuring it and correlating their data.
- Scientists can explore and map the structure of underwater habitats using techniques which sense the bottom contours.
- The greater the number of samples taken, the greater the accuracy in predicting an outcome.

MATH AND MECHANICAL SKILLS PRACTICED:

- finding coordinates on a map
- measuring depth

SAMPLE OBJECTIVES:

- Students will be able to map the bottom contours of a body of water.
- Students will be able to observe the value of repeated samples in making predictions.

INTRODUCTION:

In this activity you will make a model ocean for the students to explore using a technique that served sailors and oceanographers for thousands of years. Until recently the depth of coastal waters, rivers and lakes was measured by a weighted, marked line. Charts were laboriously made from these measurements, although any prudent sailor got out the line in shallow water as the channels could change overnight. Now depth sounders and sonar accomplish the same task.

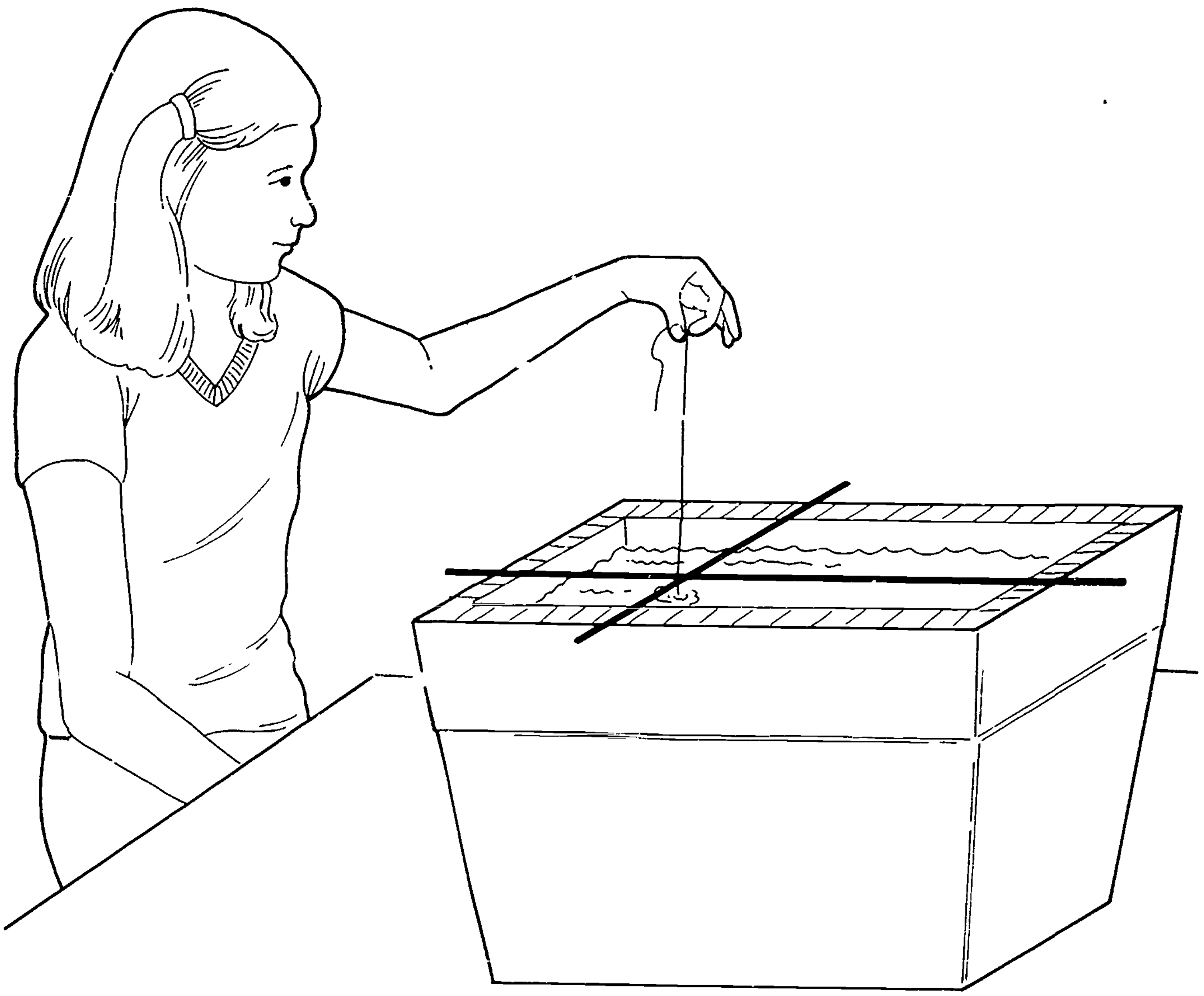
MATERIALS:

- large watertight styrofoam cooler
- dark plastic garbage bag
- water to fill cooler
- dark food coloring—blue or green
- bricks, rocks, sand or gravel
- straight pins
- 2 one meter sticks or thin wands (push plastic straws together)
- two strings marked at 1 cm intervals with a waterproof marker
- 2 small metal nuts or washers
- data sheets for each pair of students
- one enlarged data sheet on paper or chalk board
- bucket and pan to bail cooler out or siphon hose

LESSON PLAN:
BEFORE CLASS:

Make the model ocean. Take a large sturdy styrofoam cooler and test it, letting it sit overnight full of water. Do this at home in your bathtub or outside. In your classroom place the cooler where you plan to use it. Place bricks, rocks, gravel and/or sand on the bottom to make underwater mountains and trenches. The items must be heavier than water or they will pop up. You want your ocean to have an interesting, but not wildly cluttered bottom. Cut the trash bag open. Cover the bottom and sides of the cooler with it. Fill the cooler with water. It does not need to be filled to the top. You might even leave an island in your ocean. Add food coloring until the water is so dark that the bottom is invisible. Make the lead lines by tying string to two nuts or washers and marking it in centimeters with a permanent marker.

Write north, east, south and west on the sides of the cooler so your students' maps will all have the same orientation. Using pins and paper tags marked with waterproof pens, put tags every inch in each direction with a,b,c's going north to south and 1,2,3's east to west across the box. Make data sheets by modifying the included sample sheet to get it the correct size to make a map of the possible coordinates to be sampled on your ocean.

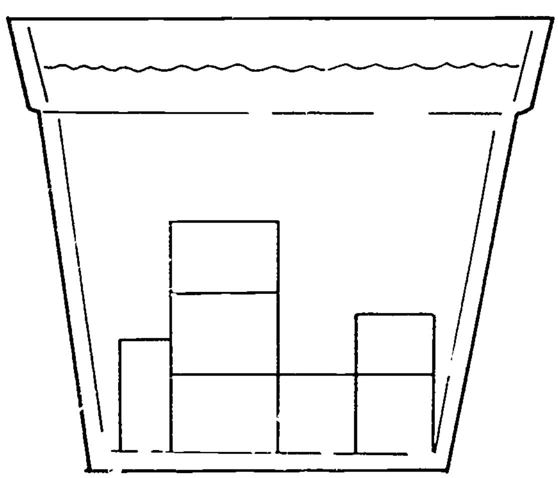


DURING CLASS:

METHOD: Introduce the question of how a scientist can make a map of the ocean bottom without ever seeing it. Have students suggest possible ways. In the "old days" people used weighted, marked lines to test depths. Mark Twain, who worked on a river boat, took his pen name from a call given by a person who rode the bow of the river boat and used such a line to measure the water depth as the boat moved. His real name was Samuel Clemens.

The more modern way to accomplish the same thing is to use SONAR, in which a sound is sent down through the water. The time it takes the sound to travel to the bottom and bounce back to the boat is measured. The length of time is a function of how deep the water is. For this activity we are going to use the old fashioned method, a marked line to sample the model sea, an unknown ocean whose bottom contours the students are going to explore during the day.

How many samples do you need to take? Have a discussion about the fact that more samples give a greater accuracy in prediction. During the class or classes, pairs of students will make 10 depth measurements and record the location and depth on their own data sheets. They will mark off the COORDINATES they have sampled by putting an X on that spot on a data sheet left by the model sea. They will need to understand the concept of imaginary lines on the surface of the world that run north and south or east and west. Any location can be defined by giving the north to south (longitude) and east to west (latitude) of its location. In this case the scale is marked on the sides of the box and wands or sticks, one running north to south and the other east to west intersect at a point which corresponds to a point on the map. Make sure the students understand that the data sheets they have are a map of the surface and that they are going to record depth at specific locations on that surface. The depth of the water in centimeters is written on the map on top of this point.



RESULTS:

When each pair of students has made measurements, the pair will predict the bottom contours based on the 10 data points taken. Each will draw its idea of what the bottom looks like from a few points. Near the end of the class each pair of students should record its data on the large map in the front of the class. When everyone has done the activity, draw lines that connect the points of common depth to make a contour map of the bottom for the whole class. Are there differences in their predictions based on a few data points and the results following the collection of many data points? There should be.

CONCLUSIONS:

Now for verification. Can marine oceanographers drain the ocean to see if they are really right in their predictions? No, but we can. Ask the students how they would get the water out of their ocean to test the validity of their predictions. Pouring or bailing might disturb the bottom. The best way is to siphon the water out of the "ocean" into a bucket using a piece of hose. Did the measurements taken and the final map drawn make a good picture of your ocean floor? Can oceanographers ever make a perfect picture of the ocean floor? No, but as they collect more and more data, their maps get better and better.

EXTENSIONS:

1. The history of exploration of the Earth has been closely tied to human technological ability to figure out where one is in relation to a fixed point and to make maps showing features and relative locations so that others can follow. Map making and the science of moving from place to place accurately (navigation) have helped early explorers move over the two dimensional surface of the Earth and now through the three dimensions of space. Compare maps of the oceans made at different periods in time. Examine the range of navigation technology used from that of early sailors like the Phoenicians to the Vikings to the Portuguese to modern day sailors that use satellite navigation.

2. Do a map-reading activity or a map-making activity on your playground or a nearby park using a compass. You might make it a contest to find buried treasure in which the clues on the treasure map require doing math problems to find distances and fill in the blank questions to give clues to important features like trees or basketball hoops.

3. The National Oceanic and Atmospheric Administration (NOAA) is responsible for mapping American waters. NOAA has free films which may be borrowed which show some of its work. Write for a current brochure: National Oceanic and Atmospheric Administration, 2001 Wisconsin Ave., NW, Washington, DC 20235

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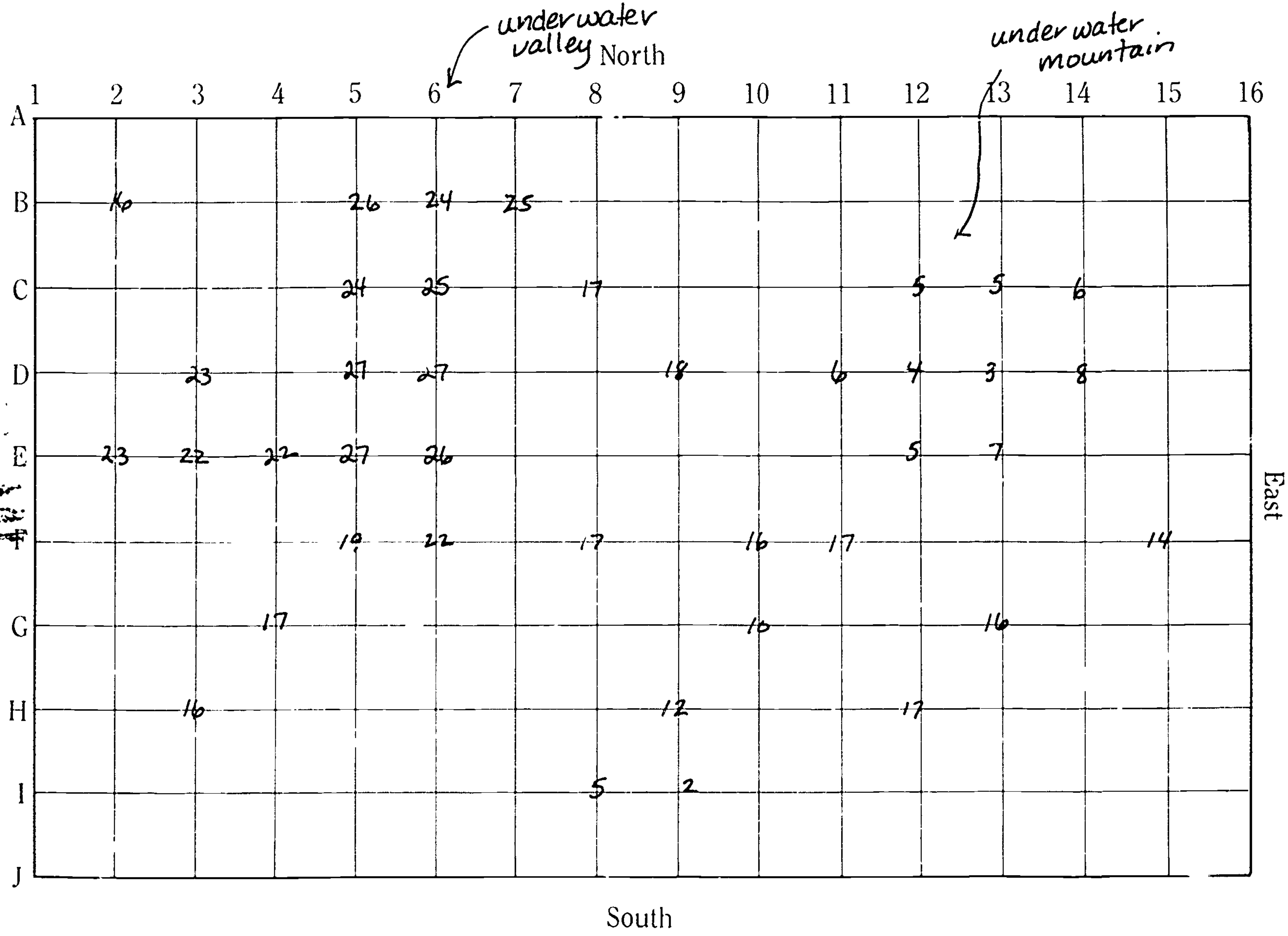
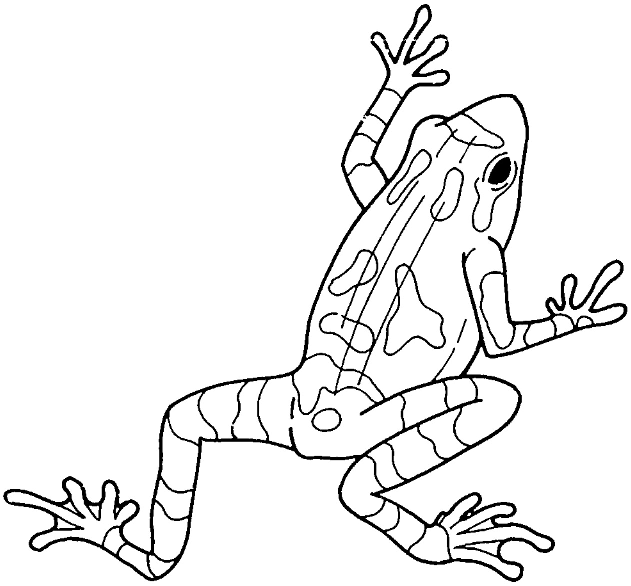
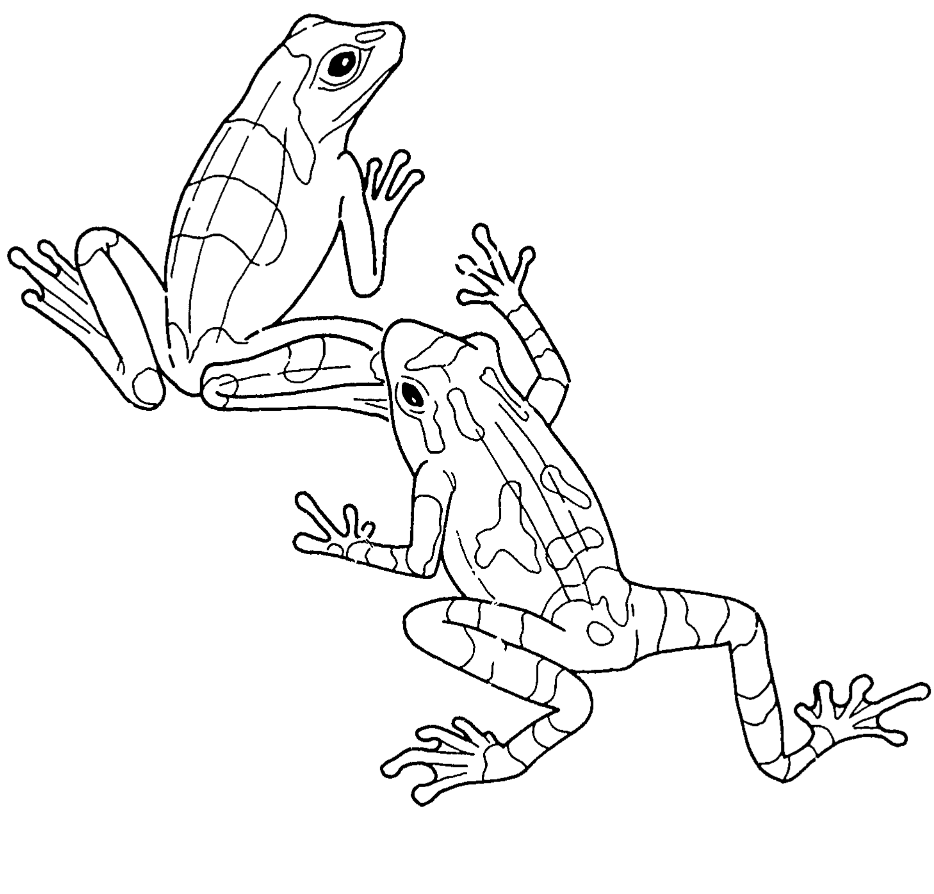
Name ____________

Write depth (in cm) next to position where lines cross.







ACTIVITY 32

UNDERWATER EXPLORATION

HOW IS MODERN TECHNOLOGY BEING USED TO STUDY THE PHYSICAL, GEOLOGICAL, CHEMICAL AND BIOLOGICAL NATURE OF THE OCEANS?

SCIENCE SKILLS:

- library research
- communicating

CONCEPTS:

- Technological advances in recent years are advancing understanding of the oceans at a great rate.
- Creative applications of technology cross traditional boundaries of knowledge.

SAMPLE OBJECTIVES:

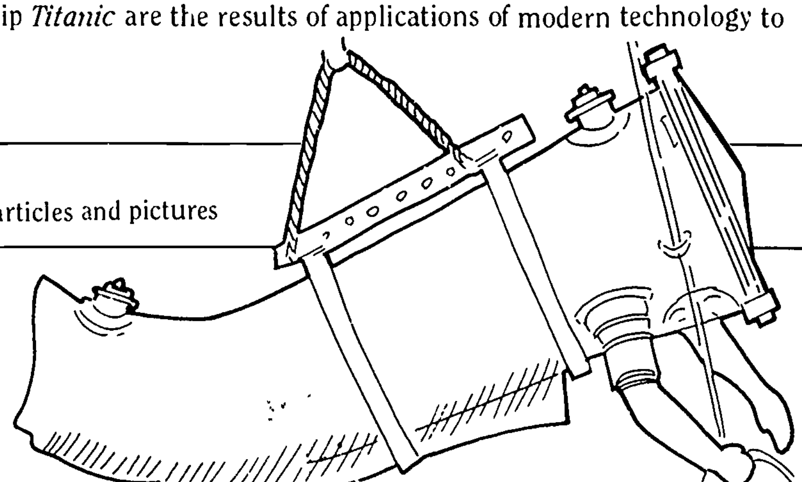
- Students will be able to find scientific information in a library.
- Students will be able to communicate their findings to other students.

INTRODUCTION:

Serious exploration of the deep sea dates from the oceanographic voyages of the British ship *H. M. S. Challenger* from 1872–5. In recent years the applications of new technology have totally changed the means by which we gather oceanographic data. No longer is data on currents gathered by setting bottles adrift. Current meters can be anchored at specific depths, spend months recording data, release themselves to return to the surface and be retrieved. Bottom samples may still be gathered by a dredge or grab from great depths, but now scientists can also go to the bottom themselves in submersibles like the *Alvin* or they can send down remote television cameras to record what they see. Instead of doing long and laborious phytoplankton tows to estimate primary production in an area of the sea, scientists use satellites to measure the standing crop of phytoplankton in vast areas over whole seasons, using surface tows for "ground truth" to make sure their measurements are valid. Satellites measure surface temperatures too, and recently gave us wonderful pictures of El Nino, a change in temperatures that affected the entire Pacific. Underwater habitats allow humans to live for weeks at a time in shallow water, avoiding the decompression problems SCUBA divers face in returning to the surface repeatedly. Discoveries like the deep vents along ocean rift zones or the ship *Titanic* are the results of applications of modern technology to oceanic exploration.

MATERIALS:

- public library
- popular scientific magazine articles and pictures



LESSON PLAN:

THREE TO FOUR WEEKS BEFORE CLASS:

This is not a scientific activity, but a library research activity. It will introduce concepts of scientific exploration which are beyond your classroom, but of great interest to your students. It also provides oral and visual communication skills practice in that your students will share their knowledge with each other. Provide the assignment in written form.

OCEAN EXPLORATION

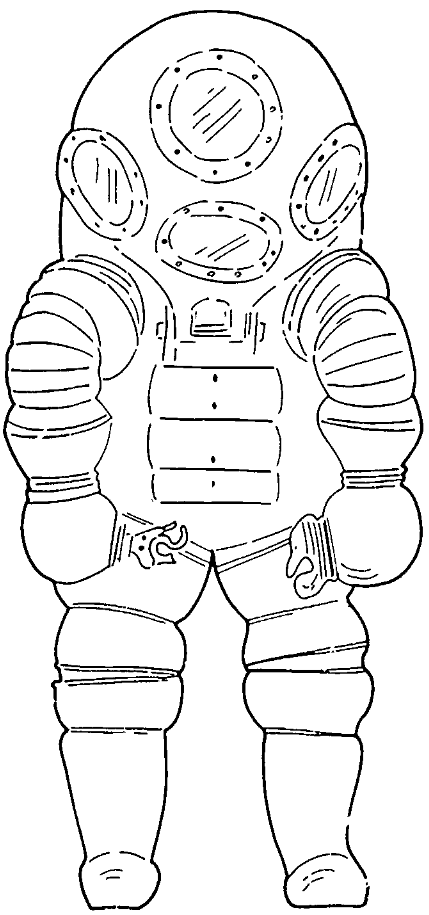
Assignment: Pick out an example of a tool or technological advance used to *explore the ocean* in order to learn more about its physical characteristics, its chemistry, its geology or its biology. Explain what it is, a little bit about how it works, where the idea came from to use it, what date it was first used, and what we can learn from its use. Make a model or a drawing big enough to share with your classmates that helps show how it works. Be able to give a five minute talk about what you learned.

Some inventions may be hundreds of years old while others may be brand new. Each shows human progress in the application of technology to exploration of the seas.

Ideas for topics could come from the following sources:

- Books on oceanography written for the general public
- Magazines such as *National Geographic, Sea Frontiers, Scientific American* and *Oceans*
- Television programs

Ask your librarian for help in using the resources of your school or public library. The *Reader's Guide to Periodical Literature* will help you find magazine articles.



DURING CLASS:

Use the dates for the first use of the technology to arrange the talks in chronological order from earliest to most recent. Draw a timeline on the blackboard so each child can locate his/her information with regard to the others. By working your way through the sequence, the students should get some idea of the tremendous progress that has taken place in recent years.

RESULTS:

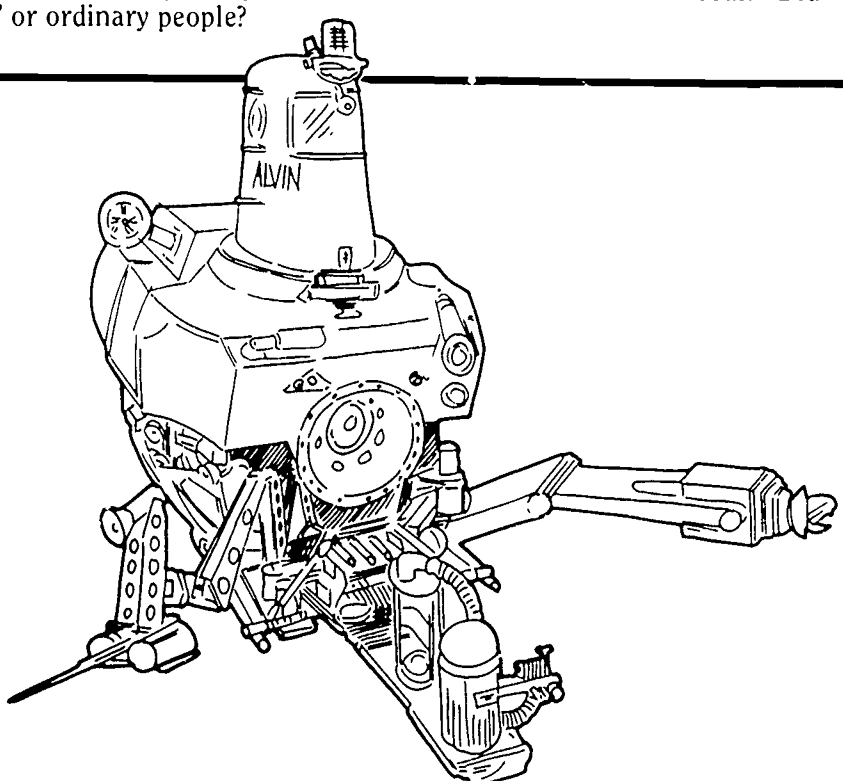
Meet privately with each student for a few minutes during the following week to discuss what was best about his/her talk and provide examples of possible improvements for oral talks. Or have a group discussion of what each person did best. No bad things allowed.

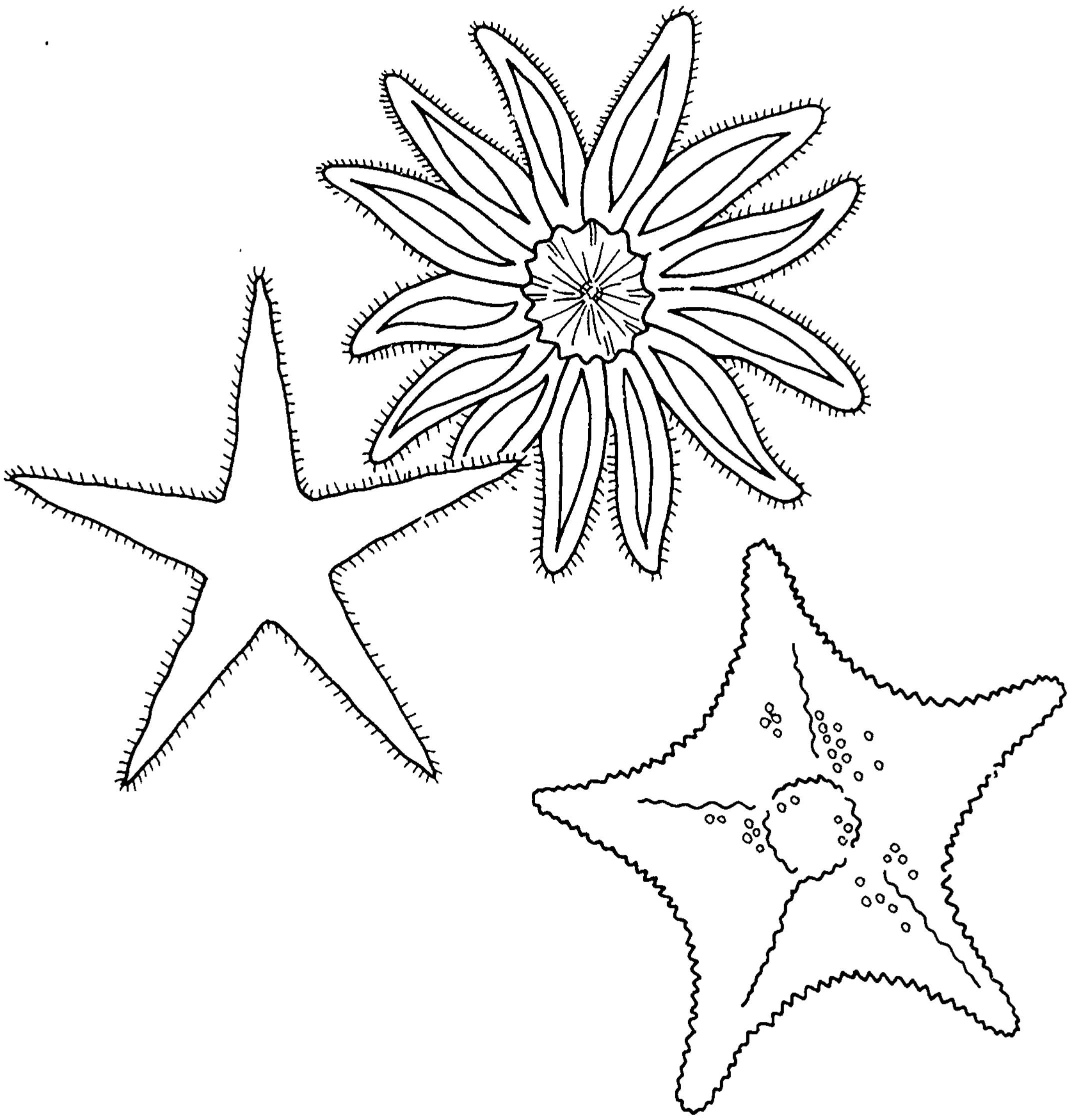
EXTENSION:

1. Follow up the talks with one of the best science films ever: "Dive to the Edge of Creation" made by the National Geographic Society. This film chronicles the first major expedition to a deep vent system on the east Pacific rise. It very clearly shows that science is not always clean and orderly, that scientists can get as excited as kids in a candy store over a discovery, and that all the good discoveries have not been made. The kind of science done in this film is the original observational level in which more questions are raised than answered. This film was shown on PBS and has won numerous awards. It may be available as videotape or film in your school system. The rental fee is high since the film is about 56 minutes long.

Ask the students to watch for answers to some of the following questions during the film:

- Do you think an expedition like this is expensive? Did you discover some of the organizations who paid for this work?
- What kind of planning was necessary to make this trip? What are some of the things that had to be planned that were not science? That were science-related?
- Where did the scientists come from? Were they all from the same place? Did they all do the same kind of work or did they have different specialties?
- What are some of the problems with working in very deep water and around the vents?
- Were there people on the trip who were not scientists? What kinds of things did they do? Were they important? Could you become a person who helped marine scientists, yet not be one yourself?
- Would you be scared to go clear to the bottom of the ocean in a little sphere of metal? Do you think these scientists were afraid? Why or why not?
- Can part of doing science be boring? Dirty? Did these scientists all wear white coats? Did they look like "nerds" or ordinary people?





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ACTIVITY 33

GETTING WET!

AN AQUATIC FIELD INVESTIGATION

SCIENCE SKILLS:

- observing
- measuring
- classifying
- organizing
- inferring
- communicating

CONCEPTS:

- Ecologists study the physical and biological characteristics of environments in order to try to explain the distribution of organisms and study their relative abundance.

MATH AND MECHANICAL SKILLS PRACTICED:

- graphing
- averaging

SAMPLE OBJECTIVES:

- Students will be able to plan and execute an ecological study of an aquatic environment.
- Students will be able to collect and analyze data.
- Students will be able to give oral and written presentations based on their field investigation.

INFORMATION:

Nothing is more work than taking students on a field trip. Nothing is more rewarding than going out to study the real world. It is impossible to write a single guide to making a field investigation. You may organize a three day extravaganza to the wild or spend a half a day working on a pond in a local park. If the site is on your school grounds, the study might cover several months of weekly measurements. Success depends on planning, planning and more planning.

The problem with many field trips is that they do not include classroom work in planning the trip or working up data collected upon return: they are not true investigations. If you are going to the trouble of planning and organizing the trip, be sure to allocate pre-trip preparation time with your students to make sure everyone knows what they will be doing and why they are doing it. Set goals and objectives. Involve students in the planning. Also, leave plenty of class time to study the things you collect or see on your field trip.

LESSON PLAN:

BEFORE THE TRIP:

The first problem is to find a place to go. There may be a very nice pond or stream within walking distance of your school which would make a great site. Ask your students. If there is a body of water nearby, some of your children will have found it. If you can afford to take a trip on a bus, you may go farther afield. Unless you are skilled in running ecological field trips, find a nature center, environmental education site, marine lab or organization that runs field trips. Working with professional field trip people will save you a good deal of time. They will have needed facilities and equipment. Call state environmental science specialists, county science specialists or high school environmental education teachers for suggestions about places to go. City, county, state or federal parks may also have environmental programs.

Visit the site yourself first. If there are staff members at the site, talk to them. Take a teacher workshop or training program there. Take slides to share with your students and collect information on the habitat you will visit. Have the students do library research on the habitat and the organisms they can expect to encounter there. If you are running the trip yourself, make sure you have permission to use the site and permission to collect. Collecting permits may be obtained from the state department of natural resources or fish and game departments. Show the permit to your students ahead of time and explain that one cannot just go out and collect without it.

Consider these things in planning:

- Is the site safe?
- Are there restrooms?
- What happens if it rains?
- Do you or the organization you are working with have adequate equipment? If not, can you borrow it from a local high school or other source?
- Do you have field guides for identification or can you check them out at the library?
- Have you made reservations early? Plan a spring field trip early in the fall.
- Have you arranged for transportation?
- Have you sent home permission slips for the trip?
- Have you recruited and trained your chaperones?
- Have you given the students orientation to the site? Do they have a list of what to bring and what to wear? Are they divided into working groups, ready to go?

What kinds of information do you want to collect on your trip? What activities will your students do? Consider trying to correlate physical characteristics of the environment with the distribution of species. For example, compare the number of species and the abundance within species of fish swimming over sandy and muddy bottoms. Look for variations in the distribution of dissolved oxygen in places: test surface versus bottom water in a lake or estuary or day versus very late night samples in a small pond. Transects across ecological gradients reveal changes in species composition. What happens to plant species as one moves from dry land into a marsh or pond? What changes are seen in invertebrates and seaweeds from the very high to the low intertidal zone? Use ideas from the activities in this curriculum.

Never collect without permission of the landowner if on private land or the authorities if on public land. Collection without a scientific permit is forbidden in many areas. Always find out what is legal ahead of time and explain the laws to your students. Collect as few plants and animals as possible. Teach your children respect for each organism. Do not have each student do a large collection of whole plants or animals. If plants and animals are needed for later classroom identification, take ONE of each and leave all the rest where you found them. Label each collection completely so that it can be used in class.

Do some of the wonderful outdoor education activities available. Check the Recipes and Resources section for some ideas. OBIS activities are fun and easy to teach. Use some of the new games which teach cooperation and leadership rather than competition. Have the students sit quietly for five minutes with their eyes closed and see what they can observe about their environment with their other senses.

RESULTS:

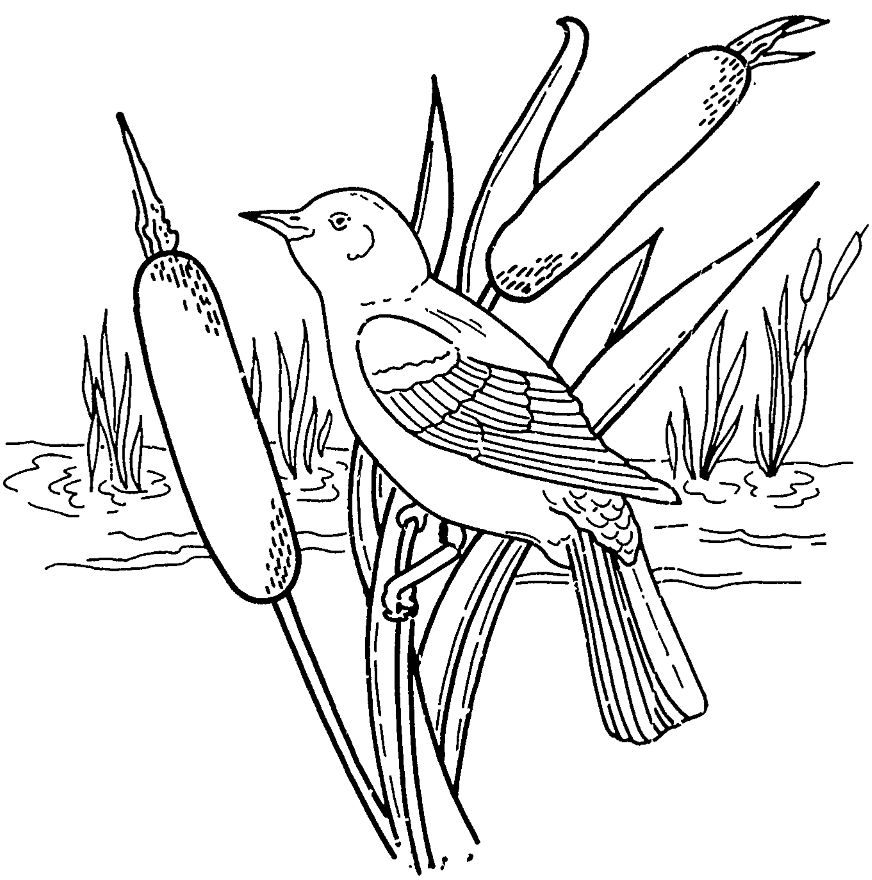
When you return to the classroom, analyze the data you collected. Graph it with line or bar graphs. Look for correlations. Have working groups write reports and give class presentations on their results. You might want to save the oral presentations for Activity 36, the parents' science symposium.

CONCLUSIONS:

Field investigations are hard work and great fun!

EXTENSIONS:

1. Have a field biologist talk to the class about what kinds of work he/she does. Thanks to television, students have very strange ideas about field studies. The rain, heat, cold, mud, insects, long hours and tedious data analysis are missing on nature programs. Look for people from your state park system, state department of natural resources, a local environmental consulting firm or nearby college. Avoid high profile institutions like zoos or aquariums where they get dozens of such requests a week. Seek people actually conducting field research.



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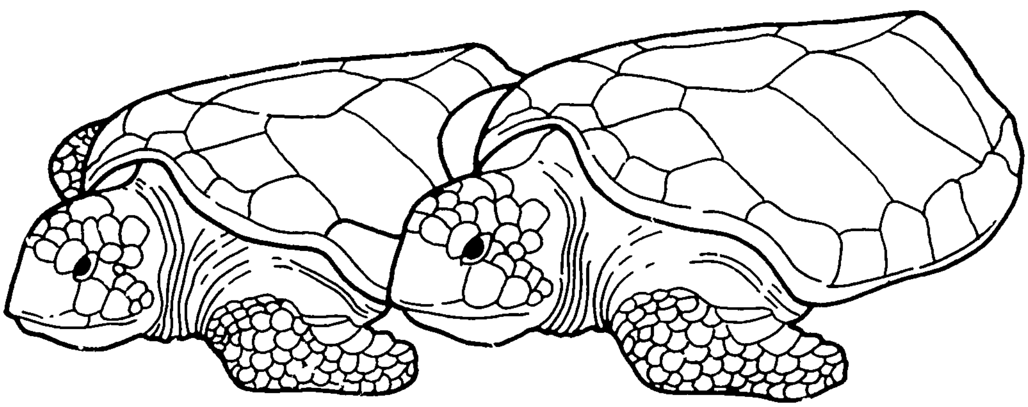

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ACTIVITY 34

AQUATIC LANGUAGE ARTS

INDIVIDUAL LANGUAGE ARTS PROJECTS WITH AN AQUATIC THEME

SCIENCE SKILLS:

- communicating

CONCEPTS:

- Scientific information may be presented to people in many different forms, not just in science textbooks.

SAMPLE OBJECTIVES:
- Students will be able to communicate scientific information through creative writing.

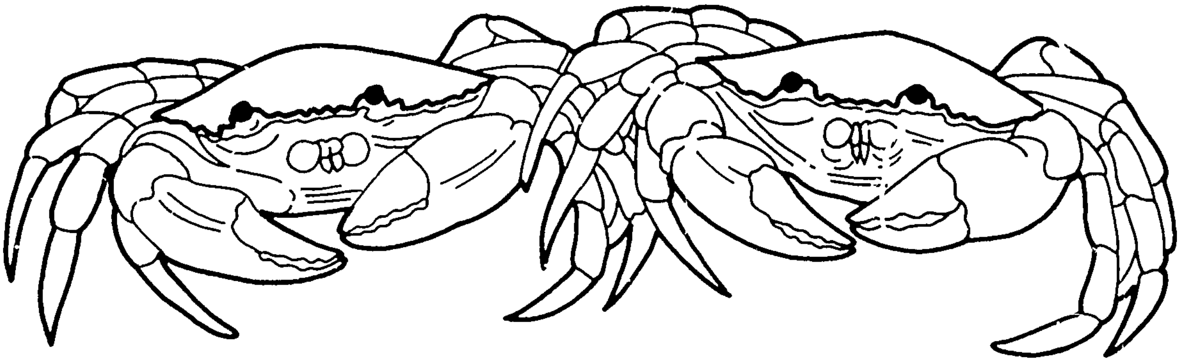
INTRODUCTION:

People gather science information in many ways, especially after they leave school. This activity allows students to use their imagination to communicate scientific information about one aquatic habitat to other people in creative writing projects. The information contained in the resulting projects should be accurate. For a list of possible habitats, consult Activity 2. Have students select from among this list or add ideas of your own.

Pick a habitat.

- write a short story about an animal living in this habitat that includes a realistic situation, but is written from the animal's point of view
- design and write a travel brochure which would make a person want to visit this habitat
- write a short adventure story about exploring this habitat
- write four weather reports, one each for spring, summer, fall and winter for this habitat
- write and tape a television commercial for this habitat
- write a poem about how this habitat would make you feel when you are in it
- write a habitat review like a theater or movie review which rates the different aspects of the environment

During class read some of the individual projects and let the children discuss them with emphasis on what worked best or was the most exciting, and what you learned from each. While you will grade the work as you see fit, have the students vote on a secret ballot for the projects they feel did the best job of communicating information about a habitat. They might be divided into categories to produce many winners. Tally the results and discuss what was really good about the selections. What helped them learn the most in a limited time? What are the characteristics of good communication? You or the students might select specific projects for presentation at the Aquatic Science Symposium, Activity 36.



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ACTIVITY 35

HABITAT DETECTIVES

A GROUP PROJECT IN LIBRARY RESEARCH AND COMMUNICATION

SCIENCE SKILLS:

- library research
- communication

CONCEPTS:

- Scientists frequently work together not only in the lab or field, but on written communications.

MATH AND MECHANICAL SKILLS PRACTICED:

- graphing
- drawing

SAMPLE OBJECTIVES:

- Students will be able to work together to research, write and present a project on an aquatic habitat.

MATERIALS:

- posterboard
- colored pens or crayons
- construction paper
- tissue paper
- scissors
- glue

INTRODUCTION:

This is a group project which combines library research skills with verbal and visual communication. It also requires practicing the organizational and leadership skills required for working in groups. Divide the class into groups of three or four students. You may choose the students with their personal abilities in mind or you may wish to make them work in new groups by having them draw their group number. Each group has one aquatic habitat to research. These are some possible habitats:

small to medium size lake
river where it flows into the sea (estuary)
ocean where the water is deep
rocky coast of ocean
sandy beach
freshwater swamp
freshwater marsh
salt marsh
kelp forest
salt lake
coral reef

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Each group will communicate the results of its library research to the rest of the class by making a large poster or bulletin board which includes both pictures and written information. Pick a standard size on which they must work based on space available in your room. You might have them work on posterboard or folding cardboard. They may work at home, but the actual application of their work to the allocated space may have to happen during class time. The primary objective for the poster or bulletin board is to teach their classmates about their habitat. All the materials should be made by the children's own hands.

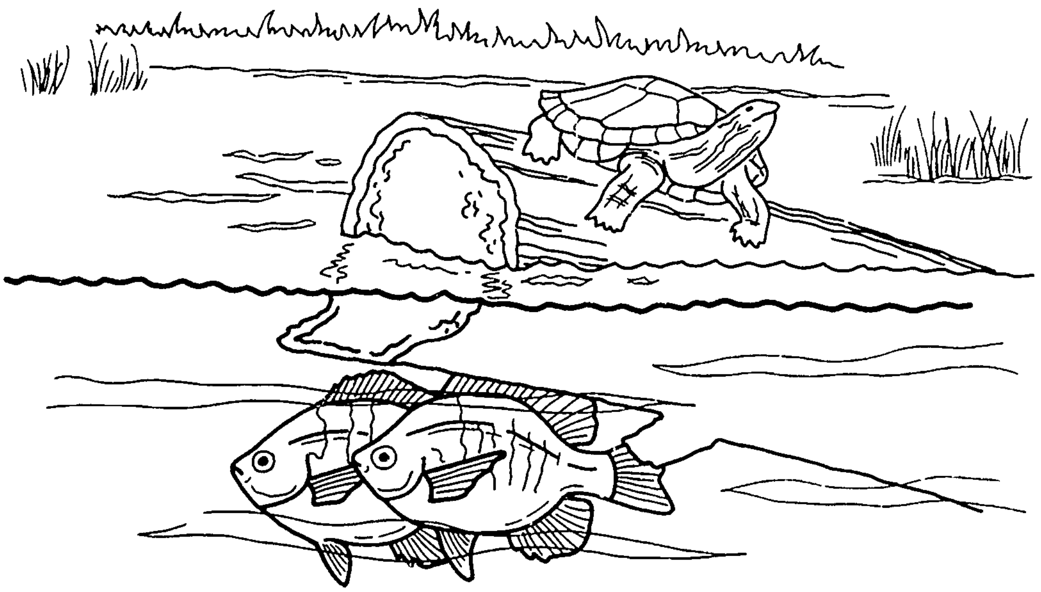
Rules for the project are:

- it can be understood completely in less than 10 minutes;
- it is designed to be read by fellow students;
- it is organized to effectively communicate concepts in ord r of importance;
- it has pictures, written information and at least one graph; maps, charts, and tables are also acceptable;
- it covers the characteristics of the habitat as a whole as well as the typical plants and animals found in it;
- everything on it has been made by the students; no magazine cut-outs although photographs they have taken themselves are allowed.

Additionally, each group will write a four-question quiz for the class which can be completed in less than 5 minutes and evaluates general understanding of the habitat. It might include true/false, multiple choice, matching or single word fill-in-the-blank questions.

RESULTS:

When the assignments are completed, have the students present their work and let the other students read the posters. Have them take the quiz as evaluation. Discuss in a general way what was best about each project in terms of communication. In addition to communicating factual information to their colleagues, the students will enjoy sharing their work with their parents at the Aquatic Science Symposium, Activity 36.



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ACTIVITY 36

AQUATIC SCIENCE SYMPOSIUM

SHARING AQUATIC SCIENCE WITH OTHER STUDENTS OR PARENTS

SCIENCE SKILLS:

- communicating

CONCEPTS:

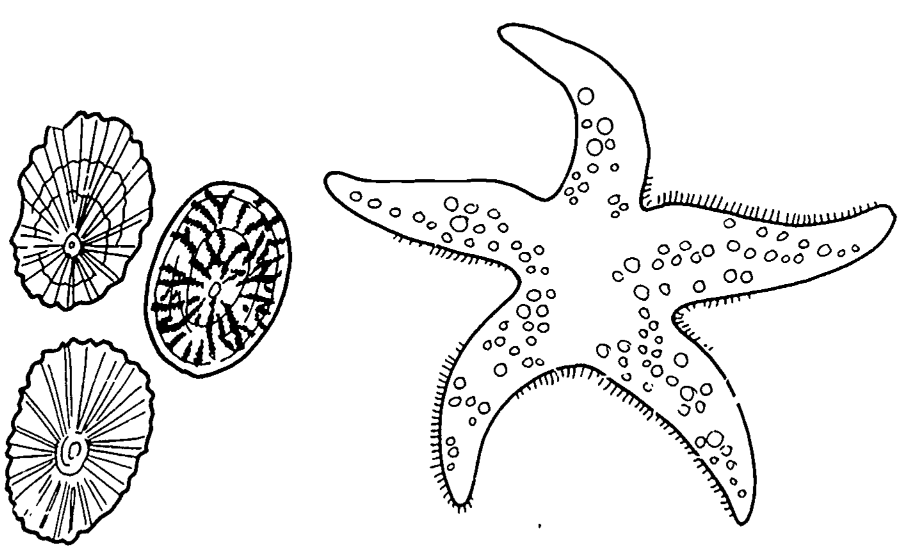
- Communication with others is an important part of the science process.

SAMPLE OBJECTIVES:

- Students will be able to organize and run a scientific meeting.

INTRODUCTION:

Scientists frequently attend meetings at which they share their most recent research with each other in formal talks, present poster sessions during which they stand beside posters displaying their work and discuss it with interested people, and have informal scientific conversations with people in social settings. Complete your aquatic science unit by holding your own meeting, an Aquatic Science Symposium. (The word symposium comes from two Greek words meaning drinking together. In ancient Greece a symposium was a drinking party at which intellectual discussion took place. In modern times the word refers to a conference organized for the discussion of a particular topic.) Use this opportunity to have some children report the results of the research from your field trip, read their creative writing projects and present data from some of the experiments in this curriculum. The posters from Activity 35 and models of oceanographic equipment from Activity 32 would make good poster sessions. Demonstrations of some activities for the guests would be fun. Issue invitations, decorate the classroom with an aquatic theme, dream up some aquatic refreshments (fish-shaped cookies and blue punch?), and really show off.



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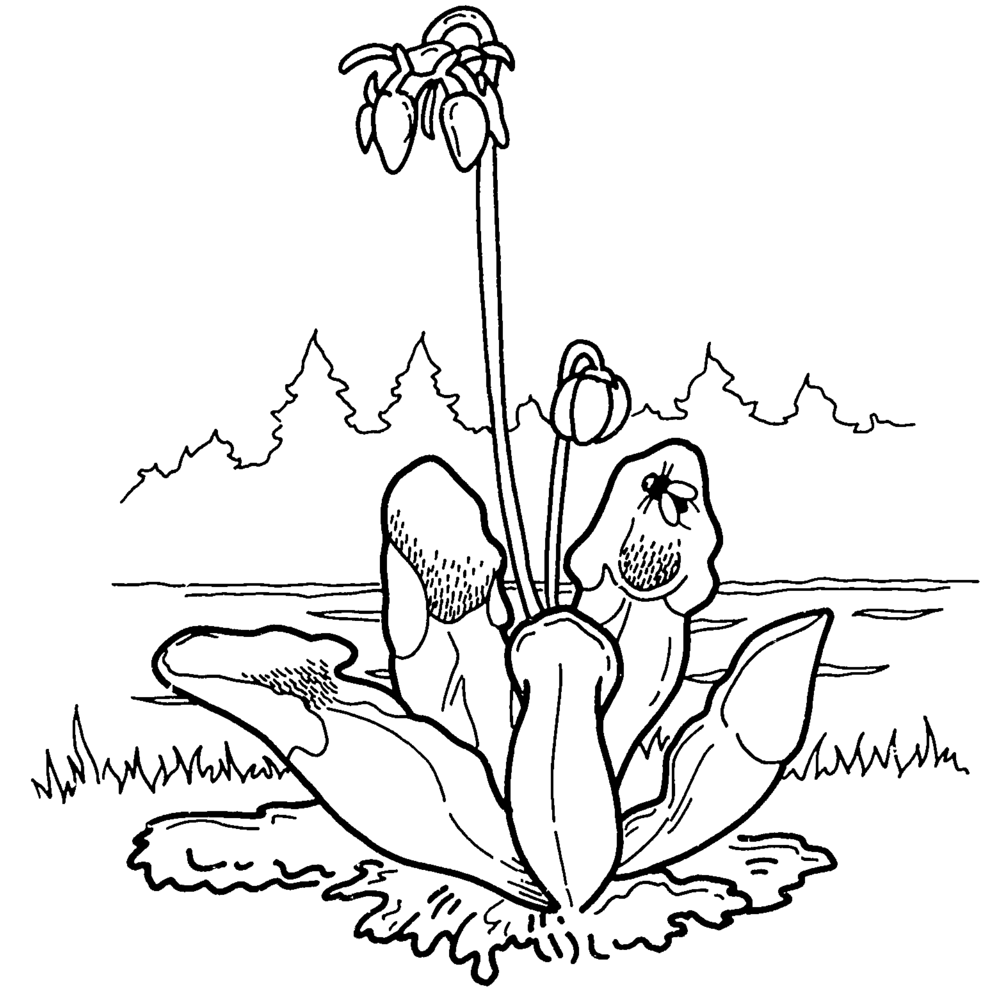

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GLOSSARY

This is not a list of words to be memorized. It is provided for the teacher's reference. Words which are appropriate vocabulary for students are in **bold face.** These are words which the students will learn as a part of doing the activities.

acclimate: change internal or external features to adjust to changes in the environment; the growing and shedding of a winter coat of heavy hair is an example of a mammalian acclimation process; aquatic organisms generally acclimate by means of internal chemical changes or adjustments; acclimation is a reversible process.

adapted or adaptation: an adaptation is a characteristic that was inherited and cannot be changed in an individual; adaptations have a genetic basis and are passed on to offspring.

alga (-ae plural): a photosynthetic organism which lacks the structures of higher plants, such as roots or seeds; may be single-celled or may be large multicelled organisms such as seaweeds.

anadromous: fish that live as adults in the ocean, but swim up into rivers and streams to lay their eggs.

anaerobic respiration: a process that takes place inside cells in which carbohydrate (food) molecules are broken down to release energy without using oxygen; less efficient than aerobic respiration which uses oxygen.

anoxic: without oxygen.

aquatic: growing, living or frequenting water; in this curriculum aquatic includes both fresh and salt water.

atom: the smallest unit into which a chemical element can be broken and still be that element.

benthos (ic): of or on the bottom of a body of water.

bony fish: fish with a skeleton made of bone as opposed to sharks, skates and rays whose skeletons are made of calcified cartilage.

brackish: water which has a salinity between that of fresh water and salt water; a mixture of salt water and fresh water; salinity between 0.5 and 35 parts per thousand.

buoyancy: the tendency of an object to rise or float when submerged in a fluid; the power of a fluid to exert upward force on an object placed in it.

carnivore: animal that eats other living animals which it catches. as opposed to a scavenger which consumes dead animals.

cartilaginous fish: sharks, skates and rays; fish with skeleton made of cartilage.

catadromous: animals that live in fresh water and move to the ocean to spawn.

characteristic: a feature or trait or property.

classification (-ying): a systematic arrangement into groups or categories on the basis of characteristics shared in common.

cohesion: attraction of molecules of a substance for each other.

cold-blooded: term used to describe animals whose internal temperature is determined by that of its environment; may be quite warm on a hot day; also called ectotherms. Plants function as ectothermic organisms.

community: an assemblage of organisms living together in association in an environment.

condense: in this case, the collection of water molecules in vapor form around a particle or on a surface as they cool to become liquid water.

consumer: an organism that does not do photosynthesis and must feed on other organisms.

control: untreated objects or organisms which are used for comparison against treated objects or organisms in an experiment.

cycle: process in which materials are not lost, but are exchanged continuously among organisms and their environment.

density: the mass per unit volume of a substance.

diffuse (-ion): random movement of suspended or dissolved particles from areas of high concentration to areas of lower abundance; mixing until evenly distributed.

displacement: the volume or weight of fluid moved by a floating object.

dissolve: to go into solution; in the case of water, a substance mixes with water and does not settle out upon standing, but stays evenly mixed.

dissolved oxygen: oxygen molecules mixed in solution with water.

ecological balance: the relatively stable conditions found in natural, undisturbed communities over time.

erode (-sion): gradual wearing away; in this case water is the agent that causes the wearing away.

estuary: region where salt and fresh water mix in a partially enclosed body of water; generally at a river mouth or in lagoons behind barrier beaches.

euphotic zone: the surface layer of water in an aquatic environment in which photosynthetic organisms can survive; photic zone is depth to which light penetrates and is deeper.

evaporate (-tion): liquid becomes a gas and disperses into the atmosphere.

fisheries management: like wildlife management, an attempt to use wild populations for human purposes without destroying them; requires an understanding of ecological principles and constant monitoring of populations managed.

flow chart: a visual representation of the choices made in a key.

food: chemical compounds containing carbon atoms along with other elements which have been assembled by other organisms and are eaten and used for growth, repair, energy and reproduction.

food web (chain): the sequence of organisms in a community which produce food and consume it; the path that food (materials and stored energy) takes through a group of organisms.

fresh water: water with a salinity of less than 0.5 parts per thousand; no taste of salt.

ground water: water stored naturally underground, generally in rock layers; comes to the surface naturally in springs; water reaches these layers by moving down through the soil and rocks from the surface; humans drill wells to reach it.

habitat: place normally occupied by a particular organism; kind of place such as a lake or stream.

halocline: point in an aquatic system which is stratified with regard to salinity at which the salinity changes rapidly; boundary between two salinities.

herbivore: animal that eats plants or algae (photosynthetic organisms).

indicators: color changes that make visible amounts of invisible products in solution or that change when chemical reactions that cannot be seen take place; markers for things that cannot be seen.

ion: an atom or molecule that has lost or gained one or more electrons and has become electrically charged.

larva (-ae plural): immature form of an animal that is physically very different from the adult.

mass: a means of expressing the quantity of a material that is not dependent on gravity as weight is; an object would have the same mass on the earth and the moon, but not the same weight; within one gravitational field, mass is the same as weight.

migration: movement of animals from one area to another; frequently done on a seasonal basis between specific areas.

modeling: process in which one constructs a system which attempts to reproduce aspects of a real system which can then be tested.

molecule: smallest possible unit of a compound substance; has two or more atoms.

nekton: free-swimming aquatic animals that are independent of currents or waves.

neuston: organisms that live at the surface of the water.

nitrogen: an element which is essential for living things; required to make proteins and nucleotides; frequently in low supply in marine environments where its lack may limit phytoplankton growth.

non-point source pollution: pollution that enters water through run-off from the land.

nutrients: in the case of plants and other photosynthetic organisms, chemicals from the environment which are necessary for life and growth.

omnivore: organism that feeds on both plant and animal sources; feeds at several levels of the food chain.

optimal (-um): most favorable or best condition for an organism.

organism: any living thing.

oxygen: an element common in the atmosphere as a two atom molecule; a waste product of photosynthesis, it is required by plants and animals for respiration.

parts per thousand (ppt): a method of expressing the concentration of salts in solution based on the relative weight of the salts to the solution.

phosphorus: an element required by living things; as a plant nutrient it is most commonly limiting in freshwater environments.

photosynthesis: chemical process which takes place inside cells in which light energy is used to make carbohydrates from carbon dioxide and water; oxygen is a waste product of this reaction; done by plants, including algae such as seaweeds and phytoplankton.

phytoplankton: small, generally microscopic aquatic organisms that are photosynthetic and drift with the currents; generally single-celled; include many kinds of organisms called algae.

point source pollution: pollution that is released from a specific known source that has an exact location.

predator: animal that hunts and eats other animals.

prey: organism that is eaten by a predator.

producers: organisms that make food; in this curriculum primary producers, generally photosynthetic organisms, are simply called producers.

respiration: chemical process which takes place in the cells of plants and animals in which carbohydrates are broken down and energy is released which can be used by the cells to do work; most common form involves the use of oxygen and the release of the waste products carbon dioxide and water.

salt: a crystalline compound made up of ions which tend to separate readily in water; hence salts dissolve rapidly.

salt water: ocean or sea water; salinity of 35 parts per thousand.

seasons: spring, summer, fall and winter; different seasons characterized by climatic conditions caused by Earth's rotation; seasons are not apparent in tropical areas.

sessile: attached; not free-moving.

simulation: a model system that imitates a real situation.

solution: a mixture, usually liquid, in which one or more substances are distributed throughout the liquid in the form of separate molecules or ions.

spawn: release eggs for fertilization in the water.

specific gravity: the density of a substance using water as a standard which is set at 1.0.

specific heat: the amount of heat a substance absorbs when its temperature increases one degree centigrade; different for different substances.

standing crop: total weight of animals or plants in existence at a point in time; as opposed to all the plant or animal material produced over a period of time, such as a year.

stratified: layered.

surface tension: condition at the surface of a fluid which acts as an elastic film due to the molecular forces within the fluid.

surface water: water on the surface of the ground such as a lake or river.

suspension: a mixture, usually liquid, in which a substance may settle out of the liquid upon being allowed to stand.

swim bladder: gas filled organ found in most bony fish which is inflated or deflated to adjust the buoyancy of the fish, and thus change its position in the water.

thermocline: boundary layer of water where temperature rapidly changes from warm surface water to colder bottom water.

tolerate: endure, resist or survive without grave or lasting injury.

turbid: prevents the passage of light; cloudy or opaque.

turnover: mixing of surface and bottom water in a previously stratified system.

variable: condition which is subject to change.

ventilation: movement of air in and out of lungs or movement of water over gills.

vertical migration: movement up and down in the water, rather than horizontally.

viscosity: resistance to flow.

warm-blooded: term used to describe animals that regulate their internal temperature to a constant warm temperature; also called endotherms.

water column: term used to describe the vertical dimension in an aquatic habitat.

zooplankton: generally small to microscopic aquatic animals, larvae or eggs that are not strong swimmers and drift with currents; may be a temporary resident of zooplankton or may be a permanent member.

MATERIALS *(numbers in parentheses are the activity number which uses this item)*

CHEMICALS:

- ☐ 5 lbs canning or kosher salt (1,2,3,4,5,6,19)
- ☐ 1 box corn starch (1)
- ☐ food coloring kit with 4 colors in dropper bottles; 2 bottles per group (3,4,5,6,15,31)
- ☐ several cups of dirt (8,25)
- ☐ dark color of unsweetened Kool-aid (1)
- ☐ ¼ cup plant fertilizer such as Rapid-gro or Peters (8)
- ☐ about 1 lb table sugar (1)
- ☐ several tablespoons of liquid detergent (9,23)
- ☐ ¼ cup vinegar (9)
- ☐ ¼ salad oil or motor oil (9)
- ☐ LaMotte dissolved oxygen test kits (7,11,12,13,27)

EQUIPMENT AND GLASSWARE:

NEEDED FOR EACH STUDENT:

containers

- ☐ 1 disposable paper drinking cup per child (2)
- ☐ 1 pint plastic or glass jar or large paper or plastic glass (6)
- ☐ 2 clear plastic cups (6)

other items

- ☐ 1 plastic teaspoon (6)
- ☐ 1 colored marker for game such as button or colored paper (16)
- ☐ 15 poker chips or other indestructible small objects (28,29,30)
- ☐ small plastic bag (28,29,30)
- ☐ plastic goggles (7,11,12,13,27)

NEEDED FOR EACH STUDENT GROUP:

containers

- ☐ 4 clear plastic glasses (1,3,7,15,19,23)
- ☐ 5 clear plastic quart soft drink bottles or glass jars (8,9)
- ☐ 3 glass or clear plastic jars or drink bottles (2 small and 1 four times as large as small ones) (10)
- ☐ 2 quart glass canning jars with lids (14)
- ☐ 4 35 mm plastic film cans or plastic vials with caps (19)
- ☐ plastic bucket (20,23,33)
- ☐ cardboard quart or half gallon milk carton (22)

measuring devices

- ☐ 1 graduated clear plastic measuring cup or plastic graduated cylinder (1,3,6,15)
- ☐ 100 ml plastic graduated cylinder (19)
- ☐ 1 plastic teaspoon (1,3,15)
- ☐ 250 gram spring scale (3,6,15,19)
- ☐ dissolved oxygen kit sample bottles and syringe (7,11,12,13,27)
- ☐ large syringe or kitchen baster (7,11,12,13,27)
- ☐ 3 breakproof thermometers (10,15)
- ☐ watch or timer that has second hands or shows seconds (14,20,24)

other items

- ☐ 3 stirrers (1)
- ☐ 2 small aluminum or plastic pans (19,23)
- ☐ 50 pennies (19,23)
- ☐ dish pan or baking pan or dissection tray (19,21,22)
- ☐ plastic funnel (19)
- ☐ calculator (16)
- ☐ 1 die (16)
- ☐ small scissors with one pointed tip (21,26)
- ☐ 12 in ruler (22)
- ☐ eyedropper (23)
- ☐ clipboard with pencil tied on (24,33)

NEEDED FOR TEACHER DEMONSTRATION OR WHOLE CLASS:

containers

- ☐ styrofoam cooler (31)
- ☐ large aquarium (25)
- ☐ 2 clear plastic aquariums or gallon glass jars (4,5,25)
- ☐ heavy coffee cup or mug (3)
- ☐ quart fruit jar (1)
- ☐ 8 or more pint or quart glass canning jars with lids (7,11,12,13,27)
- ☐ 4 clean gallon plastic milk jugs (2,3,4,5,6,19)
- ☐ large trash can (20,21,22)

measuring devices

- ☐ several simple balances (3,6,15)
- ☐ dissolved oxygen test kit (7,11,12,13,27)
- ☐ small 35 mm or Polaroid camera and 1 roll film (8,9)
- ☐ thermometer good to 100° C (13)
- ☐ tape measure or carpenter's rule (24)

other items

- ☐ aircooled slide or filmstrip projector (25)
- ☐ 3–4 feet clear plastic tubing for siphons (4,5)
- ☐ marking tape or labels (1,3)
- ☐ small prizes (6,20)
- ☐ prism (25)
- ☐ refrigerator or ice chest and ice (10,12)
- ☐ two light sources (27)
- ☐ small balloons (21,22)
- ☐ whistle (28,29,30)
- ☐ large pad and pen or portable chalk board (28,29,30)
- ☐ waterproof pen (31)
- ☐ bricks or rocks (31)
- ☐ sand or gravel (31)

PAPER AND ART SUPPLIES:

- ☐ colored pencils or crayons (1,4,35)
- ☐ construction paper and/or posterboard (2,16,18,26,31,35)

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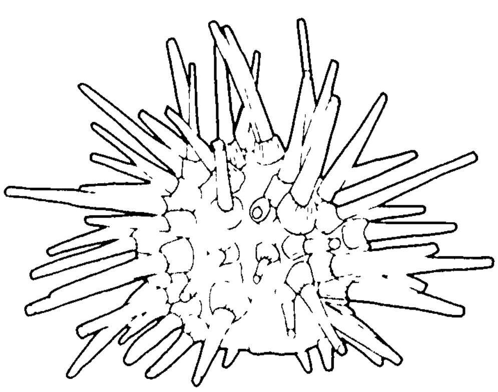
☐ red construction paper (26)
☐ blue cellophane from school art store (26)
☐ plasticine modeling clay (19,20,23)
☐ crepe paper or surveyor's flagging in three colors (29,30)
☐ tissue paper (35)
☐ old magazines with colored pictures of aquatic habitats and animals (2,18,25,26,29)
☐ rubber bands (19,20,23)
☐ plastic straws (20,23,31)
☐ toothpicks (20,23)
☐ wire (20,23)
☐ straight pins (23,31)
☐ coffee stirrers (20,23)
☐ string (20,21,23,26,30)
☐ nuts or other small weights (20,31)
☐ nails (20,22,23)
☐ aluminum foil (10,20,23)
☐ tape (22,26,35)
☐ staples (23)
☐ paper clips (23)
☐ white glue (20,23,35)

LIVING THINGS:

☐ pond water samples (8,9)
☐ 1 big bunch of *Elodea* per group (11,12,27)
☐ several dozen adult brine shrimp (5)
☐ 2 goldfish or guppies 1 in long (5)
☐ 2 goldfish or guppies 1 in long per student group (14)
☐ 1 goldfish or guppy or 1 crayfish or 1 dozen small snails per group (11)
☐ 1 fresh or frozen fish with guts per group (21)



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OUTLINES FOR TEACHING ACTIVITIES

ACTIVITY 1 *The disappearing act*

Before class:

1. gather the materials and duplicate worksheets.

During class:

1. do the demonstration of adding Kool-aid to water after challenging the students to predict the outcome.
2. introduce the words SOLUTION and DISSOLVE.
3. show the students the materials available and challenge them to design their own test to find out which go into solution and how fast; number of times stirred before material disappears is a good test.
4. help students while they work in groups.
5. review results; check corn starch later to see if conclusions were valid.

ACTIVITY 2 *Water, water everywhere*

Before class:

1. prepare aquatic habitat cards; may also make water samples to taste.
2. duplicate flow charts and keys for students.

During class:

1. introduce terms SALT WATER, BRACKISH WATER and FRESH WATER; may include tasting samples of each if there is a clean paper cup for each student.
2. challenge students to discover what kind of habitat they are and distribute habitat cards and flow chart type key.
3. have one student read as all follow on chart to demonstrate use of chart, then let students work on own; check results as they work.
4. trade cards to keep going.
5. repeat process using formal scientific key if desired.
6. review by having students list pairs of characteristics on board.

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ACTIVITY 3 *Salty or fresh?*

Before class:

1. gather materials, mix solutions and duplicate the worksheets.
2. have students practice the use of balances if needed.

During class:

1. challenge the students with the problem: which is heavier, fresh or salt water? Show them the available equipment and have them suggest ways for you to proceed.
2. use unequal volumes and unequal containers to demonstrate unfair tests.
3. let students work in groups to see if they can answer the question you posed; help groups think about ways to work.
4. review results of different groups and have students draw conclusions; introduce the word DENSITY if older students.

ACTIVITY 4 *The layered look*

Before class:

1. mix the solutions, gather equipment and duplicate worksheets.

During class:

1. define an ESTUARY and challenge the students to predict what might happen when the salt water and fresh water in an estuary meet.
2. demonstrate what might happen by siphoning:
   a. colored salt water into plain fresh water and
   b. plain salt water into colored fresh water.
3. BEWARE: do not let students shake or move surface on which tanks or jars rest.
4. discuss why it was done twice and fair tests.
5. complete worksheet and then do Activity 5.

ACTIVITY 5 *Some like it salty—some do not!*

Before class:

1. same preparation as all of Activity 4; may be done with fish alone if brine shrimp are not available.

During class:

1. show the students the goldfish (or guppies) and the brine shrimp; do the students have any clues to what these animals prefer: salt water or fresh water?
2. challenge the students to predict what the behavior of each kind of animal might be if added to one of the layered systems.
3. put one fish and some of the brine shrimp in each jar or tank and observe behavior; BEWARE: do not bump or shake the tanks.
4. remove the animals.
5. discuss observations.

ACTIVITY 6 *The great salinity contest!*

Before class:

1. prepare salt solutions; USE KOSHER OR CANNING SALT; distribute them among numbered containers, keeping a written record of which solution went in which jar; one jar gets very salty water and 4–6 get fresh water; the remaining jars are water of intermediate saltiness.
2. gather equipment and duplicate worksheets.

During class:

1. distribute one unknown solution per student and challenge the students to discover who has the saltiest water and the fresh water.
2. may use any means, but NO TASTING of unknown solutions ever.
3. check results as students work.
4. have them review the techniques they used to come to their conclusions.
5. give prizes in the salt water lottery to the one with saltiest and the several with fresh water.

ACTIVITY 7 *Oxygen for life*

Before class:

1. prepare water low in dissolved oxygen at home.
2. gather materials and duplicate worksheets.
3. practice dissolved oxygen tests in class.

During class:

1. challenge class to predict where the dissolved oxygen in water comes from.
2. unseal jars and test for dissolved oxygen.
3. pour out one half of the water, put the lid on and shake; open and shake several times; test for dissolved oxygen again after shaking.
4. complete the worksheets and discuss the results.

ACTIVITY 8 *Dirty water*

Before class:

1. order or collect pond water.
2. prepare aged water and collect materials.
3. duplicate worksheets.

During first class:

1. challenge students to predict what might happen when soil erodes and enters an aquatic environment, in this case a freshwater pond.
2. demonstrate by shaking soil in jar of water.
3. make model ponds:
   - **a.** control with aged tap water and pond water.
   - **b.** aged tap water, pond water and 1 teaspoon of plant fertilizer.
   - **c.** aged tap water, pond water and 1 tablespoon of plant fertilizer.
   - **d.** aged tap water, pond water and water which has been shaken with soil, after the soil has been allowed to settle.
4. place in good light.

Following two weeks:

1. record changes with camera.
2. complete worksheets and discuss.

ACTIVITY 9 *What's in the water?*

Three weeks before class:

1. order or collect pond water.

Two weeks before class:

1. collect materials and duplicate worksheets.
2. set up jars with aged tap water, 1 teaspoon of plant fertilizer, and pond water.
3. place jars in good light to grow until class when used.

During class:

1. have students list some of the chemicals they use that are disposed of in water and become water pollutants.
2. challenge them to do an experiment to test the effect of some of these chemicals on a miniature aquatic system.
3. add chemicals to three jars from each set, leaving one as the control, and place in good light.

Following week:

1. observe and record changes with a camera.
2. complete worksheets and discuss results.

ACTIVITY 10 *A change in the weather?*

Before class:

1. gather the materials and duplicate the worksheet.
2. have students practice reading a thermometer if needed.
3. place containers in a cold place.

D ring class:

1. challenge the students to predict which will change temperature faster: a big body of water, a small body of water or the air?
2. measure the rate of temperature change in a large container of water, a small container of water and a small container of air.
3. complete worksheet and discuss results in relation to aquatic habitats.

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ACTIVITY 11 *Plants use oxygen?*

Before class (both plants and animals):

1. gather the materials and duplicate the worksheets.
2. the day before class, set out water to age.

During class (plants):

1. on the first day, challenge students with the question, "do plants use oxygen?"
2. briefly discuss photosynthesis and respiration; test water in jar for beginning level of dissolved oxygen; add plants to one jar and seal both; place jars in a warm, dark place overnight.
3. on second day remove jars and test for dissolved oxygen; record results; complete worksheets and discuss results.

During class (animals):

1. challenge the students to design a study of oxygen use by an aquatic animal.
2. test water in jar for dissolved oxygen and gently add an animal; seal jar and allow it to remain undisturbed for about one hr; test for dissolved oxygen; STOP THE TEST IF THE LEVEL FALLS BELOW 4 PPM; otherwise several measurements may be made if surface of water is sealed with oil after first sample is removed.
3. complete worksheet and compare results.

ACTIVITY 12 *When the heat is on*

Before class:

1. gather materials and duplicate worksheets.
2. age tap water 24 hr.

During class:

1. on first day, challenge students to predict the effect of temperature on oxygen use in a "cold-blooded" organism.
2. test dissolved oxygen in one jar and add plants to both.
3. put one jar in a warm place and one in an ice chest or refrigerator; both locations must be in the dark.
4. on second day, test the dissolved oxygen in both jars and calculate the difference.
5. complete worksheets and discuss results.

ACTIVITY 13 *When the oxygen goes . . .*

Before class:

1. gather materials and duplicate the worksheets.
2. prepare sealed heated and cooled water samples at home.

During class:

1. challenge the students to predict whether temperature might have an effect on dissolved oxygen in water.
2. unseal and test water samples, having explained how each was treated.
3. compare data and complete the worksheets; discuss results.

ACTIVITY 14 *When the oxygen is gone*

Before class:

1. gather materials and duplicate worksheets.
2. make and seal low oxygen samples at least 12 hrs before so that they are cooled to room temperature by class time.

During class:

1. challenge students to predict how fish might react when put in water with almost no oxygen.
2. unseal water and gently lower fish into jars; count ventilations and/or observe the part of the jar used and other behavior; remove the fish after 5 minutes.
3. complete worksheets and compare results.

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ACTIVITY 15 *In hot water?*

Before class:

1. gather materials and duplicate worksheets.
2. just before class, get hot and ice cold water.

During class:

1. challenge class to predict whether water temperature might influence the distribution of the water in an environment; what happens when hot and cold water meet? Is one heavier than the other?
2. compare weights of equal volumes of hot and cold water.
3. carefully layer · ·t colored water on plain cold water and the reverse to observe what happens.
4. complete worksheets and discuss the results.

ACTIVITY 16 *The great anadromous fish game*

Before class:

1. duplicate the game board, cards, rules, glossary and worksheets.
2. gather or purchase game pieces and dice.
3. practice math skills with students.

During class:

1. challenge the students to predict some of the problems that ANADROMOUS fish might experience as they swim up-stream to spawn and then return to the sea.
2. play game in groups.
3. keep score on worksheet.

Following day:

1. complete worksheet and average class data.
2. discuss results.

ACTIVITY 17 *A change in the weather*

At beginning of school year:

1. order film.

Before class:

1. duplicate the worksheet.

During class:

1. challenge the students to be observant; can they pick out one animal or plant in the film and follow what happens to it during the seasons?
2. distribute worksheets before the film as an organizer of thought.
3. complete worksheets following film.

ACTIVITY 18 *To each its home*

Before class:

1. duplicate flow charts and worksheets and make cards.

During class:

1. introduce idea of many places within an aquatic habitat by using pond as an example; key out one of the pond animals as an example.
2. practice use of flow chart with one card and then have students identify the part of an aquatic habitat each group uses on their own, trading cards and filling in the numbers on the key.
3. read correct answers and give examples; use pictures if possible.
4. do language arts worksheet at home or in another session to reinforce concepts.

ACTIVITY 19 *Keeping your head above water*

Before class:

1. mix the solutions and gather the materials.

During class:

1. challenge the students to do experiments with floating and sinking in fresh water and salt water:
   - **a.** if a heavy object sinks in both fresh and salt water, does it displace the same amount of water? Do the displaced fresh and salt water weigh the same?
   - **b.** does a floating object displace the same amount of water in fresh and salt water? Do the displaced volumes weigh the same?
   - **c.** what happens to the weight of an object that floats as it is lowered into water and weighed with a spring scale?
   - **d.** is it possible for an object to sink in fresh water and float in salt water?
   - **e.** can the shape of a ball of clay determine whether it sinks or floats? If so, what shapes make a difference and why?

ACTIVITY 20 *Sinking slowly*

Order movie at beginning of school year.

Before class:

1. gather materials and duplicate worksheet.

During class:

1. introduce PLANKTON and observe plankton in film, photographs, live or preserved, or drawings.
2. challenge the students to design their own plankton that sink slowly using materials provided.
3. students build and test plankton.
4. hold contest to see whose sinks slowest.
5. discuss designs and analyze reasons for success and failure of various models.

ACTIVITY 21 *Sink or swim*

Be on the lookout for a supply of fish which you can freeze for this class.

Before class:

1. gather materials including fish with guts intact.

During class:

1. do fish printing first if it is to be done.
2. challenge students to discover why a fish is able to stay at the desired level in the water by doing a dissection.
3. discuss safe dissection procedures and allow students to work in groups while you help groups; use worksheets to guide activity.
4. discuss what was seen and review.
5. how does the swim bladder work? Use balloon in dead fish to demonstrate.

ACTIVITY 22 *Grace under pressure*

Before class:

1. gather materials and duplicate worksheet.

During class:

1. challenge students to predict what happens to water pressure as depth increases.
2. use milk cartons with holes at three depths to illustrate; measure results and test several variables such as carton diameter and hole diameter.
3. test what happens to a balloon as it is forced under water.
4. complete worksheets and discuss observations.

2?4

ACTIVITY 23 *Life at the surface*

Before class:

1. gather materials and duplicate worksheets.

During class:

1. have students fill plastic cups to the rim with water and then see how may marbles (pennies) they can add before it spills over.
2. use above example to explain SURFACE TENSION.
3. challenge the students to make a paper clip sit on surface tension and then use detergent to sink it.
4. using materials provided, challenge the students to design a model animal that sits on surface tension and is heavier than water.
5. have a contest with the models to see who has built the heaviest that will stay up on surface tension.
6. fill in worksheets and discuss.

ACTIVITY 24 *At the races*

At the beginning of the school year, make the field trip reservation.

Before field trip:

1. gather materials and duplicate reading and worksheets.
2. have students read *Moving through water.*

On the field trip:

1. pick fish and identify them; observe their behavior.
2. time fish swimming over measured course and record on worksheet.

In class on another day:

1. complete worksheets and compare results; rank fish with regard to speed and compare shapes and swimming techniques.

ACTIVITY 25 *Light to sea by*

Before class:

1. gather materials for this demonstration; no worksheets.

During class:

1. challenge students to observe what happens to light when it shines through water in an aquarium under several different sets of conditions:
   - **a.** what happens to the intensity of the light when it shines through the long versus the short dimensions of the aquarium?
   - **b.** what happens to the colors in the spectrum when they shine through the long dimension of the aquarium?
   - **c.** what happens to light when it shines through muddy or turbid water?
2. discuss observations.

ACTIVITY 26 *Hide and seek*

Before class:

1. gather materials and photographs.

First class session:

1. make goggles, using at least three layers of cellophane.
2. make red fish, reviewing external anatomy.

Before second session:

1. use tape to hide fish in plain sight in classroom, using a pair of goggles to check for match with background; look for darker colors of same value such as blue, green, brown, gray and black.
2. TURN THE LIGHTS OFF AND PULL SHADES TO DARKEN ROOM.

Second session:

1. meet students outside class and challenge them to be fish that are living in 30–40 ft of water off the coast of California, looking for dinner; dinner is the red fish.
2. let students enter and search for fish.
3. stop search and review results; distribute underwater photographs that demonstrate lack of color when artificial lights are not used and discuss.

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ACTIVITY 27 *A light snack*

Before class:

1. gather materials and purchase plants; age tap water; duplicate worksheets.

Day one:

1. place *Elodea* in jars with aged tap water and seal; place overnight in warm, completely dark location.
2. introduce PHOTOSYNTHESIS in class discussion.

Day two:

1. open each jar and test level of dissolved oxygen; replace water removed for sample and seal jars again.
2. place one of each pair of jars in bright light and the other in dim light overnight (light should be on all night) for 24 hr.
3. challenge the students to predict which plants will produce more oxygen (have a higher rate of photosynthesis).

Day three:

1. open each jar and test for dissolved oxygen.
2. compare with the level of dissolved oxygen on day two.
3. complete worksheets and discuss.

ACTIVITY 28 *Competing for food*

Before class:

1. gather materials and duplicate data sheets and worksheets.
2. select safe site.

During class:

1. challenge students to predict the possible consequences for the ZOOPLANKTON population in a pond if the supply of their PHYTOPLANKTON food were limited.
2. to test their predictions, they will be zooplankton competing for food; start with about ⅔ of students for zooplankton as you may want more in the next generation; scatter 10 poker chips or beans per student for pretend phytoplankton and distribute bags to collect food.
3. have students count food; you fill in a data sheet.
4. after one round repeat, having the offspring from one generation as the parents of the next; fill out a new data sheet for each generation.

Follow up class:

1. list number of parents for each generation on the board; complete worksheets and graph population size; discuss results.

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ACTIVITY 29 *Eating and being eaten*

Before class:

1. gather materials and duplicate data sheets; there are no worksheets because students should be allowed to change one rule or ratio at a time; have them record what they do as a class on the data sheets.
2. pick a safe location for this active simulation.

During class:

1. challenge students to test the predator-prey relationships in a pond using themselves as model organisms in the FOOD WEB.
2. in first run assign ⅓ of class to each role, zooplankton (herbivores), small fish (primary carnivores) and big fish (top carnivores), hand out arm bands of different colors for each level.
3. scatter 20 food items (poker chips or beans) for each herbivore in the game each time you run it.
4. small fish must tag zooplankton and large fish must tag small fish in order to get food; tagged player gives up poker chips and sits down.
5. when a player gets enough to eat, he may sit down and not be tagged; herbivores need 10, primary carnivores need 20, and top carnivores need 40.
6. play once and record results; ratios will be out of balance intentionally.
7. now challenge students to change rules to get a system in which some of each level survive; may change numbers, add hiding places or safe spots, have safe times for some. Record results and rules each time.

Follow up class:

1. put results on board and discuss.

ACTIVITY 30 *Getting caught*

Before class:

1. gather materials and duplicate data sheets.
2. pick safe location for activity.

During class:

1. challenge students to predict what will happen when all of the top carnivores are removed from a pond; then use a simulation to test their predictions.
2. start with balanced system from Activity 29 or use ¾ herbivores, ¼ less two primary carnivores and 2 (1 if fewer than 20 students) top carnivores and the same 20 food items per herbivore; food needs are same as in Activity 29; run game and record results.
3. now repeat exact same simulation except that the two (one) top carnivores have been killed by humans; run and record results.

Follow up class:

1. put results on board and discuss.

ACTIVITY 31 *Getting to the bottom of things*

Before class:

1. gather materials and duplicate worksheets.
2. make model ocean with interesting bottom contours.

During class:

1. challenge students to discover what the bottom of the model ocean is shaped like.
2. working in pairs, use weighted line to measure depth of water at 10 coordinates on the ocean; record results on worksheet and mark out the coordinates tested so that others will not duplicate them.
3. pairs should predict the bottom contours based on their own observations.
4. have students record their results on a master list and compare what they can tell from having many data points with the few they got themselves.
5. drain the ocean and see if their predictions were true.

Activities 32–36 are not experimental.

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SAMPLE QUESTIONS

Section I. Substances that Dissolve in Water

Activity 1

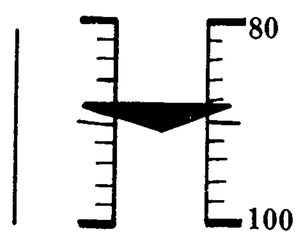
1. All substances dissolve in water at the same speed. **T or F**
2. A substance is likely to dissolve faster in ______________________ water. **(cold or hot)**

Activity 2

1. In order to identify biological things you might use ____.
   a. an encyclopedia b. a key c. a dictionary
2. Which has water that is moving or flowing?
   a. river b. lake
3. The opposite of fresh water is ______________________________.

Activity 3

1. A liter of water from the Great Salt Lake will weigh more than a liter of water from a mountain stream. **T or F**
2. When using a balance that compares two objects at once, the heavier object goes up. **T or F**
3. If the scale reads like this, how much does the object weigh?

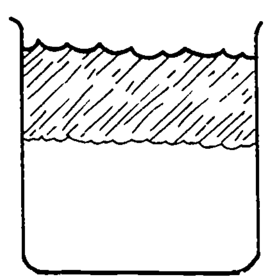


Activity 4

1. The colored water was always on the bottom. **T or F**
2. The salt water was always on the bottom. **T or F**
3. The aquatic habitat where fresh water meets salt water is called an ________________.

Activity 5

1. In an estuary you would expect to find animals that need salty water on the bottom. **T or F**
2. This jar has salty and fresh water. Make an x on the layer that has the fresh water.

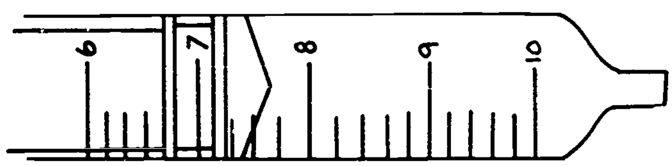


Activity 6

1. It is never a good idea to taste an unknown solution. **T or F**
2. Three students each weighed 100 ml of their unknown solution. Lisa's weighed 121 gm; Herman's weighed 123 gms and Julian's was 118 gm. They probably all ________ **(did or did not)** have the same solution.
3. If Bob has 100 ml of water that weighs more than 100 ml of Jennifer's and less than 100 ml of Juan's, who has the saltiest water?

Activity 7

1. You can measure how much oxygen is in water even though vou cannot see the oxygen. **T or F**
2. If group one measured 2.5 ppm in its sample and group two found 10.2 ppm in its, which group had a sample with the most dissolved oxygen: **one or two?**
3. Much of the dissolved oxygen in water comes from the ________.
4. How much dissolved oxygen is in the water when the syringe scale looks like this?



Activity 8

1. Turbid water is clear. **T or F**
2. Soil that washes into water always kills everything. **T or F**
3. The control had only pond water and water with no soil or fertilizer. **T or F**

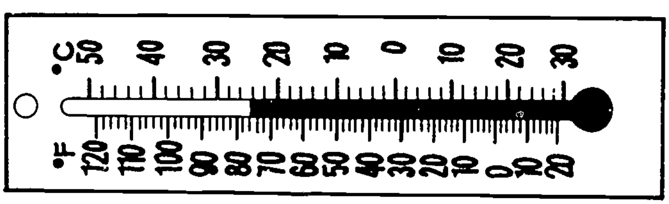
Activity 9

1. Some of the possible variables which needed to be considered in this pollution experiment were **a. temperature b. light c. both.**
2. Pollution always kills everything in an aquatic habitat. **T or F**
3. Most pollutants cause changes in aquatic habitats. **T or F**

Section II. Temperature Changes in Aquatic Habitats

Activity 10

1. In the fall a lake will cool more slowly than the air. **T or F**
2. A fish in a small pond is less likely to get frozen during the winter than a fish in a big lake. **T or F**
3. Which would cool more quickly — a **big** cup of hot chocolate or a **small** one?
4. When the thermometer looks like this, what is the temperature?



Activity 11

1. When an aquatic plant is s:aled in a jar of water and put in the dark, the dissolved oxygen in the water **a. decreases b. increases.**
2. Aquatic animals get their oxygen from the **a. air b. water.**
3. If the dissolved oxygen in the jar was 10.2 ppm before a plant was added and the jar sealed and 4.6 ppm when you measured it the next day, the plant **a. made dissolved oxygen b. used dissolved oxygen.**

Activity 12

1. Plants behave like cold-blooded animals in that their temperature is generally that of their environment. **T or F**
2. Generally, an aquatic plant uses more oxygen when it is warm than when its environment is cold. **T or F**
3. When do you think cold-blooded plants and animals use more oxygen: in the **summer** or the **winter?**

Activity 13

1. If you measured the dissolved oxygen in three water samples which had been heated to different temperatures and got results of **2.4 ppm, 7.2 ppm** and **10.6 ppm,** which was likely to have been heated to the highest temperature?
2. On a very hot summer day, the fish in a shallow pond might have **a. too much oxygen b. too little oxygen.**
3. If you were the person who was in charge of a nuclear power plant which used the water from a river to cool the plant, you would be concerned with making sure that the warm water you returned to the river did not have **a. too little b. too much** dissolved oxygen.

Activity 14

1. A fish in water with low dissolved oxygen may **a. move to a place with more oxygen b. move water over its gills faster c. go to the surface for air d. all of these are possible.**
2. A fish needs dissolved oxygen in its water to survive. **T or F**
3. If you compared two fish in different jars of water and one opened its gill covers 26 times per minute and the other 54 times per minute, which would most likely have the highest dissolved oxygen in its water? The one which ventilated **a. 26 b. 54** times.

Activity 15

1. You compared two equal volumes of fresh water on a balance and found one was heavier. You know one was hot water and one was cold. Would you predict the heaviest was the **a. hot b. cold?**
2. On a hot summer day where would you expect to find the warmest water in a lake? **a. at the surface b. at the bottom**
3. Trout are fish that need cold water. On a summer day would you choose to fish for trout in a lake at the **a. surface b. bottom.**

Activity 16

1. Which of these threats to fish can humans control to help the fish survive? **a. hungry bluefish b. toxic wastes from a chemical plant c. spring storms**
2. Which of these might help fish survive? **a. pesticide runoff b. sea gulls and ospreys c. sediment prevented from entering water**
3. If 1/4 of 1000 fish are killed, how many survive? **a. 750 b. 250**

Activity 17

1. Animals do the same things all year, regardless of the season. **T or F**
2. All animals hibernate in winter. **T or F**

Section III. Moving or Staying Put: Maintaining Position within Aquatic Habitats

Activity 18

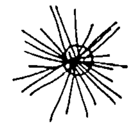
1. Phytoplankton are microscopic plants (algae) that drift through the water. **T or F**
2. If an animal lives on the bottom of a body of water, it is said to be **a. mobile b. benthic c. nektonic.**
3. A plant that lives attached to the bottom must be **a. in b. below** the zone where light penetrates.

Activity 19

1. If an object floats in fresh water, it will float in salt water **T or F**
2. If you have an object that floats in salt water, it will float **a. higher b. lower** in fresh water.
3. If you do not know how to float, do you think it would be easier to learn in **a. fresh water b. salt water?**

Acti. ty 20

1. If both of these weigh exactly the same and are a little bit heavier than water so that they sink, which would you predict would sink more slowly? **a. or b.**

a.  b. 

2. Zooplankton and phytoplankton are heavier than water so they tend to sink to the bottom. **T or F**

Activity 21

1. Which of these is a fin that a fish has only one of? **a. tail b. pectoral c. pelvic**
2. The swim bladder helps a fish adjust its **a. night vision b. swimming speed c. buoyancy.**
3. You could tell what a fish ha l to eat recently by opening its **a. gall bladder b. stomach c. liver.**
4. If a fish puts more gas in its swim bladder, it will **a. rise b. sink** in the water.

Activity 22

1. If you were a scuba diver, you would feel the greatest pressure from water against your body **a. at the surface b. at the bottom.**
2. What would you predict might happen to a sealed can of air as it is lowered to the bottom of the ocean?
   a. nothing b. the air will expand, causing the can to explode c. the can will be crushed

Activity 23

1. An insect that "rides" on surface tension will **a. sink b. float** if the surface tension is broken.
2. If a camper dumped a pan of soapy water in a small pc d, the water striders might not survive. **T or F**

Activity 24

1. Which would you predict would be faster? **a. a fusiform shaped fish b. a flattened fish c. a round fish**
2. If your watch read 11:23 and 55 seconds at the beginning of timing a fish run and 11:24 and 10 seconds at the end, how long did the fish take to swim the course?
   a. 40 seconds b. 15 seconds c. 45 seconds
3. If a fish swam 10 ft in 9 seconds on the first run and 13 seconds on the second run, its average time was **a. 10 seconds b. 12 seconds c. 11 seconds.**
4. Which swims faster? **a. a fish that covered 12 ft in 10 seconds b. a fish that swam 6 ft in 5 seconds c. both are the same speed**

Section IV. Light in Water

Activity 25

1. You are an ocean explorer on a very deep dive in a tiny submarine. You must carry your own lights with you to see much. **T or F**
2. If you are a diver looking at a sponge that you know is red but appears dark grey, you must be in very **a. deep b. shallow** water.
3. Sediment or soil particles in the water are bad because they block light. **T or F**

Activity 26

1. If you are a fish looking for a small fish to eat and you live in 50 ft of water, which would be harder for you to see? **a. a red fish b. a blue fish**

Activity 27

1. Aquatic plants release ____________________ into the water when they use light in photosynthesis.
2. Students measured dissolved oxygen in two jars containing aquatic plants that had been exposed to two different light levels. Which dissolved oxygen level was most likely the one from the jar in the brightest light? **a. 10.8 ppm** **b. 4.7 ppm**
3. If a new housing development has a big storm and lots of mud runs into a nearby pond, do you think the phytoplankton in the pond will have **a. higher** **b. lower** amounts of photosynthesis?
4. In which kind of habitat do you think plants that grow rooted or attached to the bottom would be able to live deeper? **a. clean mountain lake** **b. lake where new houses were being built**

Activity 28

1. A scientist counted the number of fish in a pond each year. In the first five years, she got 61, 55, 67, 60 and 57 fish. Which of these numbers do you think represents the number of fish she might find in the sixth year? **a. 16** **b. 160** **c. 52**
2. In the example in question 1, do you think there is **a. unlimited** **b. limited** food available to the fish?
3. If the food available to the fish in this pond doubled next year, what do you think might happen to the number of fish in the pond? **a. go down** **b. go up**

Activity 29

1. There are more prey than predators in a stable habitat. **T or F**
2. The animals that eat plants are called ____________________.
3. There are **a. many** **b. very few** top carnivores compared to the other animals in a stable habitat.

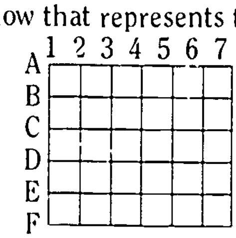
Activity 30

1. Predators are necessary for a balanced food chain. **T or F**

Section V. Exploration, Research and Communication

Activity 31

1. An oceanographer is on a boat, travelling in a straight line. The readings from a depth sounder are as follows: 1,250 ft, 1,236 ft, 843 ft, 675 ft, 723 ft, 1,098 ft, 1,290 ft, 1,279 ft. The boat has just passed over an **a. underwater valley** **b. underwater mountain.**
2. Mark the point on the grid below that represents the point C3.



Activity 32

1. Scuba means self-contained underwater breathing apparatus. **T or F**
2. Scuba became popular as a way to explore the sea after the **a. First World War** **b. Second World War.**
3. Remote sensing means using cameras or other unmanned devices to study an area. **T or F**
4. The first submarine was used in the Second World War. **T or F**

Activity 33

1. It is always legal to take plants and animals if you are collecting for a school project. **T or F**
2. Removing any living thing is usually not legal in a state or federal park unless you are catching sportfish with a fishing license. **T or F**

RECIPES

SALT SOLUTIONS

Do not use salt sold as regular salt which goes in salt shakers for any unknowns. It contains additives which make it cloudy. Kosher salt or salt used for canning do not have these additives.

Ideally, you would mix your salt solutions the way a scientist does: weigh 35 gm of salt for each liter of 35 ppt solution you need. Put 35 gm of salt in the bottom of a 1 liter container and fill to the 1 liter mark with water. For 70 ppt, use 70 gm salt/liter. Since parts per thousand is based on weight, 35 ppt sugar would be made exactly the same way.

Don't have a good balance? Here is a quick and dirty way to accomplish about the same thing for salt solutions only. For 35 ppt put 2 scant tablespoons of salt in 1 quart of water. For one gallon of 35 ppt use 7 level tablespoons of salt. For 70 ppt, just double the salt. Parts per thousand is based on weight.

MAKING WATER WITH LOW AND HIGH DISSOLVED OXYGEN

Water left uncovered in a refrigerator or in an ice chest or outside on a cold, but not freezing day, for 24 hrs will have 10–11 ppm dissolved oxygen.

Water left sitting out uncovered at room temperature at about 22–25° C for 24 hrs should test at about 8 ppm dissolved oxygen.

Heating water will drive off all of the dissolved gases, including oxygen. If you boil water vigorously for 10 minutes and then pour it into a canning jar and seal it, the water will have less than 1–2 ppm dissolved oxygen. If you use a jar not intended for canning, such as a mayonnaise jar, it may shatter when the hot water hits it. If you must use a jar other than a canning jar, put the jar in the sink. Put a table knife in the empty jar. Then pour the boiling water into the jar. It may still shatter, but the sink will catch the flood. Generally, the knife trick works. The jars must be filled completely with no air space at the top. Remove the knife and seal. If your jar lid does not have a rubber ring inside the way canning lids, peanut butter lids and pickle lids do, use wax paper or plastic wrap over the top of the jar before applying the lid. Seal immediately and do not open until just before use.

For dissolved oxygen in the range of around 4 ppm, heat water on the stove to about 50° C and hold it at that temperature for 1 hr or more. Another, easier way to get the water to hold at the correct temperature is to use a hot tray, heated serving tray, electric skillet or hot pot. For best results, allow the water to stand at the desired temperature overnight before canning it. Seal the water in canning jars with canning jar lids. If you do not have a thermometer which reads in centigrade, try a meat thermometer at 120–130° F.

Canning jars are widely available in grocery or hardware stores in summer and early fall. Sealed heated water keeps on a shelf until use. You can make it several months ahead of time. For jars that might not have a good seal, make the water the night before. Do not try to use plastic. Some plastics are permeable to gases. Many will wilt under boiling water to give an "interesting" new shape.

For safety and convenience, heat the water at home or in a prep room when children are not around. Allow all heated water to reach room temperature before children use it. If it has been sealed properly, no oxygen will enter until you open the jar, just before use.

MOVING WATER AND TAKING SAMPLES

Siphons

Water is easily moved from one container to another using a siphon. Clear, flexible plastic tubing which can be used for siphoning may be purchased from scientific supply catalogs, but is also sold in hardware and auto supply stores and pet shops featuring fish. Siphons may be started by sucking on one end with the other emersed in the solution to be moved. This practice usually results in a mouthful of the solution. Small plastic tubing clamps which can be used to regulate the flow rate prevent this problem by allowing you to seal the tubing just before the solution reaches your mouth.

While holding the end of the tubing, place it in the receiving container. The end must be at a level lower than the surface of the solution being siphoned. Remove your finger or open the tubing clamp to allow flow. Because germs may be transmitted if students are allowed to use siphons, make yourself the sole siphoner and wash your tubing regularly.

A siphon may also be started by holding the entire length under water until it fills. Remove one end while holding it closed and proceed as above.

Kitchen basters and syringes

Water samples for the dissolved oxygen test kits may also be transferred with a large kitchen baster if the bulb is squashed flat BEFORE being emersed in the solution to be sample. No blowing bubbles in the solution to be sampled. The sample is dribbled down the side of the sample bottle, not squirted in from above.

Large syringes with graduated measurements are available from several suppliers of elementary science materials. These are made of plastic and look like giant "shots" except that they lack a needle. With either the kitchen baster or the syringe, there is the chance that they will be used as squirt guns.

DISSOLVED OXYGEN

DISSOLVED OXYGEN TEST KITS

Dissolved oxygen test kits are routinely available from two companies: LaMotte Chemical Co. and Hach. The Hach kit contains dry powders. The LaMotte kit contains chemicals in solution plus one powder. Both work. The LaMotte kit is the most frequently used by teachers. It is widely available through biological and scientific supply firms. Materials may also be purchased directly from LaMotte (P.O. Box 329, Chestertown, MD 21620). Each piece of the kit is independently available so that replacing the chemicals or kit parts is easy. A teacher may extend the usefulness of the kit by combining a single kit with extra sample bottles and syringes to provide enough materials for 4 to 6 groups to work at the same time at a one time cost of $50 to $65. Check with other schools to see if anyone has an old kit. Get the catalog from LaMotte and order the new parts. New chemicals should be purchased each year. The parts number is written on each piece. The sample bottle is 0688-DO, the syringe is 0377, and the vial is 0299. Ask for both the reagents and the parts (kit) catalogues.

Detailed instructions are included with the LaMotte dissolved oxygen test kits. The old instructions are too complicated for elementary children and get ruined in use. The newer kits have addressed this problem. Read the original instructions and file them for your own use. Copy the instructions in this curriculum and laminate or cover them with plastic for your students' use. To make the kit match these instructions, label the sample bottles and solutions with tape and a permanent marker as shown below *without* covering up the original labels with their cautions and safety precautions. Explain to your students that this is an accurate test for dissolved oxygen and that when they have chemistry, they will understand it. For now, they can take it on faith. It works and is the same test scientists have used for many years.

Label the back of each bottle in the test kit as follows:

- Empty sample bottle with screw cap — A
- Empty sample bottle with snap cap with hole in it — B
- Manganous sulfate solution — 1
- Alkaline potassium iodide azide — 2 (this is the most toxic chemical)
- Sulfamic acid powder -- 3
- Sodium thiosulfate solution — 4
- Starch solution — 5

DEMONSTRATE THE USE OF THE TEST KIT, USING STUDENTS AS HELPERS, FOR THE WHOLE CLASS BEFORE ANY STUDENTS TRY IT WITHOUT YOUR SUPERVISION. ALWAYS HAVE ONE STUDENT READ THE INSTRUCTIONS WHILE ANOTHER DOES THE TEST. MAKE SURE YOUR STUDENTS ARE AWARE OF THE FACT THAT THEY SHOULD REGARD ALL CHEMICALS AS DANGEROUS AND HANDLE THEM WITH CARE AND RESPECT. AVOID ALL CONTACT WITH SKIN OR EYES. NEVER TASTE ANY CHEMICAL. WEAR EYE PROTECTION WHENEVER USING CHEMICALS.

FIELD TESTS FOR DISSOLVED OXYGEN

For use in the field with elementary children, have the students take the water samples. A teacher then adds chemicals 1–2 (steps 1-4) to each sample bottle promptly. At this point the samples will hold without change and may be taken back to school. This precludes children handling chemicals under somewhat uncontrolled field conditions. The final steps are then done by the children on a subsequent day at school where they may work carefully at desks. This requires enough sample bottles for all the sampling done on a field trip. You cannot store water samples untreated for any length of time and be sure of your results since bacteria and phytoplankton in the water may use oxygen before measurements are taken. Fixing the samples in the field solves this problem.

TAKING A WATER SAMPLE FOR A DISSOLVED OXYGEN TEST:

Rinse the bottle with sample water first if possible.

From a container: While you can carefully pour the sample down the side of the screw-capped sample bottle (A), you may also use a kitchen baster or syringe to remove water or siphon water out with aquarium tubing. Siphoning should be done by the teacher. It is a good way to collect bubble-free samples. Hold over a bucket or sink and let the sample bottle overflow for a while if possible for a good sample.

From shallow water: Put the sample bottle (A) at the depth you want to sample. Hold it sideways. Remove the cap and fill completely, tipping up at the end. Cap tightly.

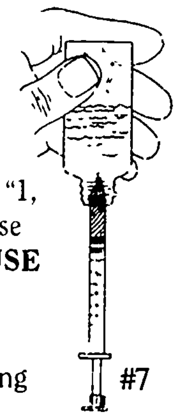
From a water sampling device: Pour gently down the side of the bottle. Do not splash or make bubbles.

From the LaMotte Water Sampling Device: The test tubes provided with this sampler are the same volume as the sample bottle (A). Use them rather than the bottle. Remove the test tube with the slanted cork on a stick and add the first solutions (1 and 2) and the powder (3) directly into the test tube, using the rubber cork as a lid or cap for the test tube. Then transfer to the sample bottle for storage.

LAMOTTE DISSOLVED OXYGEN TEST KIT INSTRUCTION

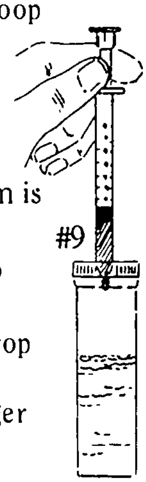
DANGER
POISONOUS CHEMICALS
DO NOT TASTE OR GET ON SKIN OR IN EYES

This kit should contain: 2 empty bottles marked "A" and "B," 5 chemical bottles marked "1, 2, 3, 4, and 5," an eye dropper, a scoop and a syringe. Check the contents first and identify these things. **ALWAYS PUT THE CAP BACK ON THE CHEMICALS IMMEDIATELY AFTER USE! USE EYE PROTECTION. PUT NEWSPAPERS ON YOUR DESK TO CATCH SPILLS.**



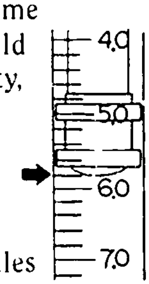
#7

1. Fill Bottle A full to overflowing with the water you are testing without splashing it c. making bubbles in the sample.
2. Add 8 drops of chemical 1 to the water sample. The drops will sink.
3. Add 8 drops of chemical 2 to the water sample. Catch spills with paper towel.
4. The sample will change color. Screw the cap o.. tightly and shake gently several times to mix. Let sample sit for 1 minute.
5. Fill the white scoop with chemical 3. The top should be level, but do not use you fingers. Remove the cap from the sample Bottle A and add the scoop of chemical 3. Do not get the scoop wet. Tap it with your finger if the powder sticks. Replace the sample cap and shake until the brown flakes go away.
6. Pour the colored sample from Bottle A into Bottle B up to the white line. Put the cap on B.
7. Push the plunger on the syringe all the way in. Put the syringe into the hole in the top of chemical 4. Turn the bottle upside down and SLOWLY pull the plunger down until the bottom is at 0. Do not pull it all the way out! This is hard so go slowly.
8. If the sample in Bottle B is very light yellow, skip the next step and go to 10. If it is yellow, do the next step, 9.
9. Put the syringe into the hole in the top of Bottle B and add chemical 4 to the sample ONE drop at a time. Do not push the syringe from the top. Twist it gently and push down. Swirl the sample each time to mix. Stop when the sample in B turns very light yellow. Leave the plunger exactly where it is. Remove the syringe. The chemical will not spill out. Remove the lid from Bottle B.



#9

10. Use the eye dropper to add 8 drops of chemical 5 to the sample in B. It will turn blue. Cap Bottle B.
11. Put the syringe back into the hole in the cap of Bottle B and add chemical 4 ONE drop at a time until the blue just barely goes away. Swirl to mix after EACH drop. Do not push from top. Hold syringe on sides and twist as you push down. If the sample stays blue and the syringe is empty, fill it and continue. Add the results.
12. When the blue disappears, look at the end of the plunger on the syringe. Read the number where the bottom stopped. Write down the number and write ppm behind it. This stands for parts per million.
13. Dispose of the remaining sample as instructed by your teacher and rinse the two sample bottles with water.
14. Wash your hands with soap.



#12

THERMOMETERS

Small, inexpensive ($6.95/dozen), plastic-backed thermometers may be purchased from several suppliers listed in this section. Because the backing is flexible plastic, the glass will snap easily, creating a safety hazard. Glue wooden tongue depressors or popsicle sticks to the back of the plastic to make them rigid. In both plastic- and metal-backed thermometers, the glass containing the red solution tends to slip up and down against the scale printed on the holder. Let them all sit out overnight on a desk so that they should read the same. Slip the glass up or down until they do show the same temperature. Use a more expensive and accurate thermometer for an idea of what the correct temperature is. When they all read about the same, attach them permanently to the backing with a big drop of strong, fast drying glue.

BALANCES

A simple balance with a stick and two pans which sits level when empty is adequate for these activities. There are seveal kinds made of wood or plastic that sell for about $15. More expensive balances which actually weigh things can also be used, but you will have to teach the students how to use them. It is much easier for elementary students to weigh things with a spring scale.

SPRING SCALES

Two kinds of spring scales are commonly sold in science supply catalogs. They range in price from $6–15 each. The cheaper scales that weigh up to 250 grams work well for the activities in this curriculum. You will have to teach the students how to interpolate between the numbers on the scale. The scales come without pans. Purchase the smallest aluminum pie tins (about 5 in across) from the housewares section of the grocery store or use the pans from individual chicken pot pies. Punch three holes equally spaced around the rim. Tie three 2 ft long strings through the holes and pull them up above the pan. Tie an overhand knot in the strings about a foot above the pan so that they are of equal length. Then tie another overhand knot about one inch above the first and cut off the remaining string. The pan must be suspended from the loop made at the top, not through one of the strings below in which case everything will be dumped out when the scale is lifted.

MEASURING TIME

Digital watches that read in seconds are becoming very cheap. Send out a call for old ones that are collecting dust in a drawer. The lithium batteries are good for 5 years or more whereas the bands break quite fast. Keep an eye out for a sale.

Many children have watches that read in seconds and even have functions like alarms and timers. I found that the students in our class were much better at working their digital watches than I was so I delegated all time-keeping. Regardless, the children may require a review of the methods used to subtract one time from another.

MEASURING VOLUME

Clear plastic measuring cups may be found in the grocery store housewares section. These cups have both metric and English markings. Many scientific supply houses offer metric volumetric measuring devices which are made of plastic. Neither of these sorts of items would be acceptable for real scientific research because they cannot be sterilized. They are perfect for elementary classroom use as you should not be using any toxic compounds. They will not break easily and will last for years. They may not be perfectly accurate, but will be fine for your purposes.

MAKING GRAPHS

There are several different ways of displaying numerical information on a graph. Bar graphs and line graphs are the two most common forms and cover the graphing needs for this curriculum. A bar graph is used when comparing different sets of numbers associated with non-continuous or discrete independent variables such as sugar and salt (independent variables) into solution. A bar graph might be used to compare the numbers of individuals of different species caught in a net.

A line graph is used to express numerical data in which the independent variable (the thing which you changed) is a continuous function, even though you only sampled parts of it. The results (the dependent or response variables) are plotted as points, but the assumption is made that the infinite number of intermediate points possible fall along a line between the points plotted. After plotting the data points you actually measured, you draw a line or curve that best fits those points. An example of a good use of a line graph would be to show the relationship of temperature to dissolved oxygen in water. As temperature increases, dissolved oxygen decreases. Sometimes the points plotted show the range of results as well as the average to indicate how much variability there was among different groups' results.

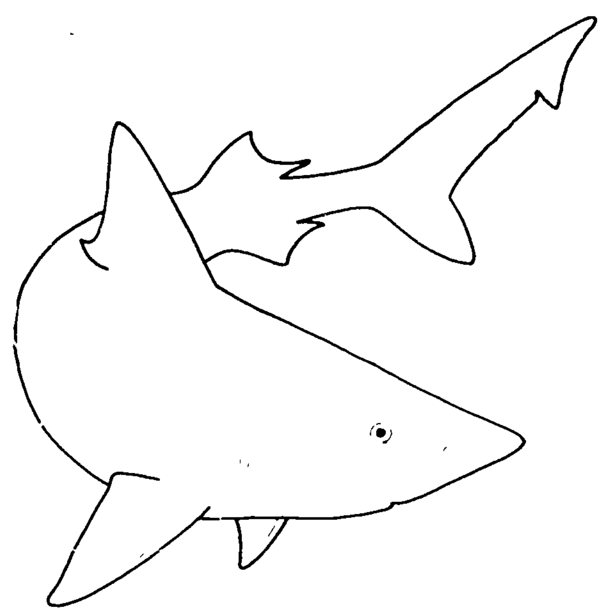
COLLECTING AND LOOKING AT ZOOPLANKTON

While plankton nets can be purchased, you can make a serviceable net from a heavy coat hanger, a sturdy pair of pantyhose and some nylon rope. Bend the coat hanger into a circle. Tie three 3 ft pieces of nylon rope or heavy cord to the rim using strong knots. Stretch the waistband of the pantyhose over the wire and sew it to the wire with sturdy thread. Distribute the rope evenly as you go so that the three ropes are equal distance from each other. Fold the band over the wire as you sew for a strong attachment and to avoid runs. Pull the ropes evenly and make an overhand knot in the ends. Use small spice or baby food jars inside the legs about knee level to collect the plankton. Hold them in place with heavy rubber bands. Pull the net with a rope. Attach a weight to the wire for a deeper tow.

Zooplankton can be viewed by the entire class with the deep well projection slides available from Carolina Biological Supply. They are dropped into a 35 mm slide projector. The zooplankton appear to swim around on the screen. These small plastic slides are somewhat expensive, but can be washed and reused. In 1988-89 Carolina Biological catalog deep well projection slides are item no. 60-3730. They are sold in sheets of 20 for $37.25.

DISSECTION

A common misconception about dissection is that a scalpel or razor blade is needed. Neither of these items should be used by elementary students. All that is needed to dissect is a pair of scissors and some wooden probes such as coffee stirrers. A pair of tweezers is useful. The critical thing is to have the correct scissors: surgical scissors with one sharp point and one rounded point. The sharp point is used to put a small hole in the body wall. The blades are then reversed with the blunt or rounded point inside for cutting along the body wall. Used carefully, very little damage is done to internal organs. Dissections may be done on newspapers or in trays or pans to catch the drips. Small fish may be dissected in styrofoam meat packing trays. Check with your butcher to see if you can purchase some.



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THE FRESHWATER CLASSROOM AQUARIUM

The best possible motivation for your students to become involved in these activities is an aquarium in your classroom. Many of the "Living in Water" activities have suggestions for using your aquarium for related work. Your students will develop a better understanding for the animals and plants used in "Living in Water" when the creatures are members of their classroom family. Care and feeding of the aquarium becomes a reward for good behavior or a well done assignment and teaches responsibility. Setting up and maintaining a freshwater aquarium is easy. If you are an old pro at aquarium keeping, you might choose to try salt water. If you want a saltwater aquarium, practice with fresh water first and read information beforehand. For a FRESHWATER AQUARIUM, you will need:

FRESHWATER AQUARIUM MATERIALS:

- tank (long and wide, not tall and skinny; 20–30 gallons is a good size)
- heater(s) (10 watts per gallon; need more than one for tank bigger than 20 gallons)
- floating thermometer
- light source (indirect sunlight or plant growlight and timer)
- undergravel filter (the same size as the tank) and air lift columns
- plastic air tubing
- air pump (the biggest, quietest one you can afford)
- air valve (gang valve)
- medium-size quartz gravel- -3/16–1/4" (not colored) 15 lbs/sq ft of tank bottom
- clean rocks, clay flower pots or other structures
- plastic screen or cover for top of tank
- large plastic bucket(s)
- large plastic tubing or a siphon to move water in and out of the tank
- net
- log book to record feeding and water changes

OPTIONAL:

- power filter
- ice scraper for removing algae from sides of tank

FRESHWATER AQUARIUM INHABITANTS:

TO START:

- two 2" fish suited to the water temperature you have chosen
- tropical fish "flake" food

SAMPLE LIST FOR 20 GALLON TROPICAL FRESHWATER TANK AFTER IT IS BROKEN IN:

- 6 guppies (swordtails or platys 1–2")
- 1 plecostomus (fish with a scraping mouth)
- 6 zebras
- 1–2 small catfish
- 10 snails
- a crayfish
- several large bunches of *Elodea*
- 10 rooted water plants

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Read this entire section before starting. You will need to complete the following tasks a full month before the aquarium can be completely stocked. Start setting it up with the class watching and talk about the function of each part as it is added. The students will enjoy watching their tank taking shape before their eyes over the weeks.

1. Rinse the aquarium tank with water. Do not wash it with soap. If it is an old one and needs scrubbing, use a soapless sponge and table salt for scouring.

2. Pick the location for the aquarium. Indirect light from a window is ideal. Do not put it over a heater. Pick a location away from rapid temperature changes. The aquarium will be very heavy, so the location must be sturdy and level. The tank cannot be moved if there is any water in it so make sure you have it where it is going to stay. An electrical outlet must be nearby.

3. Put the tank in place and add the undergravel plastic filter plate and air lift columns.

4. Put the quartz gravel in a bucket and wash it with tap water until the water is clear. Pour the water off. (For a saltwater aquarium use dolomite gravel.)

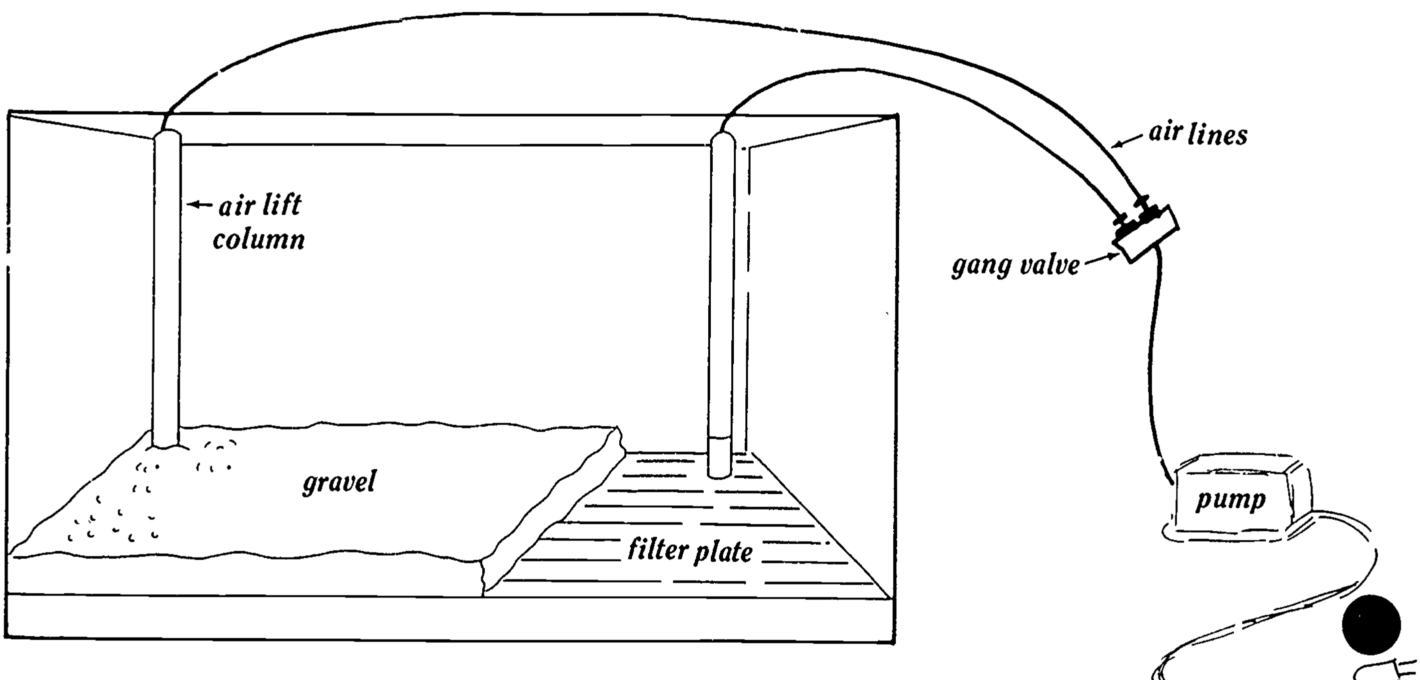
5. Gently add the gravel and spread it over the filter plate. It should be at least an inch deep.

6. If you can, add about one cup of gravel from an established aquarium. This will have the kind of bacteria you want to grow on your gravel. If you cannot do this, you will still have bacteria because they are in the air. They may take a bit longer to get going, however.

7. Put a bowl on the gravel so that when you pour water in, it will hit the bowl and not dig a hole in the gravel. Fill the tank part way with water. You may use tap water as you are not going to put any animals in today. In the future, you will let your water sit in a bucket for several days to "age." This gets the chlorine out so that it does not hurt the animals. You may also use chlorine remover purchased from a pet store. Put a heater in the bucket several hours before the water change to warm the new water.

8. Use clean rocks and/or flower pots to make hills and caves in several places. Make hiding places for your crayfish. Do not add corals or shells to a freshwater aquarium as they can alter the pH of the water.

9. Attach air tubing to the air lift columns and the air pump. The little gang valve will help you regulate the airflow. Plug in the pump. Bubbles should be traveling up the air lift columns. Water is pulled down through the gravel and then up the columns by these bubbles. This traps food and feces in the gravel, filtering it out of the water. Bacteria will take up residence on the surface of the stones and break down organic material like food particles. Bacteria also become established that convert the toxic waste product of aquatic animal urine, ammonia, to nitrate which is less toxic. These bacteria are essential and take about a month to grow. You cannot put all your animals in until this month is up!



10. Add water until the top of the air lift column is covered. Adjust the air flow so it is even.

11. Add the thermometer and heater(s). Make sure the heaters are immersed correctly. Refer to the package for instructions. Plug them in and set them for 76° F if you are going to have freshwater tropical fish. 65° F should be about right for temperate freshwater species. Let the aquarium sit for a day and check the temperature. Adjust the heaters if needed. NEVER LET THE WATER LEVEL FALL BELOW THE HEATERS. UNPLUG THEM WHEN DOING WATER CHANGES AND REPLUG WHEN DONE.

12. Get the top ready. If it has a light built in, plug it in. You need a top to keep your fish from accidentally jumping out. If you have crayfish, the top must fit very tightly as they are genuine escape artists. If you have a lighted top, the light should be turned on and off on a regular daily cycle to avoid stress to the animals. A simple timer made to turn your home lights on will take care of this. Tropical fish should have 12 hrs of light and 12 hrs of dark.

13. Let the tank sit with the air pump running for at least one full day. The water should be clear and clean. If there is still dust from the gravel, siphon the water out and add more.

14. When the temperature is correct, acclimate (see below) and add several small (2") fish. Wait at least two weeks to add the "fancy" fish or go collecting. Use goldfish or bait fish for a 65° F tank or big guppies for a tropical tank. Feed them "flake" food from a pet store. These will be the only occupants for two weeks. If you ignore this two week wait, you may lose all the animals in your tank because of toxic waste build-up.

15. After two weeks, your aquarium should be beginning to have a bacterial population. You can add some animals now IF you do a good partial water change each week and continue to do so. That means draining about ⅓ of the water and replacing it with tap water that has aged by sitting in a bucket several days before being added. If you load the tank up and do not do water changes, the fish may die from the build up of their own wastes. After one month, add plants and a few more animals. After one month the volume of water change can be reduced to about ¼ of the water every second week. NOTE: check the temperature of the aged tap water before adding. If it is more than 5° F below that of the tank, immerse the heater in it to warm it. Replace the water slowly with aged tap water to avoid temperature shock. Unplug the heaters before removing water and plug them in again when done.

ADDING AQUARIUM ANIMALS AND PLANTS

Choose a variety of plants and animals. Some plants may be floating while others are rooted. Include several varieties of fish and some invertebrates such as snails and a crayfish. Experiments in this curriculum use guppies (live bearers which will reproduce over the school year) or goldfish, snails, crayfish, and plants called *Elodea*. Select other species that are nonaggressive, but active swimmers that are fun to watch or have interesting adaptations. Also look for animals that occupy different parts of the aquarium such as bottom-dwelling algae-eaters. If you have designed a habitat with lots of places to hide and plants that form structure, a diverse community of animals is possible. Do not use species that have weird anatomy, such as fancy goldfish. Regular goldfish do better at a lower temperature than tropical fish. If you purchase the fish from a pet store, the staff can help you make selections. Most biological supply catalogs will also have some information on each species offered.

If you are collecting local species, make sure the temperature of your tank matches that of the fishes' natural environment so that the animals are not temperature shocked. Taking fish from a cold pond in the late fall into a heated classroom could kill them. Whatever kind of fish you choose, get small ones and avoid species like oscars that grow to dinner plate size. Also avoid large predators. If you bring home a largemouth bass from a farm pond, it will grow to eat all its tankmates. RESIST THE TEMPTATION TO OVERLOAD THE TANK.

To add plants, unplug the heaters. Drain about ½ of the water from the tank and "plant" the rooted plants in the gravel. Try for natural looking clumps rather than an even spacing. Gently, refill with aged tap water or the drained water. Go slow if the temperature is different from the tank. Plug the heater back in.

To add fish, acclimate the animals to the tank by floating the fish or other animals in plastic dishes or their shipping bags on the surface of the tank. Roll the top of the plastic bags to trap air so they float. Gradually, add a bit of tank water until the temperatures are the same. Slowly release the animals into the tank. Acclimation should take about 30 minutes.

DAILY TASKS

These tasks can be done by students. Initially you should supervise them. They will develop the ability to do them without your help.

1. Feed daily with just a little bit of food. Feed little tiny bits at a time for five minutes and then quit. Use commercial flake food and a variety of other things. We know one teacher who kept her tank going entirely with worms and insects the children caught plus carefully selected, non-greasy bits of meat from their lunch sacks. DO NOT OVERFEED. Unused food will decay, causing bacterial growth.
2. Remove any dead or dying organisms.
3. Check temperature.
4. Record everything done each day in a log (notebook). Record water changes, addition of plants and animals, feeding, daily temperature, and any behavioral observations about the animals. If you have any problems, the key may be in the notes. This also encourages observation and recording of data, good scientific practices.

WEEKLY OR BIWEEKLY TASKS

1. Do a partial water change. Use a siphon to remove water at the gravel surface, getting the "grunge" off the bottom. Replace the water slowly with tap water that has been sitting out overnight in a bucket. Use a slow siphon to gradually replace the water. Rate of flow can be regulated by tying a knot in the tubing to pinch it shut or using a tubing clamp.
2. If you have a power filter, stir the gravel gently, avoiding disturbing the plants. Put the power filter in place and let it run overnight.

WHERE TO FIND HELP

If you have purchased your supplies from a locally owned pet store, the staff will probably be a good source of information. Pet stores have books on aquarium keeping written for the general public. Check the card catalog at your local library under aquariums. Ask the staff of a local nature center or math/science center if they keep aquariums. Ask your science supervisor for suggestions about persons who might be knowledgeable about aquariums. Join your local aquarium society. Large public aquariums receive so many calls that they are generally unable to answer them and may have a policy of not doing so.

If you purchase animals and plants from biological supply houses, they may send you information with the shipment, such as *Carolina's Freshwater Aquarium Handbook.*

SOURCES OF EQUIPMENT

The best way to get an aquarium is to have a family donate it. Many an attic has an aquarium. Yard sales and want ads are also sources. Make sure that the tank has no cracks in the glass or plastic. If it leaks along a seam, a tube of silicone sealant can cure the problem. Remove the old sealer and use generous amounts of the new to replace it. Is there equipment gathering dust on a school shelf? Check around your school system. Ask your science supervisor. Most teachers we know have found free tanks within their system, leaving their limited funds to purchase the rest of the supplies.

Aquarium equipment can be purchased at pet stores. Most scientific supplv houses also offer aquarium supplies. Both offer packages with all the parts in one order. Most package deals will need an additional heater to be adequate for cold schoo! rooms over a long weekend. Packages are easiest, but more expensive.

SOURCES OF PLANTS AND ANIMALS

Pet stores and biological supply catalogues carry a wide range of animals and plants suitable for aquariums. Stick to the cheap, common species unless you are going to get very involved in this project. Stores that sell live bait for fishing are a cheap source of an interesting variety of animals that are tough and inexpensive.

If you live at the seashore or in the country where there are farm ponds, you may collect animals yourself. Make sure you are collecting legally. Federal, state and county parks generally prohibit collecting without a permit. Many states require permits or fishing licenses regardless of location. Freshwater pond animals are great aquariun. specimens if you get small ones. Marine species from cold waters or that live along rocky shores \:here there a'. waves are hard to keep alive without special tanks. Animals from warm estuaries or that live completely below the low tide li.ie in tropical areas are more likely to survive.

DEALING WITH SCHOOL VACATIONS

In these energy-conscious days chools can become ver\ cold over the w ˀkend or a break. Regardless of what kind of fish you keep, you should purchase a heater(s). Buy more watts than needed: 10 watts per gallon for tanks over 20 gallons. Heaters are designed for homes, not free:ing schools, so make sure you have power.

Fish and invertebrates do not use food energy to keep warm, so they eat less than birds or mammals. One of the most frequent mistakes made by new aquarium owners is overfeeding. Fish and invertebrates can do fine without eating over the weekend. For a week or two break, feed and do a water change just before you leave and immediately on returning.

AT THE END OF THE SCHOOL YEAR

Tropical species may be adopted by students or their parents for home aquariums. Pet stores may accept the return of healthy specimens. If the animals came from the wild, they may be returned only if they go back to exactly the same place you got them and are slowly acclimated to the water. NEVER RELEASE ANY ANIMALS THAT ARE NOT NATIVE TO THE EXACT BODY OF WATER THEY ARE ENTERING. INTRODUCTION OF FOREIGN SPECIES CAN DO INCALCULABLE ECOLOGICAL DAMAGE.

MAKING WATER WITHOUT CHLORINE OR HOW TO AGE TAP WATER

Water supplied by most municipal districts is treated with chlorine to kill bacteria which might be in the water. Chlorine is also toxic to most aquatic plants and animals. Consequently, if you put fish or plants in water right out of the tap, they may die. The chlorine is a gas dissolved in the water. If the water is exposed to air for 24 hrs, the chlorine gas will diffuse out of the water. Gases in the water will reach equilibrium with those in the air during this time. Fortunately, there is *very* little chlorine gas in the air, so the chlorine leaves the water. Always allow water from the tap to sit for 24 hrs before animals or plants come in contact with it.

LIVING THINGS

POND WATER

A pond water sample should contain small, single-celled algae. Pond water samples or algal cultures can be purchased from a biological supply house. You may find that collecting a natural sample is easy, however. A sample of algae scraped from the sides of a well-established freshwater aquarium should work. During spring, summer and fall samples can be collected from outdoor sources such as a greenish farm pond, animal water trough or goldfish pond. Look for sources where the water is rich in nutrients and is standing, not flowing.

ELODEA

This cheap common aquarium plant is available from pet stores and biological supply houses. It grows in long strands which tend to float unless anchored. If *Elodea* gets sufficient light, it will live through the entire school year in a classroom aquarium. With care of the plants between use, all of the activities in this curriculum may be done with the same materials. As *Elodea* grows, it will remove animal waste products from the water. Indirect natural light or plant growlights provide the best spectrum for growth.

GOLDFISH AND GUPPIES

Goldfish and guppies are two of the most commonly available freshwater fish. They are incredibly tough and can survive the uses in this curriculum quite nicely. They may be purchased from biological supply companies, but are frequently available in pet stores or variety stores at a much lower price. Stick to animals in the 1 to 2 in size range for the uses here. Feed them flake food. The guppies prefer a warmer tank than the goldfish, so do not mix the two. Use either goldfish (65° F) or guppies (75° F), but not both. Guppies do fine in a freshwater tropical aquarium with other species. They may surprise you by reproducing. In the case of both species, do not subject them to temperatures above those at which they are kept.

BRINE SHRIMP

Brine shrimp (*Artemia salina*) are small crustaceans found in salt lakes throughout the world. They are referred to in some places as sea monkeys. They may be purchased as dry eggs which hatch in salt water. The newly hatched animals are truly microscopic. They will not work for these activities. The adults may be purchased live from some pet stores (call ahead of time) and may also be purchased from some biological supply houses. If you are really brave, you might want to try raising the newly hatched animals. Instructions for this project are in the October, 1986, *Tropical Fish Hobbyist*. A mother who has raised six generations of brine shrimp for her son's science fair project fish to feed on was successful after she learned that the eggs had to dry before they hatched for each new generation. Her animals were reproducing sexually, making eggs that could survive cold and drying. Under other environmental conditions, brine shrimp reproduce asexually, making eggs that develop without fertilization into new adults.

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SOURCES OF EQUIPMENT AND ANIMALS

These are companies who came to the NSTA 1987 conference with displays of equipment appropriate for elementary science and had materials used in this curriculum. Many also offer computer software, texts and other science aids. Write for catalogs and have a good read. They will be the source of many good ideas. There are many other good supply companies. This is not a comprehensive list. The publishers offer science sets to go with other curricula, but you can get individual items from their replacement parts catalogs which are quite nice. For a comprehensive list of suppliers of equipment and software, check the January issue of *Science and Children* each year.

Aquarium and Science Supply Co.
P.O. Box 41
Dresher, PA 19025
new company; "discount prices"

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
or
Box 187
Gladstone, Oregon 97027
living materials, aquarium supplies and equipment; everything needed for this curriculum except art supplies; computer software, slides and filmstrips

Connecticut Valley Biological Supply Co. Inc.
P.O. Box 326
82 Valley Road
Southampton, MA 01073
living materials, aquarium supplies and equipment

Damon
Instructional Systems Division
80 Wilson Way
Westwood, MA 02090
balances, syringes and other equipment

Delta Education, Inc.
P.O. Box M
Nashua, NH 03061-6012
curricula and equipment for hands-on science replacement parts for Silver Burdett, Charles E. Merrill, Holt and other science curricula as well as OBIS, ESS, SAPA II and SCIS II materials

Harcourt Brace Jovanovich
School Department Sales
Eastern Region
5 Sampson Street
Saddle Brook, NJ 07662
balances, scales and other science equipment; ask for replacement parts catalog for HBJ Learning Boards for Science

LaMotte Chemical Co.
P.O. Box 329
Chestertown, MD 21620
kits and replacement parts for water testing; ask for Limnology booklet

Nasco
901 Janesville Ave.
Fort Atkinson, WI 53538
scales, balances, volumetric measures; ask for replacement parts catalog for SciQuest

Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, CA 94720
SAVI/SELPH: science equipment and curricula for visually and physically limited students, but useful for all students; also OBIS outdoor biology materials and other useful materials

Schoolmaster Science
745 State Circle
Box 1941
Ann Arbor, MI 48106
scales, balances, "glassware" and other equipment

Science Kit, Inc.
777 East Park Drive
Tonawanda, NY 14150
general science equipment

Teachers' Laboratory
214 Main Street
P.O. Box 6480
Brattleboro, VT 05301-6480
interesting equipment and curriculum materials for elementary science

Chaselle, Inc.
9645 Gerwig Lane
Columbia, MD 21046
school art supplies, including blue cellophane in 20" × 150" rolls

Accent! Science
P.O. Box 1444
Saginaw, MI 48605
ask for field biology catalog; good selection of nets and water samplers

Forestry Suppliers, Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39204
field supplies, including some equipment for aquatic sampling gear

CURRICULUM IDEAS AND COMPUTER SOFTWARE

Cambridge Development Laboratory, Inc.
P.O. Box 605
Newton, MA 02162
ong list of software, including "Oh, Deer!"

Collamore Educational Publishing
(D. C. Heath and Co.)
125 Spring Street
Lexington, MA 02173
software and texts

Computers in Marine Education
c/o Skip McLamb
316 Angus Road
Chesapeake, VA 23320
a network of educators using computers in marine education; bibliorraphies and descriptions

Educational Materials and Equipment Co.
Old Mill Plain Road
P.O. Box 2805
Danbury, CT 06813-2805
computer software

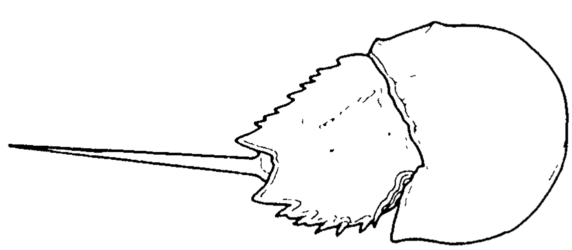
Holt, Rinehart and Winston
383 Madison Avenue
New York, NY 10017
Voyage of the MIMI is a multidisciplinary program of video, computer software and texts which includes oceanography; produced by Bank Street College

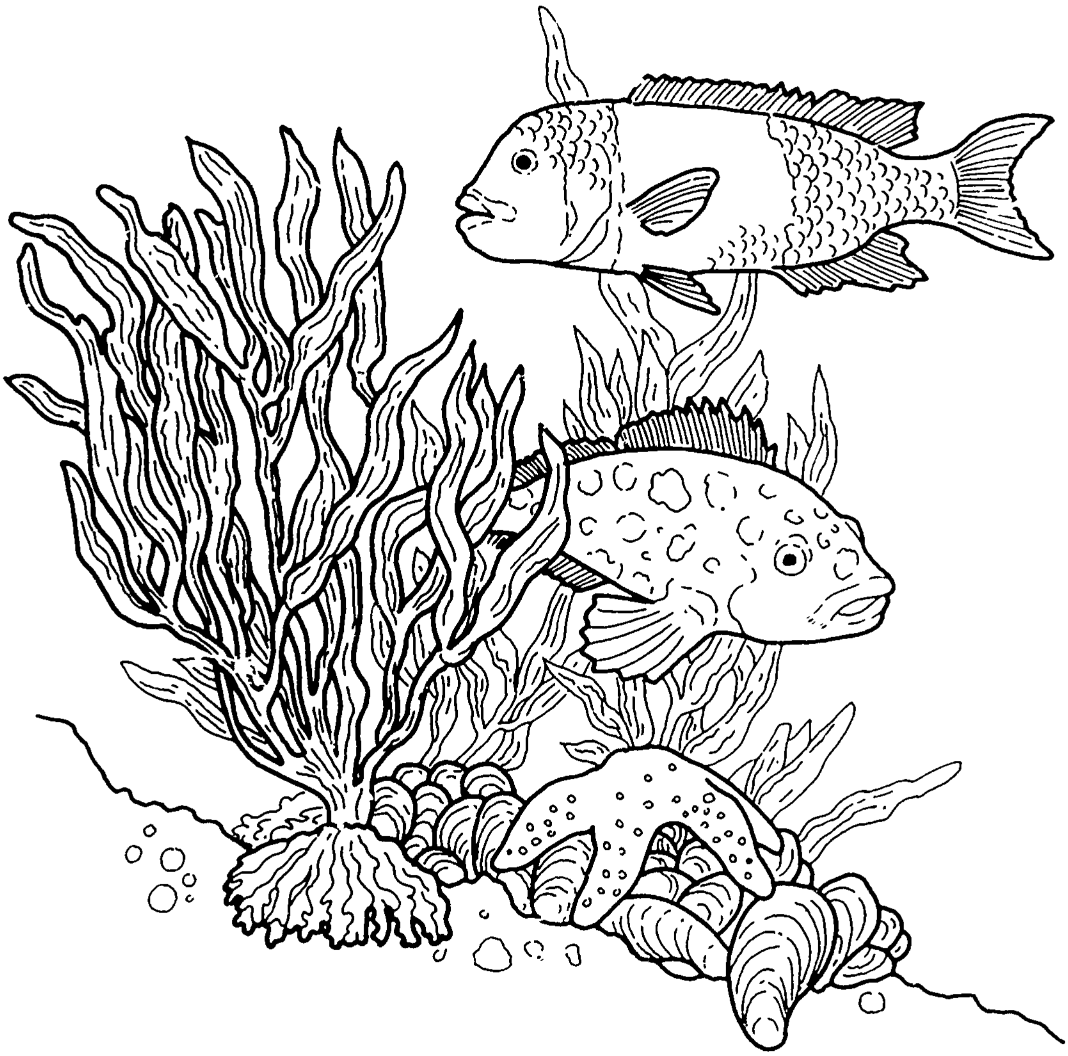
MECC
3490 Lexington Avenue North
St. Paul, MN 55126
excellent selection of computer software, including "Oh, Deer!"

National Marine Educators' Association
P.O. Box 130
Kure Beach, NC 28449
newsletter and journal; network of teachers, aquarium, museum and Sea Gront educators

National Science Teachers Association
1742 Connecticut Avenue NW
Washington, DC 20009
publishes Science and Children (elementary) and Science Scope (middle school) as well as booklets on science education; ask for classroom animal and plant safety information

National Wildlife Federation
1412 Sixteenth Street NW
Washington, DC 20036-2266
NatureScope, a quarterly magazine of natural history activities for grades K-7; each issue is on a single topic such as birds or oceans





ACTIVITY 1 Name ______________________

THE DISAPPEARING ACT!

You are going to add table salt, sugar and corn starch to cups of water. What do you guess (predict) will happen to the substance in each cup?

Salt: ____

____

Sugar: ____

____

Corn starch: ____

____

Fill three clear plastic cups with about the same amount of water. Leave about an inch at the top so you can stir. Label each so you know which gets salt, sugar and corn starch.

How many teaspoons will you add to each cup? Circle 1 2 or 3.
Each gets the same number.

After adding the substances, sit and observe for two minutes. What can you see happening?

____

____

____

____

Stir each cup 10 times using the same technique. Did any dissolve?

Repeat stirring each 10 times and then observing all of them. Mark out the number of times stirred before a substance dissapeared if it did so.

Salt:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

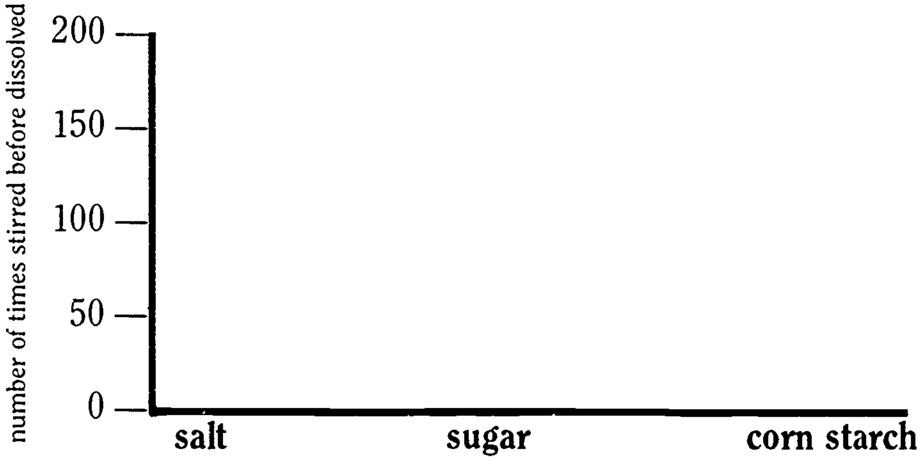
Sugar:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Corn starch:

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Make a bar graph of these results:



Did each dissolve? ____

____

Which dissolved fastest? ____

Write a complete sentence that is one conclusion that you could make based on the results of your experiment.

____

____

____

____

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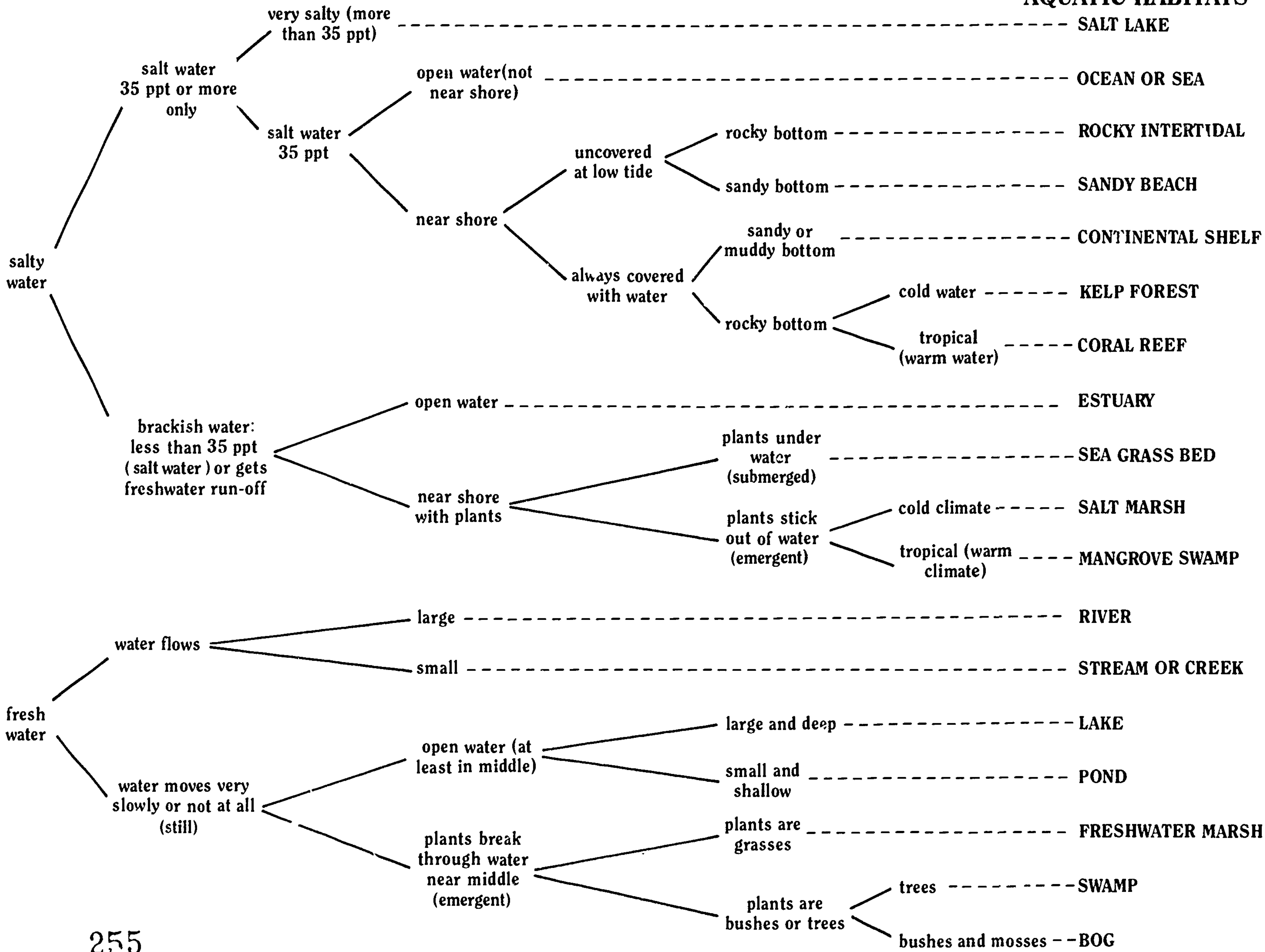
AQUATIC HABITATS



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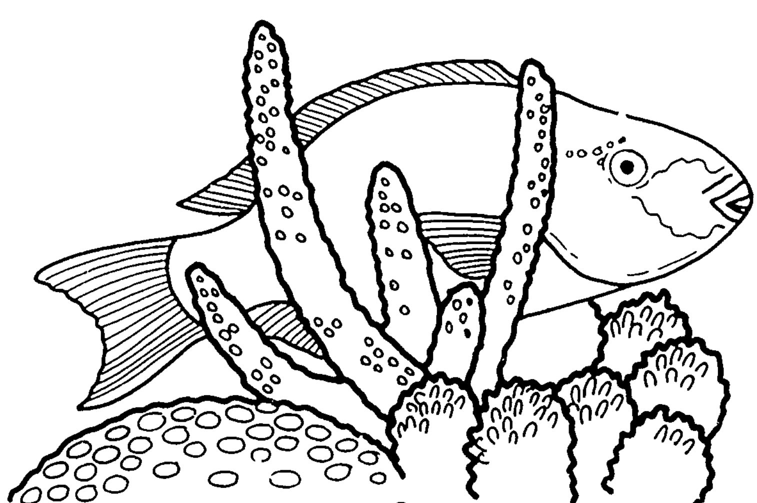
WATER HABITATS

1. Water is salty 2
1. Water is fresh 12
2. Water is salt water (sea water) or saltier than sea water only 3
2. Water is brackish, less salty than the sea or salt water 9
3. Water is saltier than sea water .... **SALT LAKE**
3. Water is salt water, 35 ppt* 4
4. Open water, not near shore .... **OCEAN OR SEA**
4. Near shore 5
5. Part uncovered at low tide 6
5. Always covered with water 7
6. Sandy .... **SANDY BEACH**
6. Rocky .... **ROCKY INTERTIDAL**
7. Bottom of sand or mud .... **CONTINENTAL SHELF**
7. Bottom hard and rocky 8
8. Cold water and cold winters (temperate) .... **KELP FOREST**
8. Warm waters and warm climate year-round (tropical) .... **CORAL REEF**
9. Open water .... **ESTUARY**
9. Near or at shore with green, rooted plants 10
10. Plants are entirely under the water (submerged) .... **SEA GRASS BED**
10. Plants grow out of the water (emergent) 11
11. Climate is cold during winter (temperate) .... **SALT MARSH**
11. Climate stays warm all year (tropical) .... **MANGROVE SWAMP**
12. Water flows in a definite bed 13
12. Water appears not to move at all unless windy (still) 14
13. Large, flowing over muddy bottom .... **RIVER**
13. Small, flowing over sandy or rocky bottom .... **STREAM OR CREEK**
14. Has open water although shores with plants are around it 15
14. Plants grow out of the water all over (emergent) 16
15. Large and deep; plants grow under water only near shore .... **LAKE**
15. Small and shallow; plants grow under water everywhere .... **POND**
16. Plants are grasses .... **FRESHWATER MARSH**
16. Plants have woody branches; they are trees or bushes 17
17. Plants are trees with definite trunk .... **SWAMP**
17. Plants are bushes; moss grows on ground .... **BOG**

**35 ppt is a way of expressing how salty the water is in the ocean or other saltwater habitats. If you had one kilogram of sea water, 35 grams of the weight would be salt.*



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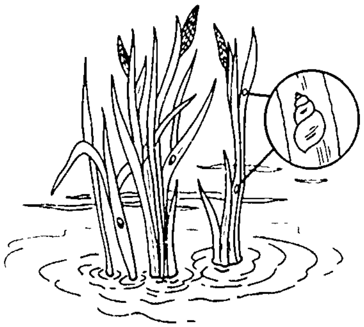
AQUATIC HABITAT CARDS:

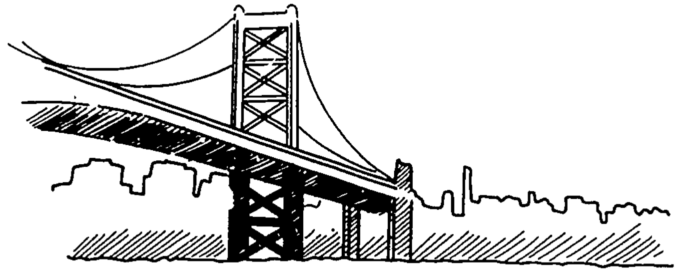
Your brackish water is full of nutrients for the tall grasses that emerge along your shore. In the winter these grasses die, but each spring they come back from their strong roots. The decaying grass particles are food for crabs and oysters. The grasses protect the shore from storms.

YOU ARE ______________________________



Your fresh water flows over a wide, muddy bottom. Big catfish lurk in your murky waters. Cities were located on you because in the old days you were the easiest place to travel. Barges are towed up and down you in many states even today.

YOU ARE ______________________________



Your quiet, fresh waters are home to many fish which hide deep beneath your surface. Storms may make waves on your wide surface. Where winters are very cold, you may be covered with ice.

YOU ARE ______________________________

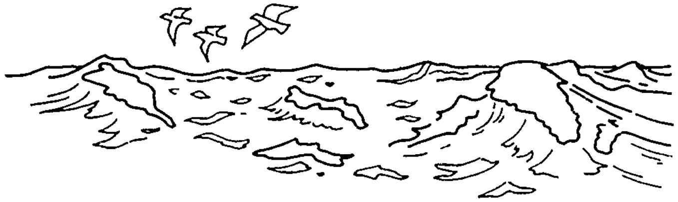
Grasses grow out of your still, fresh waters. Red-winged blackbirds build nests in the grasses. The air is filled with the calls of the male blackbirds.

YOU ARE ______________________________

AQUATIC HABITAT CARDS:

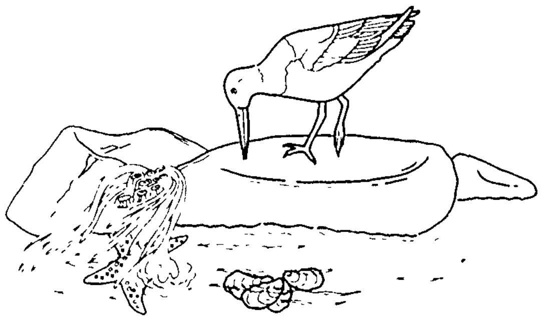
You have salt water and are a big body of water. When the wind blows, waves roll over your surface. During storms the waves get huge. Things on you are far from land.

YOU ARE ______________________



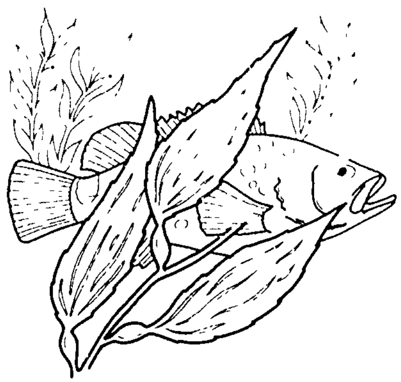
Your rocky shore is covered with seaweeds that live attached to the rocks. When the salt water is at low tide, the sun or snow or rain falls on your seaweeds and animals. Waves crash into you, so animals and plants have ways of clinging tightly to your rocks.

YOU ARE ______________________



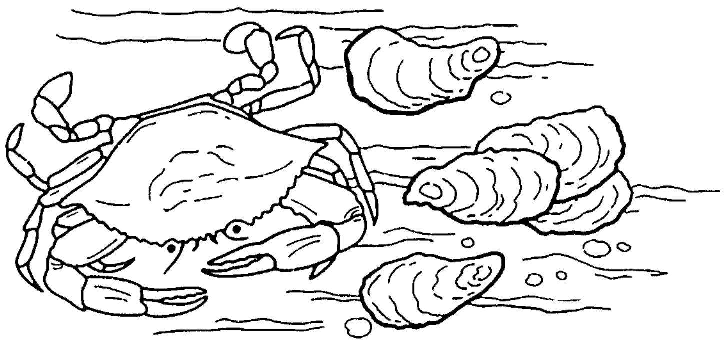
You have cold, salt water. You are found near rocky shores. Your plants and animals are always covered by your cold water. You have forests of seaweeds called kelp which hide hundreds of kinds of animals.

YOU ARE ______________________



Salt water mixes with fresh water from a river in your wide shallow waters. You have lots of food for fish and crabs in your open waters above your muddy bottom. You are a nursery for many ocean animals.

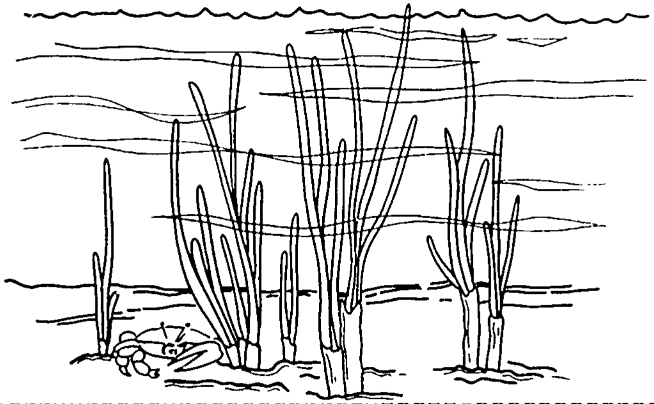
YOU ARE ______________________



AQUATIC HABITAT CARDS:

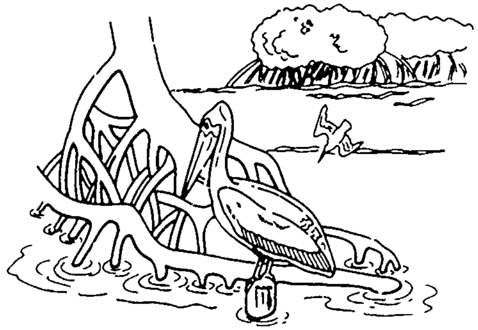
Underwater fields of plants grow in your shallow, brackish water or salt water. Many animals find food and shelter among the plants. The plants protect the nearby shore from erosion because they break the force of the waves.

YOU ARE ____________________



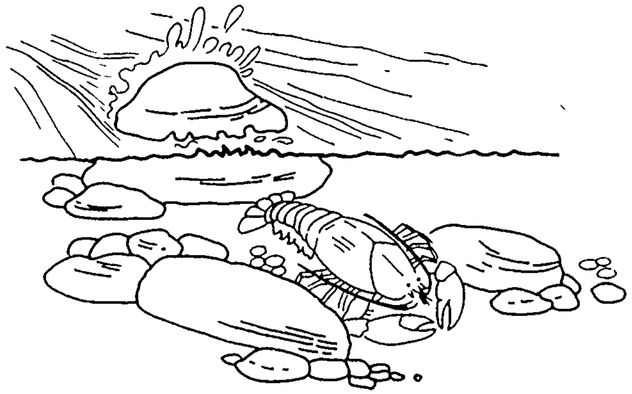
Short trees line the shores of your brackish or salt water. Their big roots hold the trees in the mud, even when hurricanes disturb your constant warm days. Many animals and plants find a home on your tree roots or in your waters. Because it is warm all year-round, you are said to be a tropical habitat.

YOU ARE ____________________



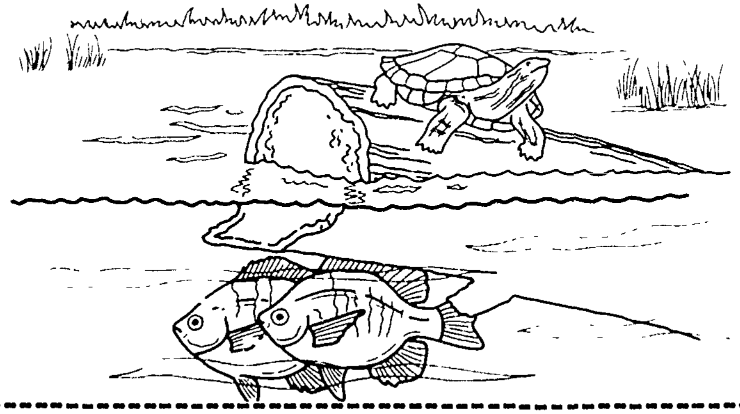
Your fresh water tumbles down over rocks and through small pools where fish and crayfish hide. Your water comes from rain that runs off the land and from springs that bring underground water to the surface.

YOU ARE ____________________



Sun shines through your shallow, open, fresh water, allowing underwater plants to grow on the bottom. Still and small, you may freeze solid where winters are cold. In the summer turtles bask on your shore and deer drink from you.

YOU ARE ____________________



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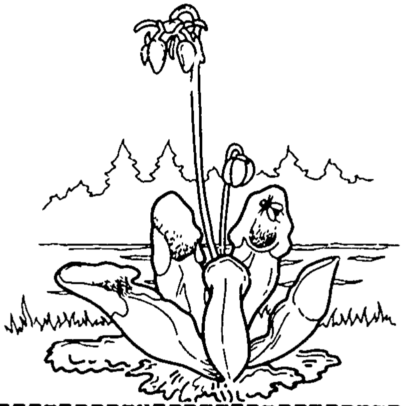
AQUATIC HABITAT CARDS:

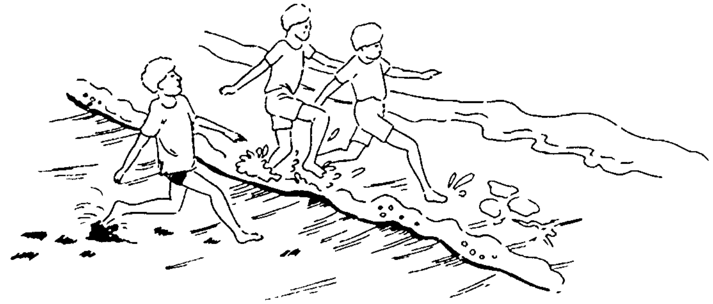
Bushes and mosses grow in your shallow, still water. Patches of very wet ground are home to pitcher plants which get their nutrients from the insects they catch in their leaves. Your water is fresh, but very acid.

YOU ARE ______________________



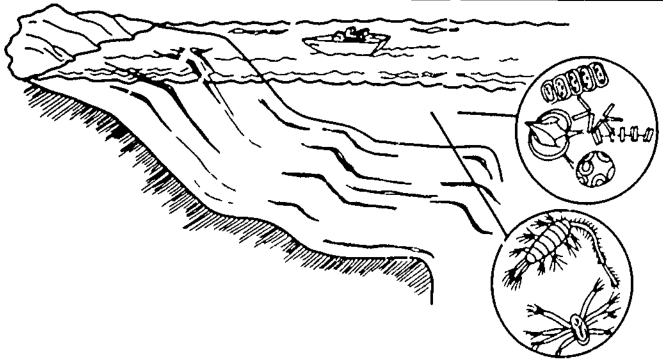
You have salt water that rises and falls with the tides. Sometimes the waves roll way up on your sand while at other times much of your sand is not covered with water. Children play on you. When a storm comes, your sand is moved all around.

YOU ARE ______________________



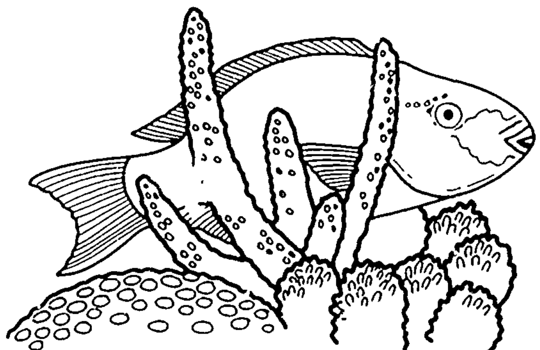
Your sandy or muddy bottom is under salt water. In some places the water is deep, but you are along the shore. Animals burrow in your sand or mud. Your water is rich in tiny plants which provide food for many animals. Fishermen harvest your animals.

YOU ARE ______________________



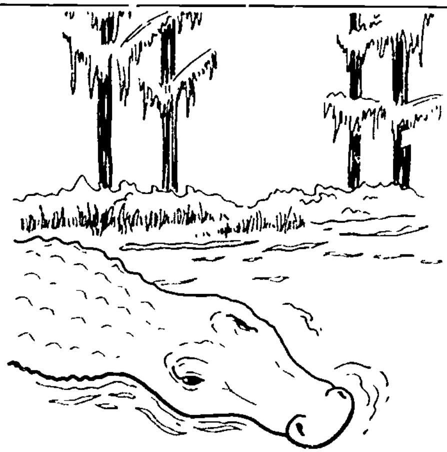
Your warm, salt water and rocky bottom provide the perfect place for animals called corals to grow. Their skeletons make a great place for fish to live. Because you are in a place that is warm all year-round, you are a tropical habitat. Tourists swim out from the beach to visit you.

YOU ARE ______________________



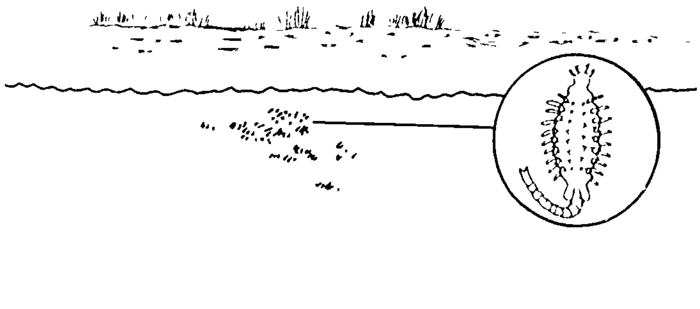
Tall trees stand in your quiet water. Freshwater turtles bask in a patch of sun while mosquitos buzz. It is very dark in the shade of the trees.

YOU ARE ______________________________



Your water is very salty, saltier than the sea. Water flows into you, but there is no way for it to leave except by evaporation in the hot sun. You form in low areas in deserts.

YOU ARE ______________________________



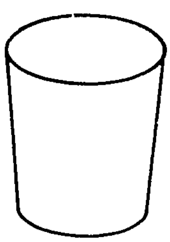
ACTIVITY 3 Name ____________________

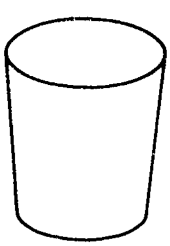
SALTY OR FRESH?

Which is heavier: salt water or fresh water? ____________________

How did you compare salt and fresh water to reach your conclusion? ____________

What happened when salt water and fresh water were very gently layered on each other? Draw and label your results.





Predict what might happen to the distribution of salt and fresh water in the mouth of a river where it meets the sea.

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ACTIVITY 4:
THE LAYERED LOOK

Name ______________________

State the question you are trying to answer by observing this demonstration.

____

____

____

____

____

Draw the results of the demonstration here:

First tank or jar   second tank or jar

Based on the results of this demonstration, where would you expect to find the saltiest water if you were studying the mouth of a river where it formed an estuary as it meets the ocean? The top of the water or the bottom?

____

____

____

____

____

____

ACTIVITY 5 Name ____________________

SOME LIKE IT SALTY — SOME DO NOT!

Predict which layer(s) the animals will prefer. ____________________

____

____

____

Draw the two tanks. Label the salty and fresh water. Draw the animals in the locations they prefer.

Did the animals always stay in the same kind of water? If not, describe their behavior.

____

____

____

____

____

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ACTIVITY 6 Name ____________________

THE GREAT SALINITY CONTEST!

My sample number is _____

These are the steps I will take to determine if I have fresh water, slightly salty water or the very salty sample:

I think my sample is
___ fresh water ___ slightly salty ___ very salty.

This is the evidence for my conclusion:

ACTIVITY 7 Name ______________________

OXYGEN FOR LIFE

What did you observe happen as the plastic cup of cold water warmed to room temperature?

____

____

____

Record the results of your group's dissolved oxygen test here.

Amount of dissolved oxygen in the water when the jar was first opened:
____ppm (parts per million)

Amount of dissolved oxygen in the water after it was exposed to the air:
____ppm

How much change in dissolved oxygen did you measure in your water sample?

____

Record the results for the class on this table:

	group number 1	2	3	4	5	6	average
dissolved oxygen in newly opened jar in ppm							
dissolved oxygen in water exposed to air in ppm							

difference ____ ppm

How can you explain the difference in dissolved oxygen in the two samples?

____

____

____

____

____

ACTIVITY 8
DIRTY WATER

Name ____________________

Arrange all the pictures in order from the first date to the last. Study the changes you can observe with over time in each. Describe them here:

Tap water: ____________________

One teaspoon of fertilizer: ____________________

One tablespoon of fertilizer: ____________________

Water from soil: ____________________

Which grew the most algae? ____________________

Which grew the least algae? ____________________

One tablespoon is three times as much as one teaspoon. What was the result of one jar having three times as much fertilizer as another?

Why did one jar get only tap water? ____________________

ACTIVITY 9 Name ____________________

WHAT'S IN THE WATER?

Arrange all the pictures in order from the first date to the last. Study the changes you can observe over time in each. Write in the pollutant used in each and describe the changes:

Tap water: ____________________

____

____

- - - - - - - - - - - - - - - - : ____________________

____

____

- - - - - - - - - - - - - - - - : ____________________

____

____

- - - - - - - - - - - - - - - - : ____________________

____

____

Which pollutant had the greatest effect? ____________________

Which pollutant had the least effect? ____________________

Were you surprised at the results? How did they compare with your predictions?

____

____

____

Why did one jar get only ' ¬ water? ____________________

____________________ 273 ____________________

ACTIVITY 10
A CHANGE IN THE WEATHER?

Name ______________

What is the question that this experiment will answer?

____

____

____

Record the TEMPERATURES for your group here:

container	start	5	10	15	20	25	30	35	40	45	50
	time in minutes since starting										
air											
small water											
large water											

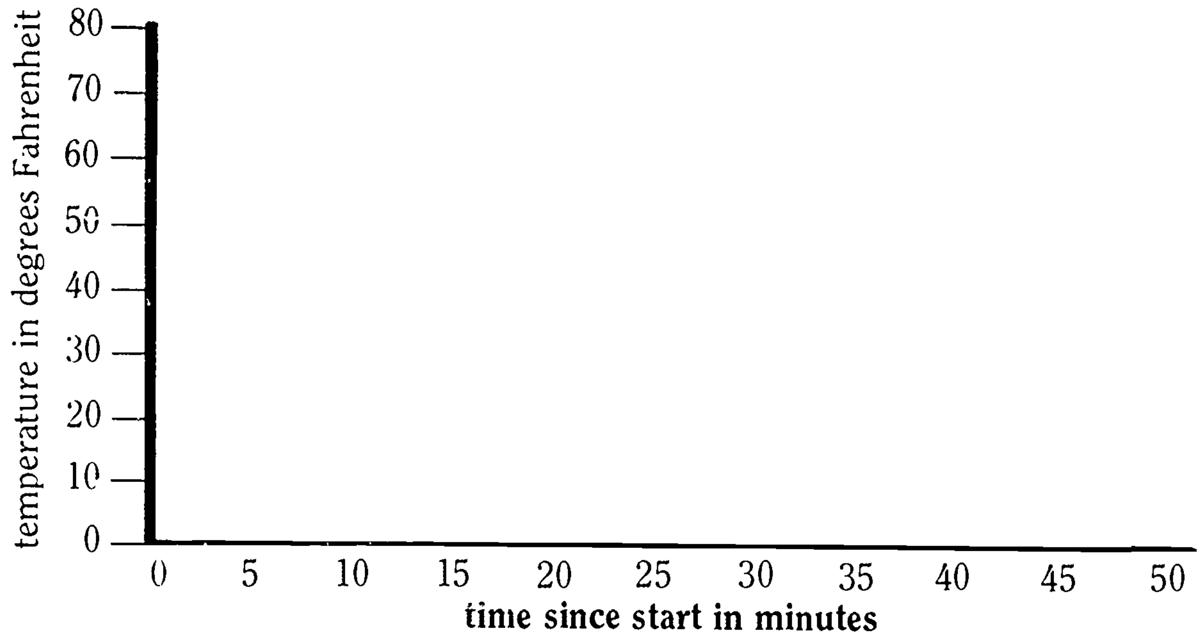
These temperature readings are in Farenheit ______
Centigrade ______

Calculate the average temperature for all groups and record here:

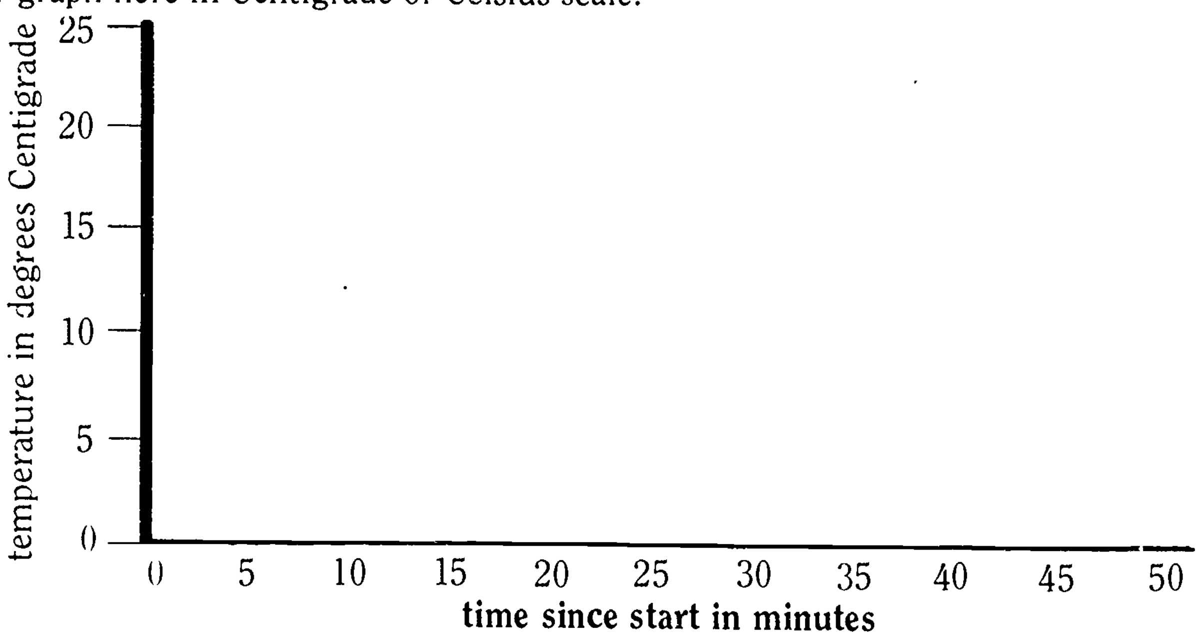
container	start	5	10	15	20	25	30	35	40	45	50
	time in minutes since starting										
air											
small water											
large water											

These temperature readings are in Farenheit ______
Centigrade ______

Graph the temperature changes with a line graph here for Farenheit scale:



Or graph here in Centigrade or Celsius scale:



Which container changed temperature fastest? ______________________

______________________ ______________________

Which changed most slowly? ______________________

Based on your experiment, which of these would change temperatures through the seasons least? Most? Middle?

ocean ____________ pond ____275____ lake ____________

ACTIVITY 11 Name ______________________

PLANTS USE OXYGEN?

PLANTS

What question are you going to answer by doing this experiment? ____________

____

____

____

Record the results of your experiment here:

jars	dissolved oxygen in ppm		
	when plants are put in the jar	one day later	change with time
control			
plants			

Record the class results here as change in dissolved oxygen in each jar. Write the numbers in parts per million (ppm).

	group number						
	1	2	3	4	5	6	average
control							
plants							

Which changed more, the control or the plants? ____________

What conclusions about plants and dissolved oxygen can you make based on these results? ____________

____

____

____

____

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AQUATIC ANIMALS AND OXYGEN

What kind of animal are you going to test? ____________________

What question are you going to answer by doing this experiment? ____________________

____

____

____

Record the results of your experiment here:

jars	dissolved oxygen in ppm: when animal is put in the jar	after 1 hour	after 2 hours
control			
animal(s)			

How much oxygen did your animal(s) use per hour? ____________ ppm per hr

How much did your animal(s) weigh? ____________ grams

Divide oxygen used per hour by animals' weight ____________

Now you can compare your results with those of otner groups. Were your results the same as those of groups who had the same kind of animal(s)?

____

____

____

Can you make any comparisons about how much oxygen different kinds of animals use? Can you compare how much oxygen plants use with that of animals? To do this you will need to weigh the animals and plants so that you are comparing the same weights of crayfish to snails to plants.

____

____

____

ACTIVITY 12
WHEN THE HEAT'S ON

Name ____________________

Write what you think the word cold-blooded" means: ____________________

____

____

____

____

____

____

What question are you trying to answer by doing this experiment? __________

____

____

____

The original amount of dissolved oxygen in the water was ________ ppm

Record the results of your experiment here:

end temperature **dissolved oxygen in ppm**

	beginning	after 24 hrs	difference
cold plants temp. ________			
warm plants temp. ________			

Record the results for your class here:

	difference in dissolved oxygen in ppm						
	1	2	3	4	5	6	average
cold plants							
warm plants							

Based on the class results, what conclusion can you draw about plants' use of oxygen in the dark as it relates to temperature?

Why do you think you added all the class results together and took an average for your results?

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ACTIVITY 13 Name ____________________

WHEN THE OXYGEN GOES . . .

State the question you want to answer by doing this experiment. ____________

____

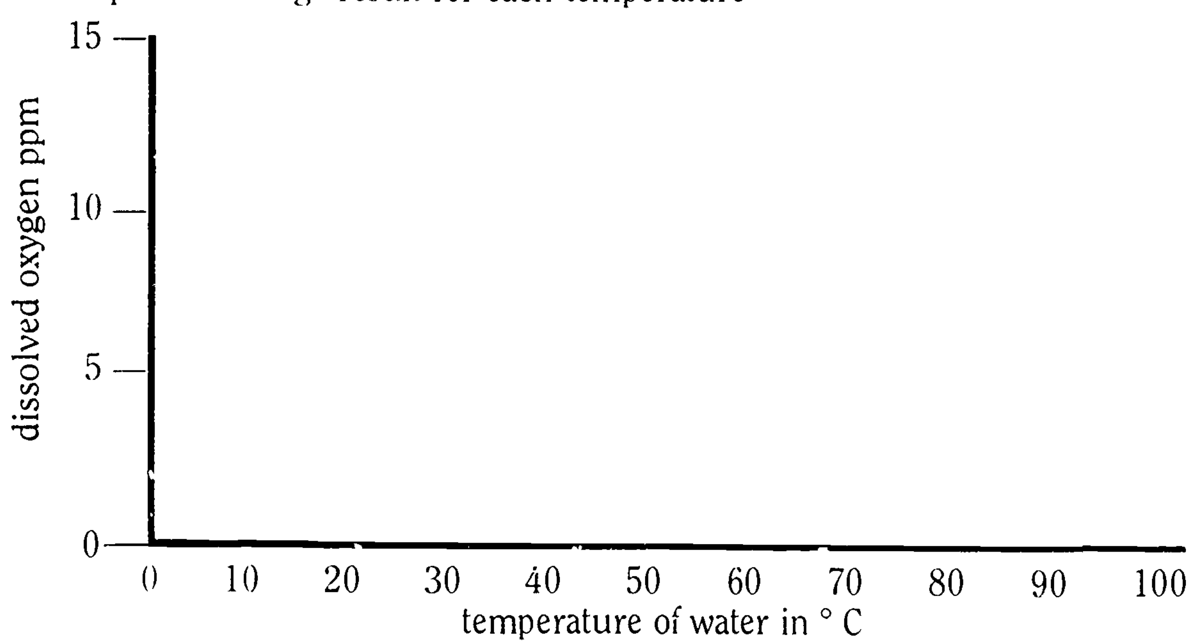
____

____

Record the results from each group's tests:

temperature of water when sealed	dissolved oxygen in the water in parts per million		average

Graph the average result for each temperature·



What conclusion can you make based on the results of this experiment?

____

____

ACTIVITY 14
WHEN THE OXYGEN IS GONE

Name ______________________

Describe the experiment you are going to do. ______________________

____

____

____

	number of times gill covers are opened per minute	
	water with oxygen	water without oxygen
Fish number one		
Fish number two		
average		

What conclusions can you make from your experiment? ______________________

____

____

____

Compare the behavior of the fish in low dissolved oxygen water with that of the fish in water with normal oxygen levels.

Low oxygen: ______________________

____

____

Normal oxygen: ______________________

____

____

ACTIVITY 15

Name ______________________

IN HOT WATER?

What question can be answered by doing these experiments? ______________________

____

____

What did you do for your first test? ______________________

____

____

Compare the results of your first test with hot and cold water: ______________________

____

____

Draw the results of your second experiment:

What conclusion can you make based on your experiments? ______________________

____

____

ACTIVITY 16 Name ____________________

THE GREAT ANADROMOUS FISH GAME

You have a school of herring trying to reach the spawning grounds. There are 100,000 fish in your school. There are many dangers waiting for your school. Each time you meet a hazard, deduct the number of fish that died from your school. Use this chart to keep track of how many fish you have.
Round your numbers to the nearest thousand if it helps.

GOING TO THE SPAWNING GROUNDS No. of fish at start ____________

Ocean	Estuary and River	Streams

The number of adult fish that reached the spawning ground is ________.
Now how many baby (larval) fish did these adults produce? Here is how to find out:

1. Roll the die. Your number was ________.
2. Multiple this times 10 to get ________.
3. Multipl^ this number by the total number of adult fish to get the number of baby herr:;g that start down stream ________.

Now the baby herring will head for the ocean. Keep track of the changes in the number of fish as they swim.

RETURNING TO THE OCEAN No. of baby herring headed for the ocean ______

Streams	Estuary and River	Ocean

The number of young herring that reached the ocean is ________.
The average number of young herring that reached the ocean for the group I played the game with was ________. (Add all your total young together and then divide by the number of you that played.)
Are the total number of herring increasing each year or decreasing?

____

____

If you were a fisheries biologist, what actions would you take which could increase the number of herring in future years?

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THE GREAT ANADROMOUS FISH GAME

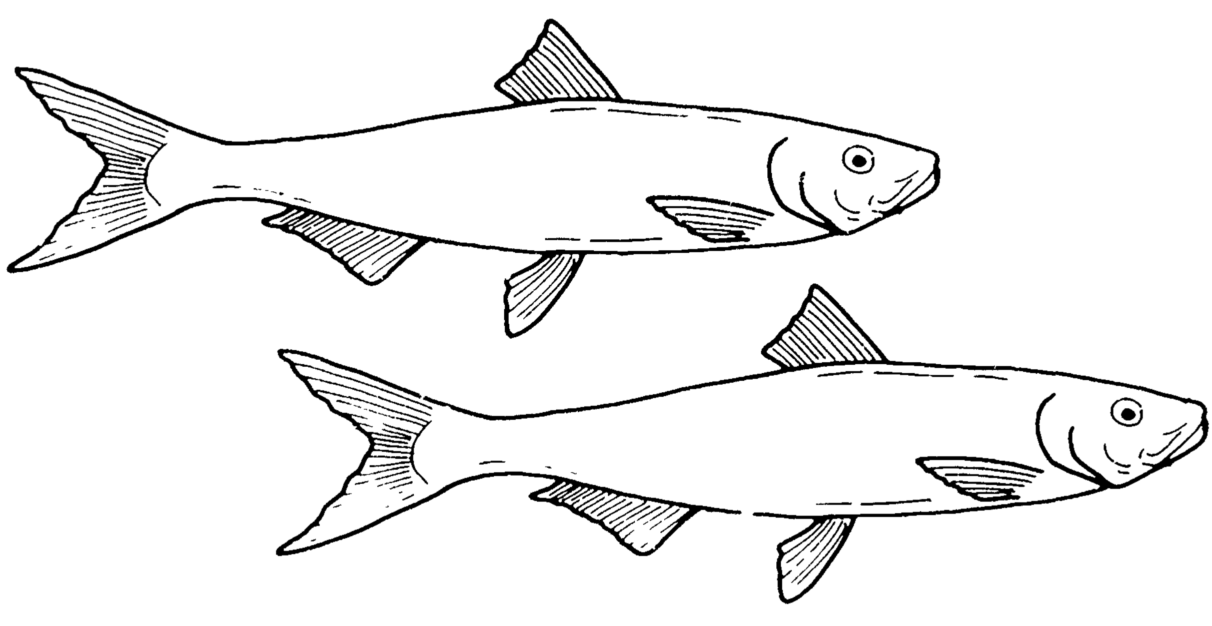
RULES:

Goal:

You are a school of herring. Your objective is to produce as many offspring as possible by successfully swimming to the spawning grounds. Once there, you will then see how many of the baby herring you can get back to the sea. The player with the most fish wins! But beware, there are many hazards lurking along the way.

How to play:

1. Open the board. Shuffle each set of hazard cards and place them in the marked locations.
2. Select your marker and place it in the Open Ocean. This is your starting point as an adult herring school. You will swim into the estuary and then upstream where you will spawn. As offspring you will swim back down to the ocean.
3. You get 100,000 herring to start so record that number on the worksheet
4. Roll the die. The highest number starts first. Play proceeds clockwise from that player.
5. Roll the die to determine how far you move your marker. If you land on a space that says to draw a card. do so and read it aloud. If you have a hazard card, you must record the change in number of fish in your school on your worksheet. For example, if you have 50,000 herring left and your card says that half of them were caught in nets, then you must reduce your herring to 25,000 fish. Your teacher will review fractions. You may round your results off to the nearest thousand if you wish.
6. Going to the Spawning Grounds, draw only cards that say TO Spawning Grounds.
7. Each female herring may lay 100,000 eggs, but most do not survive to hatch into baby fish (larvae). When you arrive at the Spawning Grounds, you need to figure out how many baby fish your school produced. Roll the die. Multiply the number on the die by the number of fish you have left (for example, 5 times 1,250 adult herring = 6,250) and then multiply by 10 (6,250 × 10 = 62,500) to get the number of baby fish (larvae) that you will start back down the river with.
8. Return to the Ocean, drawing RETURN to Ocean cards as you go.
9. The player who gets the MOST fish back to the ocean WINS. not the player who gets there first.
10. If you find words on the cards that you do not know. look them up on the Vocabulary List.



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VOCABULARY LIST

bait: fish or other animal used to lure a larger animal into a trap or onto a hook

bluefish: a species of fish larger than herring which are good predators on smaller fish; they follow prey into the estuary and are well-known for their feeding frenzies; are eaten by humans who catch them for sport as well as food

commercial: things that are sold; activity done to earn money or wages

delicacies: expensive, rare, fine

dolphin: a marine mammal in this game sometimes also called a porpoise; there is also a species of fish called dolphin

gill nets: nets which hang from floats in the water and catch fish that try to swim through the holes by tangling their gill covers

haul seine: large net pulled from shore by boat to circle fish school and then towed up on beach with catch; this method is not used much

hors d'oeuvres: French word pronounced or-dervs; bits of food served before a meal

kippers: herring that is salted and then smoked over a fire to preserve it

larvae: form different than adult which hatches from egg and will change into the adult form as its grows

leech: a worm that sucks blood from its prey; a parasite

pesticide: a chemical used to kill insects that humans regard as bad (pests)

plankton: tiny drifting plants and animals that live in water

purse seine: large circluar net used from boat to catch fish; draws shut at bottom

school: a large number of fish that swim together

seine: net with floats at top and weights at bottom used to encircle fish

snag hooks: hooks designed to catch on a fish's body

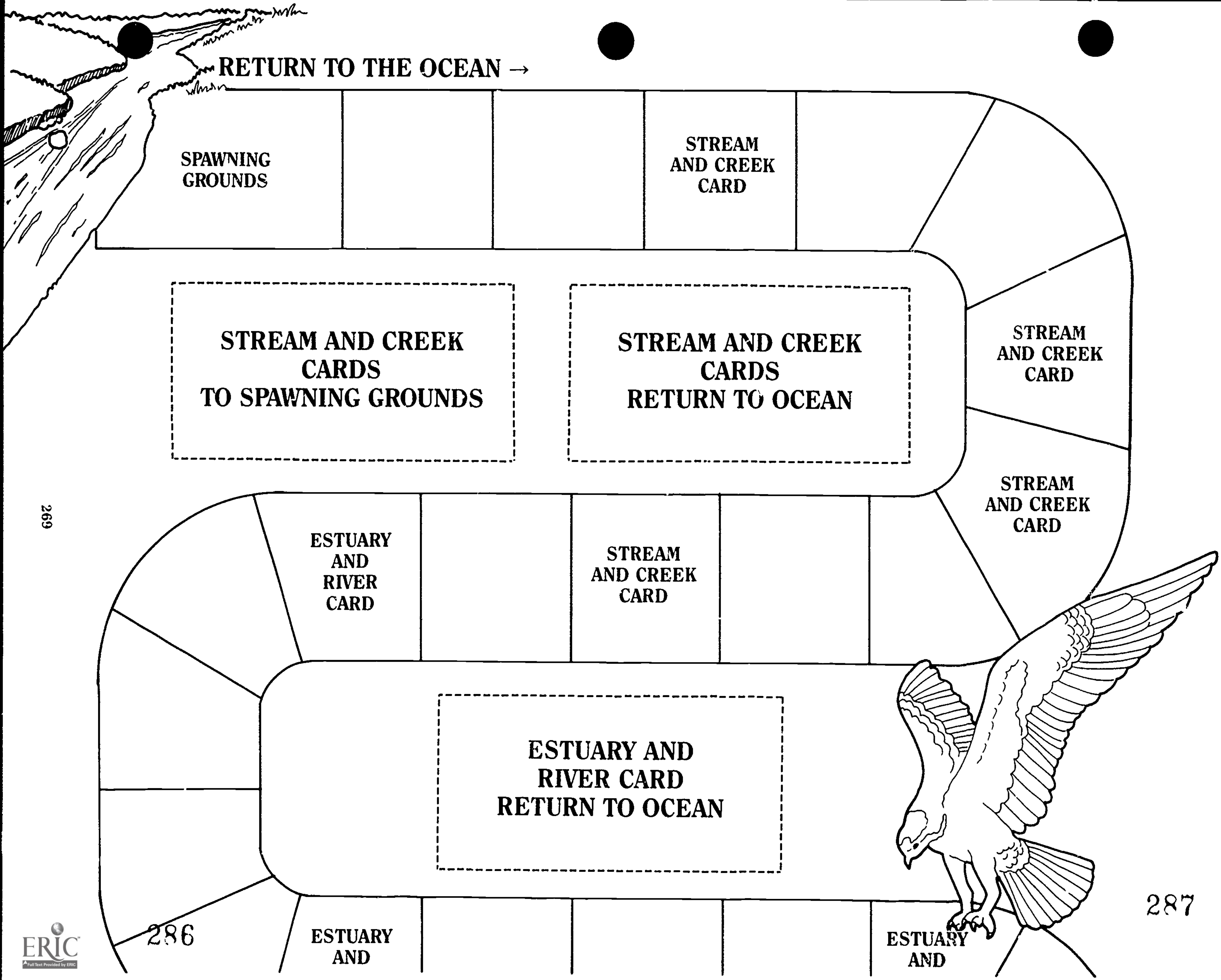
sport: an activity done for fun or excitement that requires skill

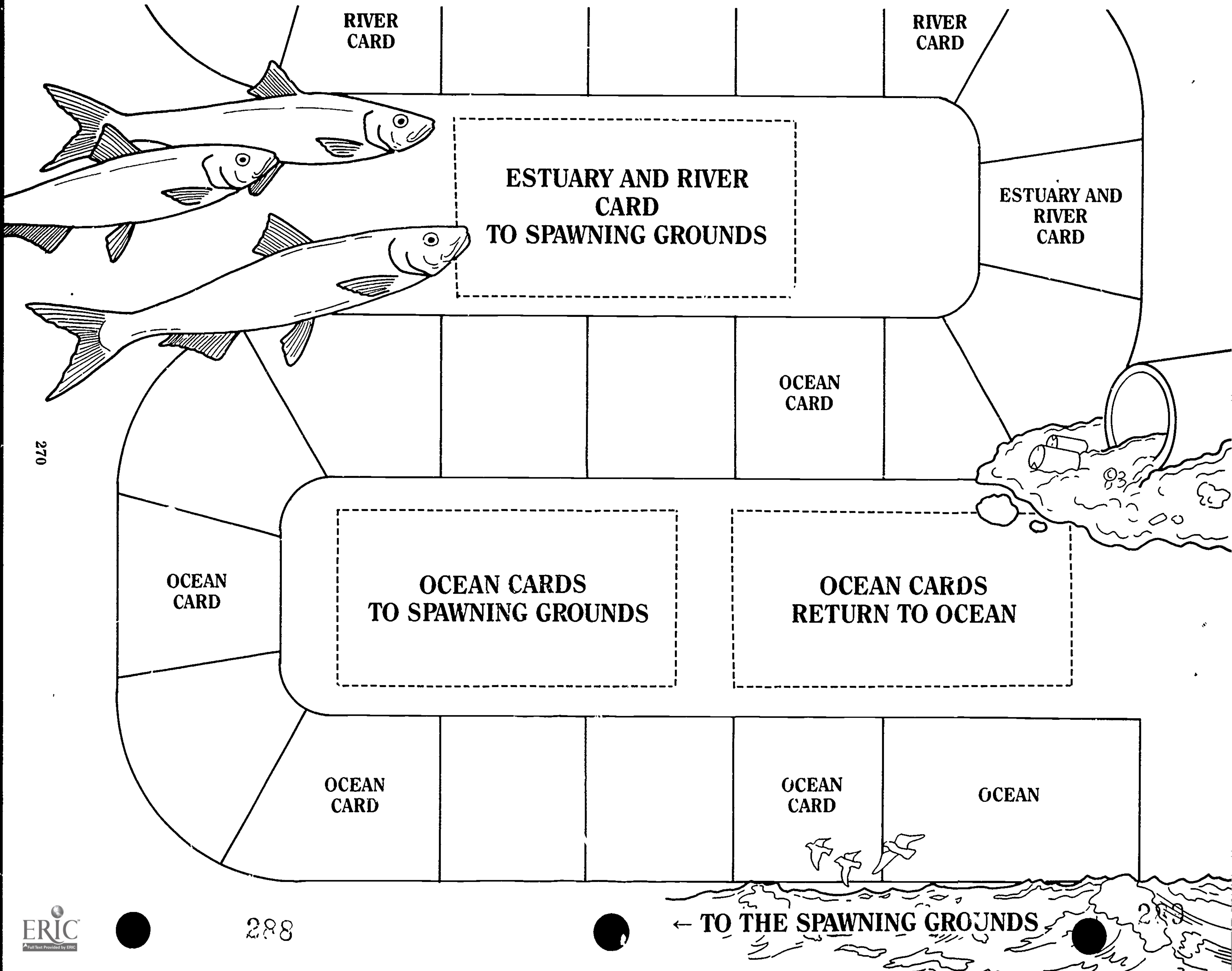
striped bass: large predatory fish; also anadromous and are themselves reduced in numbers in recent years; enter estuaries in search of smaller fish; protected in some areas because of declining numbers

trawl nets: large nets towed behind a boat that scoop fish up

tuna: very big predatory fish that live out in the ocean

weir traps: traps that funnel fish through a narrow space where it is easy to net them from shore by hand


RETURN TO THE OCEAN →
SPAWNING GROUNDS
STREAM AND CREEK CARD
STREAM AND CREEK CARDS TO SPAWNING GROUNDS
STREAM AND CREEK CARDS RETURN TO OCEAN
STREAM AND CREEK CARD
STREAM AND CREEK CARD
ESTUARY AND RIVER CARD
STREAM AND CREEK CARD
ESTUARY AND RIVER CARD RETURN TO OCEAN
ESTUARY AND
ESTUARY AND


RIVER CARD
RIVER CARD
ESTUARY AND RIVER CARD TO SPAWNING GROUNDS
ESTUARY AND RIVER CARD
OCEAN CARD
OCEAN CARD
OCEAN CARDS TO SPAWNING GROUNDS
OCEAN CARDS RETURN TO OCEAN
OCEAN CARD
OCEAN CARD
OCEAN
← TO THE SPAWNING GROUNDS

Ocean to Spawning Grounds
1/2 of your school is caught by commercial fishermen using gill nets. They will be used to make plant fertilizer.

Ocean to Spawning Grounds
1/2 of your school is eaten by a school of hungry dolphins which herd the fish while eating them.

Ocean to Spawning Grounds
1/4 of your school is caught by commercial fishermen using trawl nets. They will be processed into fish meal for chicken feed.

Ocean to Spawning Grounds
1/2 of your school is caught by commercial fishermen using gill nets. They will be made into kippers and canned.

Ocean to Spawning Grounds
1/4 of your school is caught by commercial fishermen using a haul seine. They will be sold for bait for crab and lobster traps and for fish bait.

Ocean to Spawning Grounds
1/2 of your school is caught by commercial fishermen using gill nets. The roe (eggs) from these will be processed and sold as delicacies in Japan.

Ocean to Spawning Grounds
None of your school dies; it has found enough food, has not been caught by predators, and has encountered normal weather.

Ocean to Spawning Grounds
1/2 of your school is caught by commercial fisherman using a purse seine. They will be processed into fish oil for use in paint, medicines and cosmetics.

Ocean to Spawning Grounds
None of your school dies as the weather has been perfect for spawning. Advance one space.

Ocean to Spawning Grounds
1/4 of your school is eaten by a school of striped bass.

OCEAN CARDS
TO SPAWNING GROUNDS

OCEAN CARDS
TO SPAWNING GROUNDS

OCEAN CARDS
TO SPAWNING GROUNDS

OCEAN CARDS
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OCEAN CARDS
TO SPAWNING GROUNDS

OCEAN CARDS
TO SPAWNING GROUNDS

OCEAN CARDS
TO SPAWNING GROUNDS

Ocean to Spawning Grounds
1/4 of your school is eaten by a school of hungry bluefish.

Estuary to Spawning Grounds
1/2 of your school is caught by commercial fishermen using haul seines. They will be made into smoked herring.

Estuary to Spawning Grounds
1/4 of your school is eaten by a large flock of seagulls that caught the school in shallow water.

Estuary to Spawning Grounds
1/2 of your school is caught by commercial fishermen who sell them to an aquarium or zoo for seal food.

Estuary to Spawning Grounds
1/4 of your school dies as it gets pulled into the cooling water intake of a huge electric power plant that does not yet have a screen.

Estuary to Spawning Grounds
1/2 of your school dies as part of the school takes a fork in the river that leads to a dam with no way around.

Estuary to Spawning Grounds
1/4 of your school is eaten by a school of hungry striped bass.

Estuary to Spawning Grounds
1/4 of your school dies in an early spring storm that blows them ashore when they were in shallow water.

Estuary to Spawning Grounds
1/2 of your school is caught by commercial fishermen using gill nets staked out along the shore. They will be made into salt herring.

Estuary to Spawning Grounds
1/4 of your school is caught by sport fishermen lining the banks of a narrow river channel using snag hooks. They will be used for food and bait.

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

OCEAN CARDS
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
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ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

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Estuary to Spawning Grounds
1/4 of your school is eaten by a school of hungry bluefish.

Stream to Spawning Grounds
1/2 of your school dies because your stream was channelized as a flood control project since they were born and left it. Many of the places to spawn have been destroyed.

Estuary to Spawning Grounds
None of your school dies as it has found the conditions for the trip through the estuary and up the river to be excellent. Advance one space.

Stream to Spawning Grounds
1/2 of your school dies after entering a stream that has high pesticides because of runoff from a farm.

Estuary to Spawning Grounds
1/4 of your school is caught by commercial fishermen using weir traps and dip nets in narrow sections of the river. They are sold fresh to a seafood market.

Stream to Spawning Grounds
1/2 of your school dies in very low water because there has been no rain or snow this winter or early spring.

Stream to Spawning Grounds
1/2 of your school dies because improper farming methods have choked the stream with mud.

Stream to Spawning Grounds
None of your school dies as the stream you enter is protected as part of a park. Dams have been removed, sediment is kept from running into the water and fishing is limited. Advance one space.

Stream to Spawning Grounds
1/4 of your school are caught by seagulls which have followed your schools upstream.

Stream to Spawning Grounds
1/2 of your school dies because the forest along the stream was cut and stumps and logs have formed dams which many cannot cross.

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
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STEAM AND CREEK
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TO SPAWNING GROUNDS

ESTUARY AND RIVER
CARD
TO SPAWNING GROUNDS

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

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Stream to Spawning Grounds
1/4 of your school is eaten by predators such as raccoons and river otters.

Stream Return to Ocean
1/2 of your school is eaten by small predatory fish in the stream.

Stream to Spawning Grounds
1/2 of your school is caught by local fishermen with nets and traps in the shallow, narrow creek. They are used for food.

Stream Return to Ocean
1/4 of your school is killed by pesticide runoff from a nearby farm.

Stream to Spawning Grounds
1/2 of your school dies after entering a stream next to a toxic waste dump in which the chemicals have leaked into the ground water that feeds the springs that form the creek.

Stream Return to Ocean
1/2 of your school is killed before it even hatches into larvae when mud from a new housing development smothers the eggs.

Stream to Spawning Grounds
1/4 of your school dies as your stream has been partially blocked temporarily by a highway project.

Stream Return to Ocean
1/2 of your school dies after passing through toxic chemicals leaking into the stream from an illegal waste dump.

Stream to Spawning Grounds
1/4 of your school dies after entering a stream which has an old, leaky sewer pipe running next to it. Parts of the stream are unsafe because of the leakage.

Stream Return to Ocean
1/4 of your school dies after entering a section of the stream where industrial pollutants have been dumped.

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

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STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STEAM AND CREEK
CARDS
TO SPAWNING GROUNDS

Stream Return to Ocean
1/2 of your school dies from chlorine entering the water from a small sewage treatment plant.

Stream Return to Ocean
None of your school dies as the stream where they hatched has been cleaned up and protected by a park.

Stream Return to Ocean
1/2 of your school dies because the food the larvae need is not abundant.

Stream Return to Ocean
1/4 of your school dies after swimming into an area of very hot water where the stream is being used to cool heavy equipment.

Stream Return to Ocean
1/4 of your school is killed during a huge rainstorm as the tiny larvae are tumbled against rocks.

Estuary Return to Ocean
1/2 of your school dies after swimming through an area polluted with industrial wastes that would not have harmed the adults, but are toxic to young.

Stream Return to Ocean
None of your larvae die as the spawning grounds are protected by laws which preserve their natural state. Advance one space.

Estuary Return to Ocean
1/2 of your school dies when it swims into an area where an algal bloom has died, using all the oxygen in the water as the algae decompose.

Stream Return to Ocean
1/4 of your school is left stranded in shallow pools by a passing flood. They cannot get back to the creek and die.

Estuary Return to Ocean
1/4 of your school is eaten by eels, wading birds, water snakes and other natural predators of small fish.

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

STREAM AND CREEK
CARDS
RETURN TO OCEAN

Estuary Return to Ocean
None of your school dies as it has avoided predators, has not been exposed to toxic wastes because laws have helped control wastes, and has found normal food supplies and weather.

Estuary Return to Ocean
1/2 of your school dies after swimming through water polluted with runoff from farms that used all the oxygen in the water as it decomposed in the summer heat.

Estuary Return to Ocean
1/4 of your school dies after swimming into the intake pipe of a steel mill.

Estuary Return to Ocean
1/2 of your school is eaten by gulls and other birds when caught in a shallow area of the river caused by unusually dry weather.

Estuary Return to Ocean
None of your school dies as it manages a safe passage toward the sea. Advance one space.

Estuary Return to Ocean
1/2 of your school is eaten by a large school of hungry bluefish. The rest escape as sport fishermen scare the bluefish away while moving their boats through the school trying to catch the bluefish.

Estuary Return to Ocean
1/4 of your school dies after being attacked by brackish water fish leeches which are parasites that weaken the young herring.

Estuary Return to Ocean
None of your school dies. Advance one space.

Estuary Return to Ocean
1/4 of your school dies from lack of food caused by salinity changes due to unusually dry summer weather.

Ocean Return to Ocean
1/4 of your school is eaten by a large flock of hungry gulls which caught them at the surface where the school went to escape from a bluefish school.

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

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RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

OCEAN CARDS
RETURN TO OCEAN

ESTUARY AND
RIVER CARD
RETURN TO OCEAN

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Ocean Return to Ocean
1/2 of your school is eaten by a hungry school of bluefish.

Ocean Return to Ocean
1/2 of your school dies due to lack of sufficient plankton, the food on which you depend.

Ocean Return to Ocean
1/2 of your school is caught by commercial fishermen to be used for bait.

Ocean Return to Ocean
1/4 of your school dies due to lack of food caused by an unusually dry summer.

Ocean Return to Ocean
1/4 of your school is eaten by striped bass.

Ocean Return to Ocean
None of your school dies as you have escaped predators and gotten plenty of plankton to eat.

Ocean Return to Ocean
None of your school dies as you have escaped predators and found plenty of plankton to eat.

Ocean Return to Ocean
1/4 of your school is eaten by a large school of tuna.

Ocean Return to Ocean
1/2 of your school is taken by commercial fishermen seeking immature fish to make into bite-sized hors d'oeuvres.

Ocean Return to Ocean
None of your school dies as they have found sufficient food and escaped the notice of predators.

OCEAN CARDS
RETURN TO OCEAN

OCEAN CARDS
RETURN TO OCEAN

OCEAN CARDS
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OCEAN CARDS
RETURN TO OCEAN

OCEAN CARDS
RETURN TO OCEAN

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ACTIVITY 17 Name ____________________

A CHANGE IN THE WEATHER

Observe the film carefully, paying particular attention to one animal or plant. When the film is over, write your observations about what the plant or animal is doing during each of the seasons.

The organism I chose to observe in the film is ____________________.
Draw a picture of it here:

This is what it was doing during each season:
Spring: ____________________

Summer: ____________________

Fall: ____________________

Winter: ____________________

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ACTIVITY 18
Name ______________________________

TO EACH ITS HOME

Can you be a word detective? A scientific word often has the definition of the word hidden within it in the ancient languages of Greek or Latin which make up its parts. For example, the word *photosynthesis* may scare you unless you know that *photo* is Greek for light and *synthesis* means put together in Greek. Photosynthesis means put together with light and is a chemical process in which small chemicals are put together to make bigger ones using energy supplied by light. Here is a list of Greek and Latin roots which make up the scientific terms used in the Animal Homes flow chart or key. Parts written with a hyphen (for example: epi-) are prefixes and appear only at the beginning of a word. (Words with Gr are from Greek; those with L are from the language of the ancient Romans called Latin. A few are from old English and have roots in the languages of tribes that invaded England, the Anglo-Saxons. These are AS.)

benthos (benthic): Gr depth of sea or bottom

e-: L out of, from

epi-: Gr upon, on

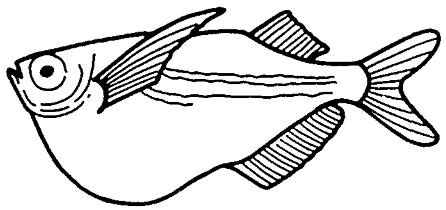
fauna: L groups of animals; Fauna was the sister of the god of agriculture

flora: L groups of plants; Flora was the goddess of flowers

in-: AS same as English word in

merge: L to plunge

mobile: L moves or movable



nekton: Gr swimmer or swimming

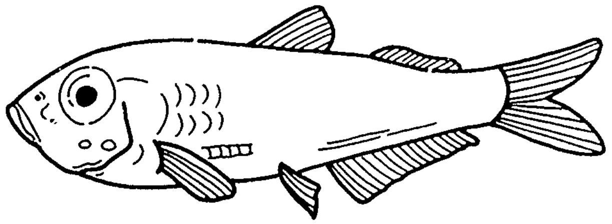
neuston: Gr swimmer or floater

photo-: Gr light

phyto-: Gr plant

plankton: Gr wandering or drifting

sessile: L sitting or sit



sub-: L under

zoo-: Gr animal

3^5

Using these pieces, can you write the words whose definitions appear below?

plants that drift with the currents and waves ______________________

an organism that lives on the surface of the bottom ______________________

an organism that lives attached and does not move is ______________________

an organism that lives under the surface is said to be ______________________

animals that drift with the currents and waves ______________________

animals that swim actively in the water ______________________

Can you think of some other words that use some of these Greek and Latin parts that you use?

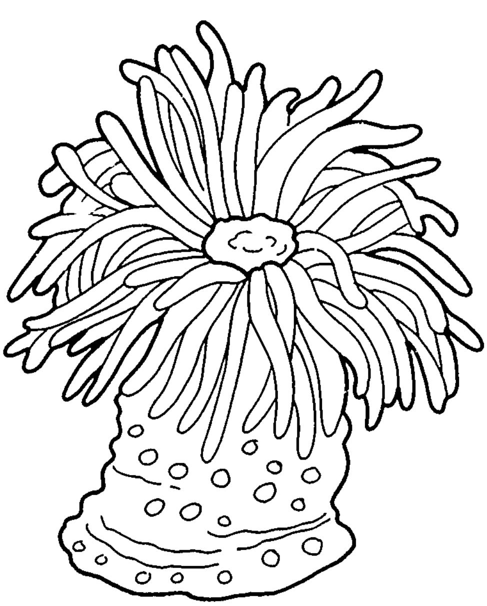
a boat that goes way down under salt water ______________________

a place where wild animals live that you can visit ______________________

using light and film to make a record of a scene ______________________

the things written on a tomb (Greek for tomb is taphos) ______________________

a machine that you yourself can drive ______________________



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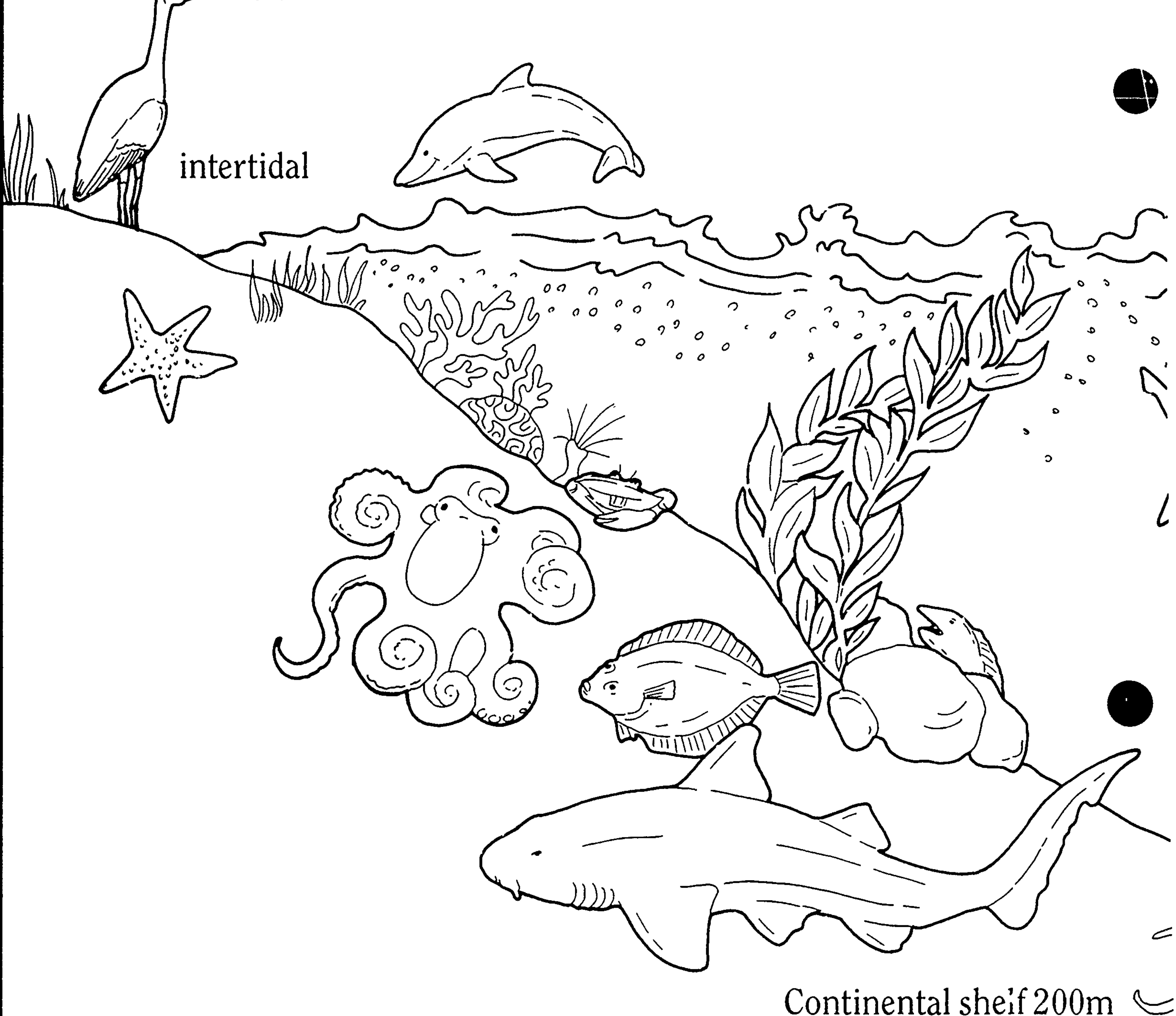
COASTAL



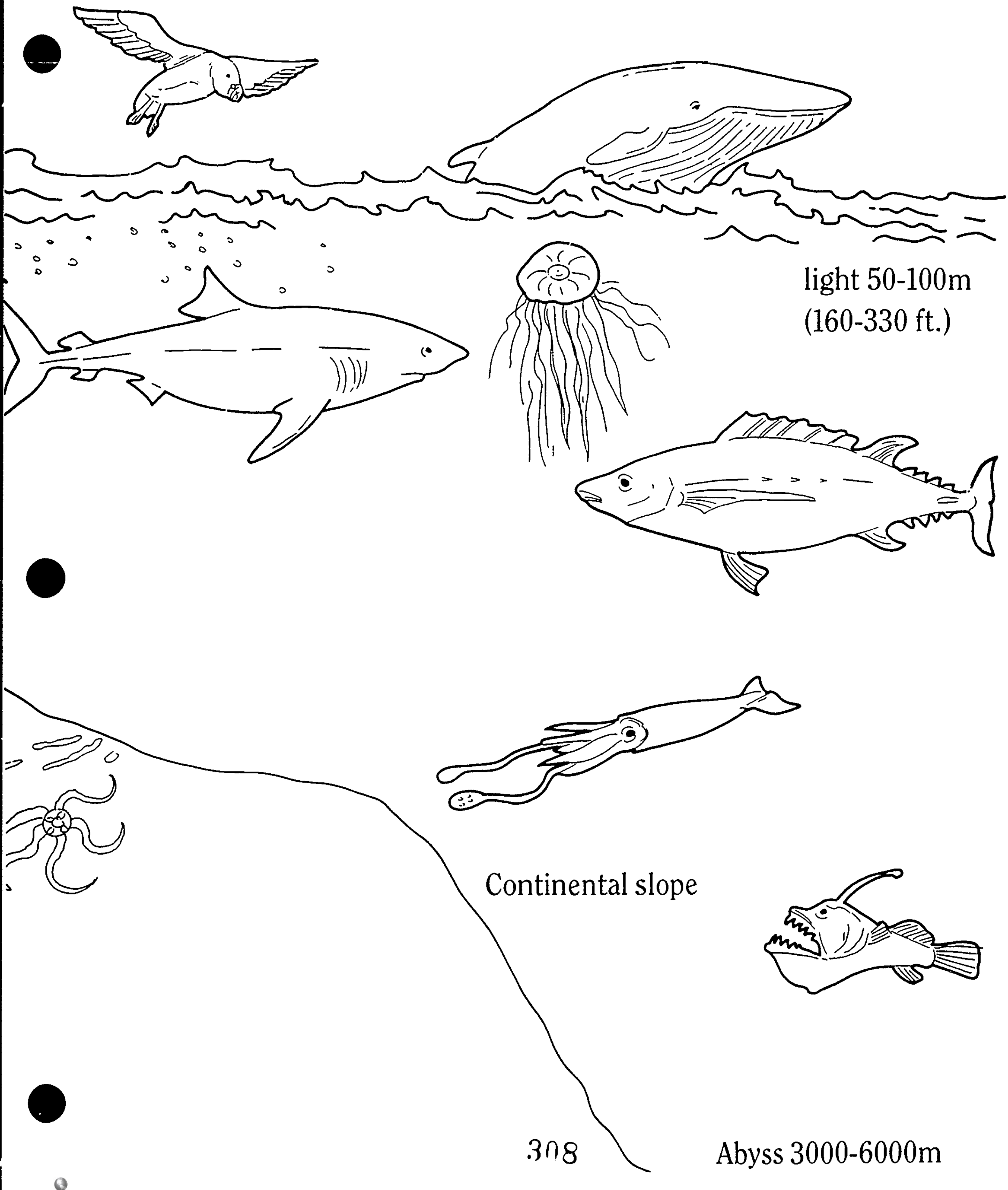
benthic - bottom

nekton - swimming

plankton - drifting

- phytoplankton - plants
- zooplankton - animals

PELAGIC OCEANIC



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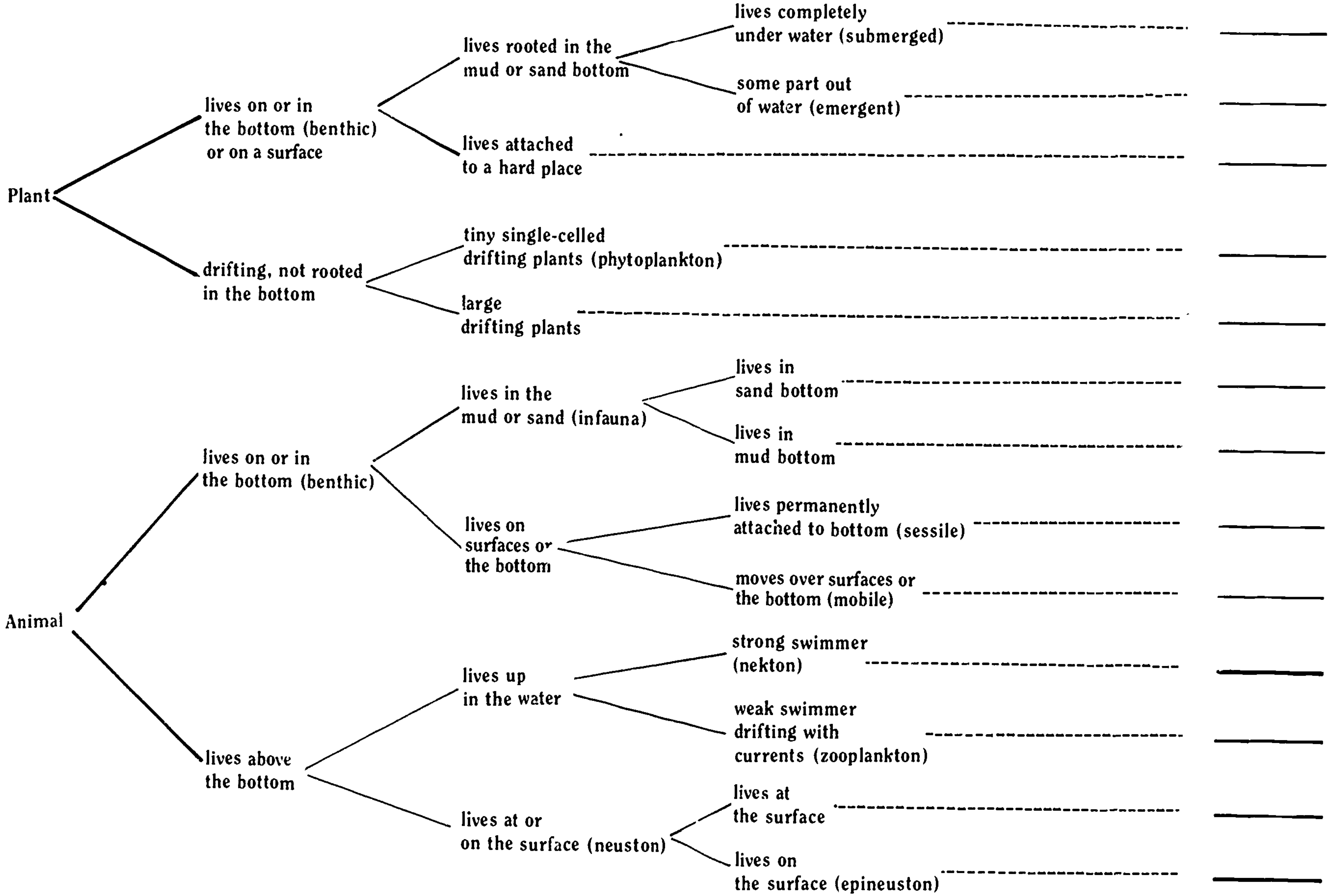
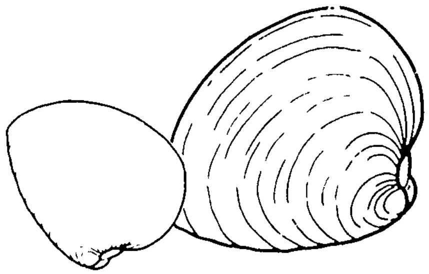
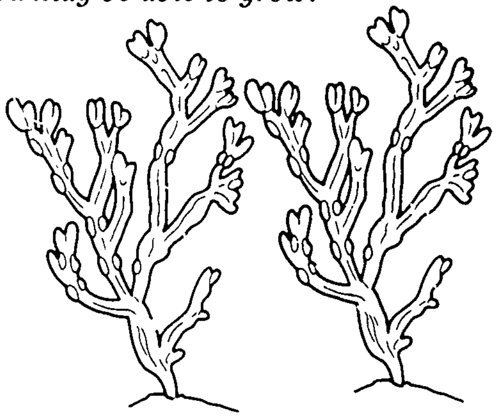

Plant
lives on or in the bottom (benthic) or on a surface
lives rooted in the mud or sand bottom
lives completely under water (submerged)
some part out of water (emergent)
lives attached to a hard place
drifting, not rooted in the bottom
tiny single-celled drifting plants (phytoplankton)
large drifting plants
Animal
lives on or in the bottom (benthic)
lives in the mud or sand (infauna)
lives in sand bottom
lives in mud bottom
lives on surfaces or the bottom
lives permanently attached to bottom (sessile)
moves over surfaces or the bottom (mobile)
lives above the bottom
lives up in the water
strong swimmer (nekton)
weak swimmer drifting with currents (zooplankton)
lives at or on the surface (neuston)
lives at the surface
lives on the surface (epineuston)

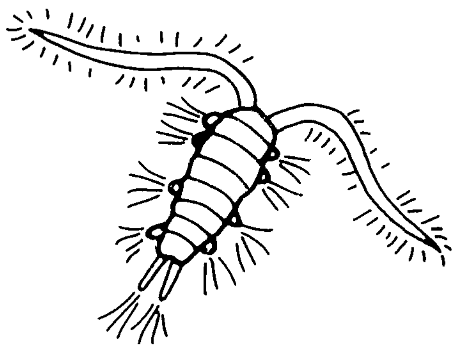
1. You are surrounded by dark mucky mud. Bacteria and fungi are working to decompose (rot) all of the dead animals and plants that sink to the bottom. You have tubes that reach into the water to get oxygen and filter food



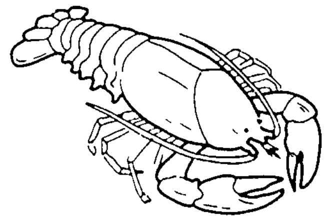
2. You look like green hair waving in the water and feel very slippery. Wherever there is an available space on rocks or logs, where the sunlight reaches through the water, you may be able to grow.

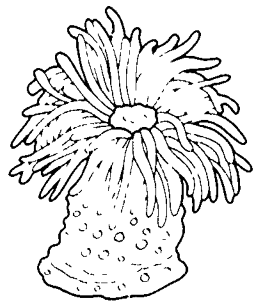


3. You are a very weak swimmer now, but you may grow out of this stage. Or you may spend your whole life in this community, drifting through the water from one meal to the next.

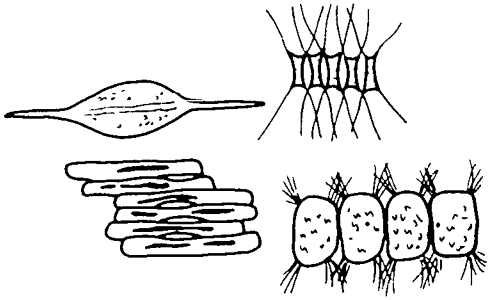


4. You are not speedy. A hard shell, camouflage, stinging cells, or a place to hide may keep you safe as you move along the bottom looking for food. If you were dropped, you might sink like a rock or might swim to hide on the bottom.

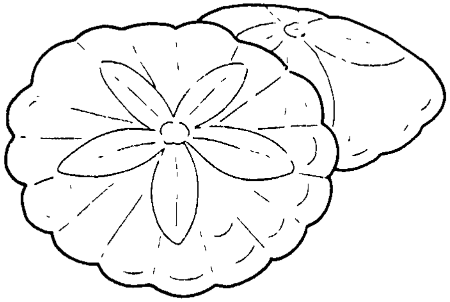




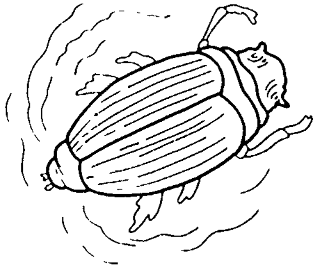
5. *You live in areas where sunlight shines through the water. When water looks very green, it is because of you. You are tiny, but you are not alone. Others like you are also slowly sinking and are an important food source for small animals and filter feeders.*



6. *If you are on a beach, you may get uncovered by waves. You live between the sand grains of your home. Other animals may dig in the sand searching for you as a meal.*



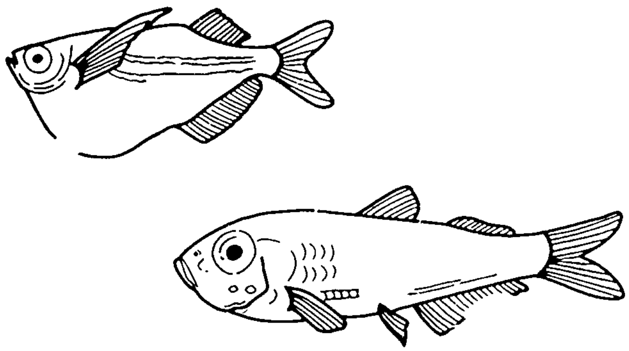
7. *Special structures and body shapes help you to "walk on water." Wherever you step, you make small dimples on the water surface. You look down on things you might eat, but also have to watch out for animals in the air that might eat you.*



8. *Many animals hide in your stalks or swim over the tips of your stems. You must live in shallow or clear water so that sunlight can reach you. You may be green or brown in color or even reddish.*

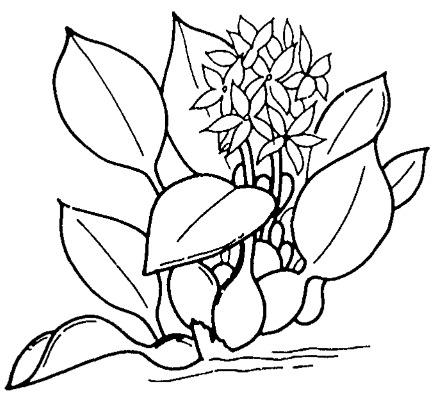
IDENTITY CARDS

9. You swim in the deep. It is too dark to see, so you will have to use another sense. If you spend your whole life here, you may even carry your own "light."

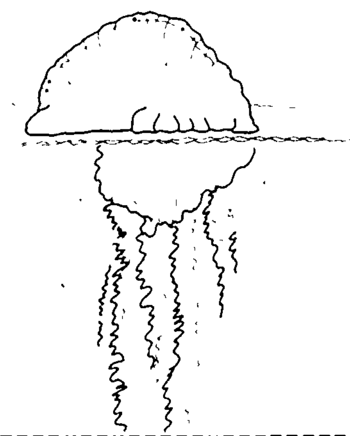


10. Although you cannot swim actively, you are able to rise or sink in the water. Your food is near the surface, but so are animals that might eat you, so you sink in the day to hide in dark waters and make your way up later to feed.

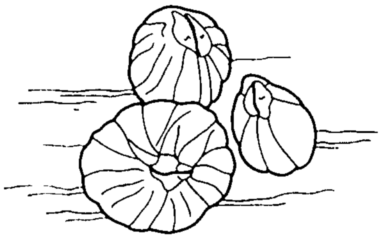
11. Without roots to hold you to the bottom you float wherever the currents or winds move you. Because of this, you often end up in a clump in quiet water, where you use sunlight to grow.



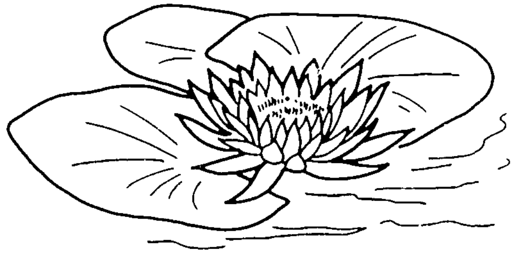
12. Your bubbles of air or oil are lighter than water and help you to stay floating at the surface, where you find food to eat.



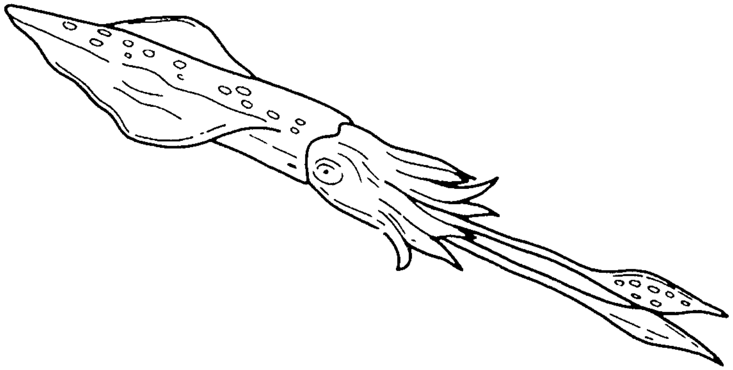
13. You might be found on everything from pier pilings to rocks and coral beds. Wherever you are, you're there to stay and must wait for food to come to you for the rest of your life.



14. Waves or breezes may make your leaves move in the air but your roots in the water help to hold you in place, while your leaves are in sun to grow.



15. You can see the food you eat and can swim after it if it moves. You may live by yourself or travel in schools.

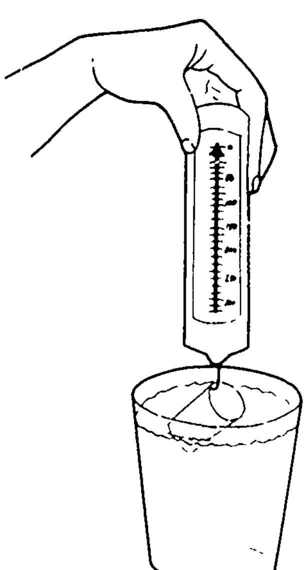


ACTIVITY 19 Name ____________________

KEEPING YOUR HEAD ABOVE WATER

Use this sheet to record each test that you did and the results.

Can you make a general conclusion about things that float based on your tests?



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ACTIVITY 20 Name ______________________________

SINKING SLOWLY

Draw a picture of the model plankton you designed.

If you did not have the slowest sinking model, compare how your model differed from the winner in terms of its shape. How would you change your design to make it sink more slowly?

3̃20

ACTIVITY 21

SINK OR SWIM

Name ______________________________

I. THE OUTSIDE

A. What is your fish's general shape? ______________________________

____

Draw your fish in the space below and label all its fins and other parts as you do this worksheet:

B. Feel the surface of the SKIN. What does it feel like? ______________________

____

The skin is covered with MUCUS which helps protect from disease.

C. Most bony fish have tiny pieces of bone in their skin called SCALES. Scales help waterproof the fish's skin and also help protect the fish. Remove a scale and observe it under the microscope or a hand lens.
Draw the fish's scale:

Does the scale have rings? ______________________________

How many rings can you count? ______________________________

What might the rings tell you? ______________________________

____

D. Is there a line down the side of your fish? ________ Most fish have a LATERAL LINE which senses movement in the water near the fish. Label the lateral line on your diagram if your fish has one that can be seen.

E. Can you find two little holes in front of the eyes? ______ These are called NARES and provide the fish with a sense of smell. Mark them on your drawing.

F. Find and label these FINS in your drawing.

1. The tail fin is called the CAUDAL FIN.

   What do you think is this fin's main use? ______________________

   ____

   A narrow, forked tail means your fish is a constant and pretty fast swimmer. A broad tail gives good power but in short bursts.

   Which is the way your fish swims? ______________________

2. DORSAL FIN(S) are those on the fish's back. In most fish these fins help keep the fish upright in the water, but some fish move their dorsal fins in a s-shaped wave to swim.

   How many dorsal fins does your fish have? ______________________
   Does your fish have spines (hard and sharp) or rays (soft and flexible) in its

   dorsal fins or both? ______________________
   The spines can protect the fish by sticking a predator's mouth.

3. PECTORAL FINS are the pair of fins on either side of the head. Most fish use these for stopping, steering and turning, but some swim with their pectoral fins.

4. PELVIC FINS are the pair of fins on the fish's "chest" or belly. While they may help with steering and balance, in fish that rest on the bottom the pelvic fins may be specialized for crawling or hanging on like a suction cup.

   Does your fish have pelvic fins? ______________________

5. The ANAL FIN is the single fin along the bottom, near the tail. It works like the dorsal fin.

6. How many fins does your fish have altogether? ______________________

7. Do you think all fish have the same number of fins? ______________________

8. Can you think of a type of fish with fewer fins? ______________________

3?2

G. MOUTH

Pick your fish up and take a good look into its mouth. What do you see?

1. Does your fish have a tongue? ____________________
2. Does your fish have teeth? ____________________
3. Where are the teeth located within the mouth? ____________________
4. Given the location of your fish's mouth and the teeth it has, can you make a guess about where it might feed and what it might eat? ____________________
5. Put a stick or pencil into the fish's mouth. Does it come out the side of the fish's head? ____________________

H. GILLS

Lift the flap on the side of the fish's head. Can you see red, feathery looking things? These are the GILLS. They get oxygen from the water and lose carbon dioxide in exchange.

1. The covering over the gills is called the OPERCULUM. What do you think it is for? ____________________
2. Can you guess why the gills are red? ____________________
3. What is the path of water as it moves over the gills? ____________________
4. Do you see GILL RAKERS that keep the food in the fish's mouth? ____________________
5. Can you see where the food goes? ____________________

II. INTERESTING INSIDES

Now that you have studied the outside, it is time to open your fish up! Find the VENT (anus) on the underside of the fish near the tail and carefully insert your scissors into the hole. Make a shallow cut from the vent all the way to the "chin" area of the fish, being careful not to disturb or cut any organs below. Gently pull apart the flaps of skin and muscle to show the organs below.

A. The circulation situation

Cut away the gill cover (OPERCULUM) on one side of the fish's head and carefully remove a section of the gills.

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1. Look at the section of gills. Use a hand lens if you have one. Do you see the feathery GILL FILAMENTS attached to stiff GILL BARS? Label the parts diagram on the last page of this data sheet.
2. Blood in the gill filaments receives oxygen from the water. This oxygen-rich blood is pumped to all of the fish's body by the HEART, a small, dark, slightly triangular organ just below the gills. Label it in the drawing. Unlike your own heart which has four chambers, the fish's heart generally has just two. Blood flows from the heart to the gills and then directly to the body where oxygen is used and carbon dioxide is made. The blood carrying carbon dioxide goes back to the heart.

B. The food factory

There are a number of structures involved in the digestion of food in fish.

1. Behind the heart are several large, reddish organs. They are the LIVER. Find it in your fish and label it on the diagram. It helps in digestion and stores fats and blood sugars.
2. Can you see a small, green-colored section of the liver? The GALL BLADDER also aids digestion.
3. Under these you should be able to find the STOMACH which is connected to the mouth and receives the food, and the INTESTINES where digestion is finished and the food absorbed. They are connected to the vent where solid wastes are eliminated.
4. Take out the stomach and cut it open; look at the contents. Can you tell

   what your fish ate before it was caught? ______________________

   ____

C. Sink or float

Between the stomach and the backbone is a space that may be filled with air, called the SWIM BLADDER. It is fragile and you may have deflated it already. In some fish it is connected to the fish's throat and the fish fills it by swallowing air, but in most it is a sealed sac and the gas comes from the fish's blood.

1. When the swim bladder has more gas, the fish will ______________.

2. When it loses gas, the fish will ______________________.

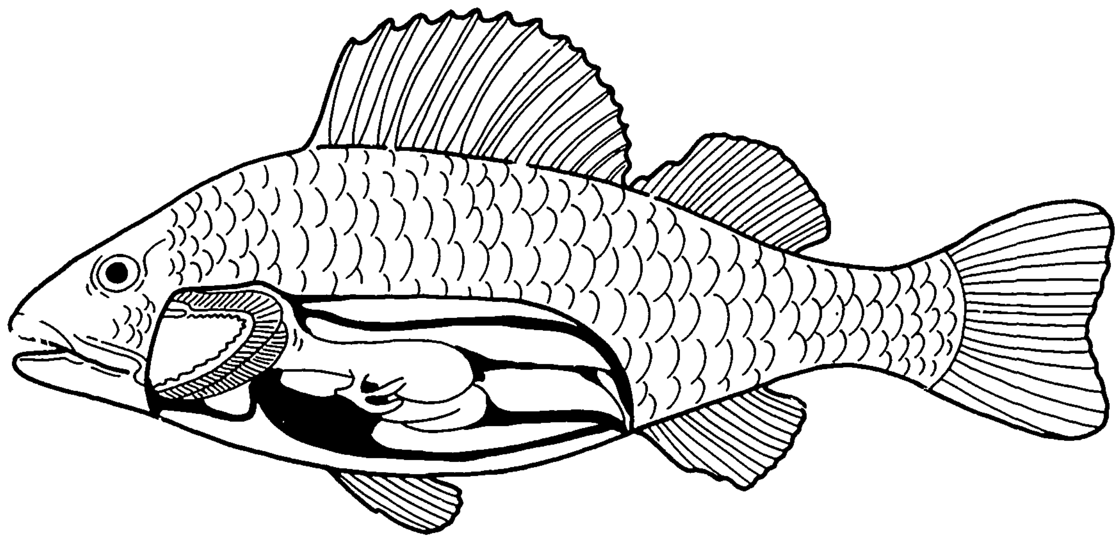
D. Other goodies

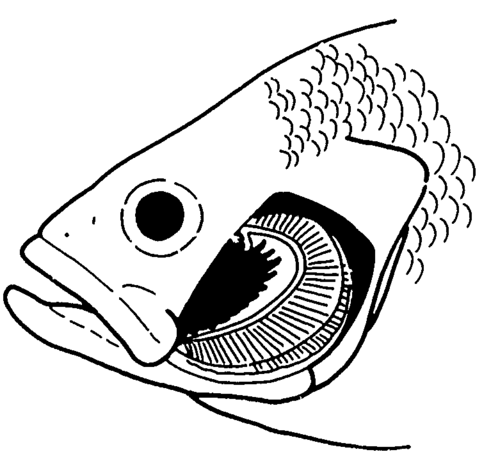
1. Can you find two long string-like organs running along each side of the backbone? They will probably be dark in color and very thin. These are the KIDNEYS; they remove wastes from the blood. They are hard to see.

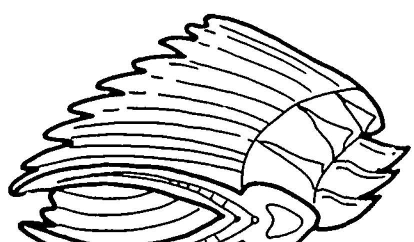
ACTIVITY 21 Name ____________

SINK OR SWIM

Label the internal and external parts of this fish as you go.







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ACTIVITY 22 Name ____________________

GRACE UNDER PRESSURE

What question are you going to answer with this experiment? ____________________

____

____

What size container do you have? ____________________
How far below the water surface was each of your holes?

Top ______________ Middle ______________ Bottom ______________

Did you have large or small nails? ____________________
How far from the base of the container did the water flow from each hole?

Top ______________ Middle ______________ Bottom ______________

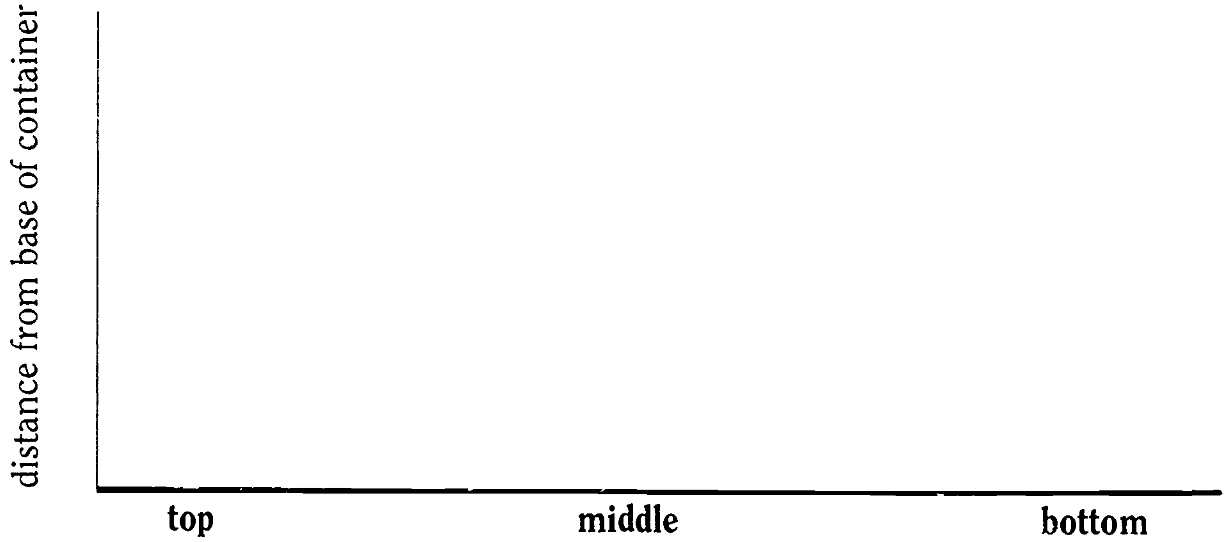
Compare your data with others in the class by filling in this chart. Write the distance from the carton, using the same units for all measurements.

distance from container

hole position	groups								average
	1	2	3	4	5	6	7	8	
top									
middle									
bottom									

3?6

Make a bar graph to compare these results:



What conclusion can you make based on the results of this experiment?

____

____

____

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ACTIVITY 23 Name ____________

LIFE AT THE SURFACE

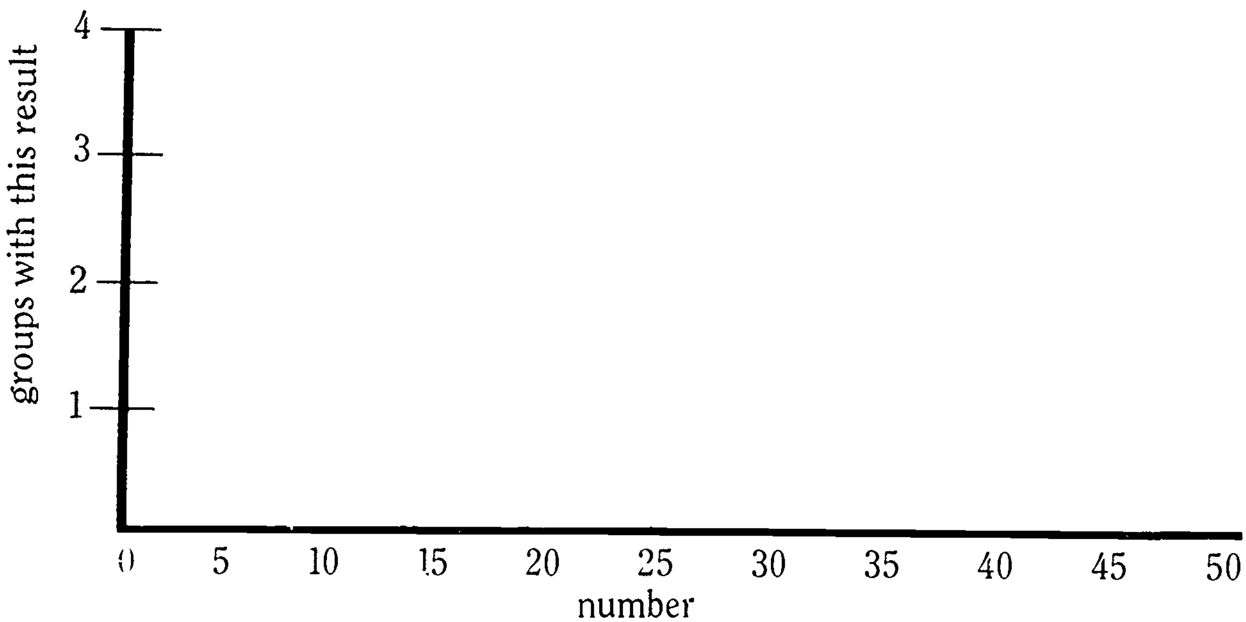
How many objects do you predict that you will be able to add to the glass before the water runs over? ________

How many did you actually add? ________

What happened when you added objects to a full glass of water? ____________

____________ ____________

Plot the number of objects each group added before their water ran over:



What is the average of all these numbers? ________

How did it compare with your estimate? ____________

____

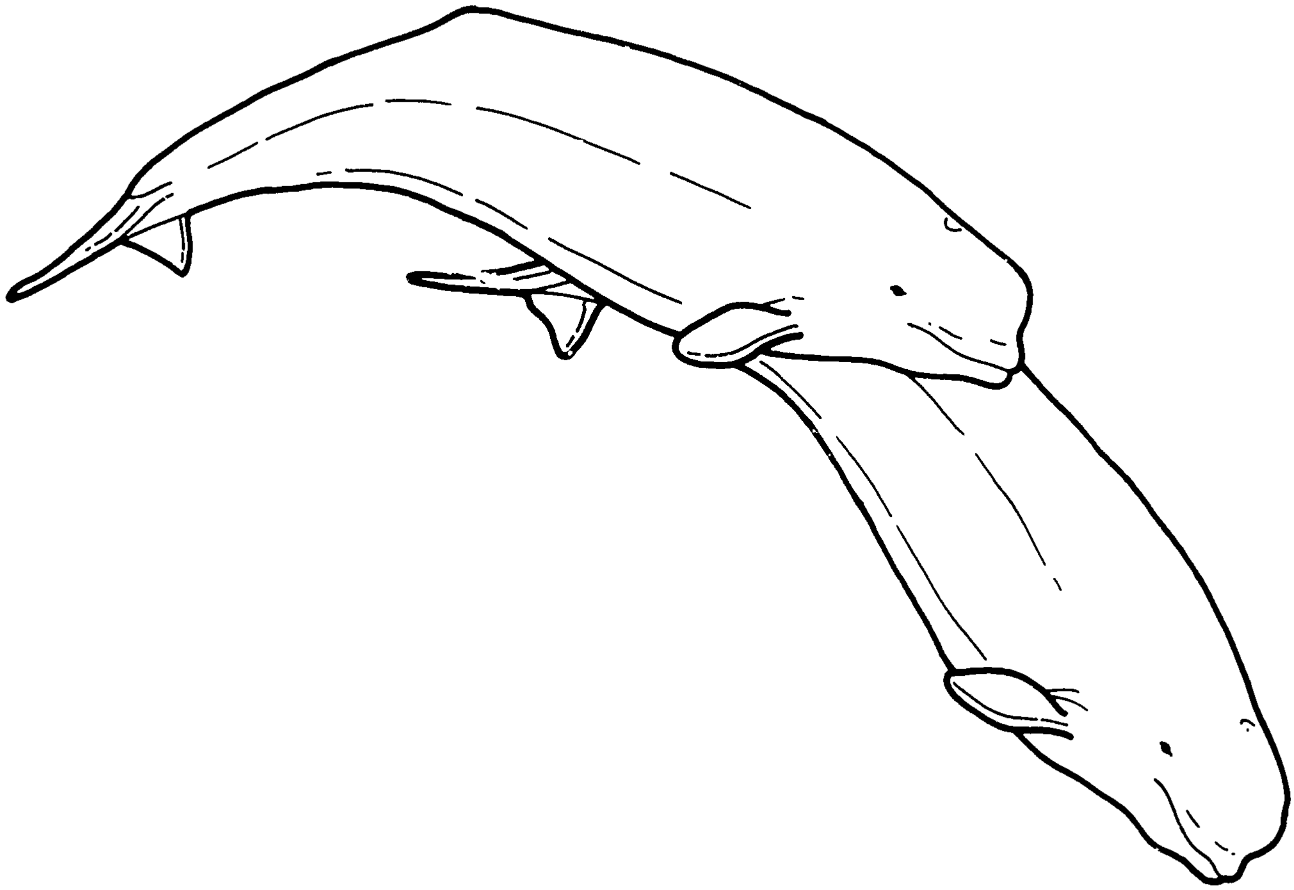
Did you succeed in making the paper clip ride on surface tension? ________

What happened when detergent was added? ____________

____

Draw a picture of your model of an animal that rides on surface tension here. If it did not stay up, what could you change that might make it work better?

____

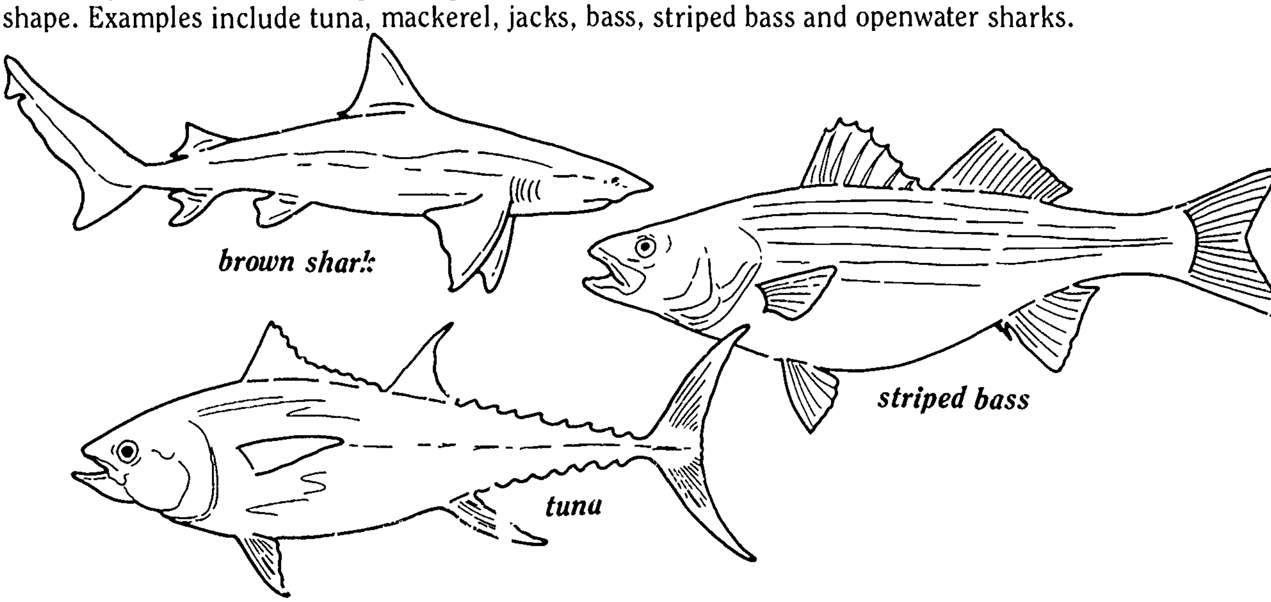


MOVING THROUGH WATER: HOW FISH SWIM

Water is harder to move through than air. It resists movement more. Think of how hard it is to run through water. Fish must deal with this problem. There are many different solutions.

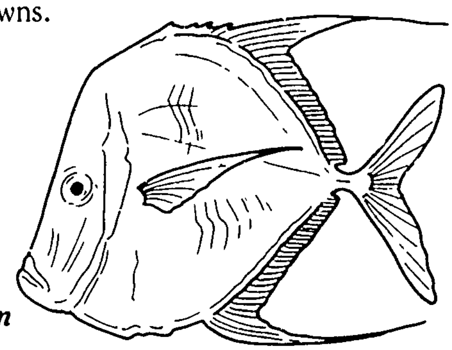
BODY SHAPES

Some body shapes slip through water easily. The FUSIFORM or STREAMLINED body shape is extremely efficient for moving through water. Most free-swimming and fast-moving fish have this shape. Examples include tuna, mackerel, jacks, bass, striped bass and openwater sharks.



LATERALLY COMPRESSED fish are flattened from side to side. They are not as swift as fusiform fish, but still slide through the water well. Many laterally compressed fish live in relatively quiet waters such as ponds, lakes, or coral reefs, or they are schooling fish found in shallow open waters. This body shape, though not as fast as the fusiform shape, is well-designed for maneuvering in dense cover and making short, quick turns. Examples include pumpkinseeds, bluegills, sergeant majors, butterflyfish, triggerfish, pompano, and lookdowns.

The flounder is a laterally compressed fish which rests on the bottom. Both eyes are on one side of its head. One eye migrates to the other side during development.

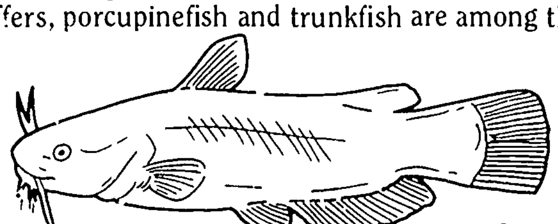


lookdown

Bottom-dwelling fish very often have a **DEPRESSED** body shape such as skates, rays, sculpins, and catfish. They are flattened from top to bottom. As you might imagine from their shape and habitat, these may not be fast swimmers. Losses in swimming efficiency are offset by other protective adaptations such as coloration, and behaviors such as burrowing into the substrate.

Some kinds of fish have square or rounded shapes which force them to swim quite slowly. They generally have very good defenses against predators such as spines or poisons and eat slow moving prey. Puffers, porcupinefish and trunkfish are among these slow swimmers.

catfish



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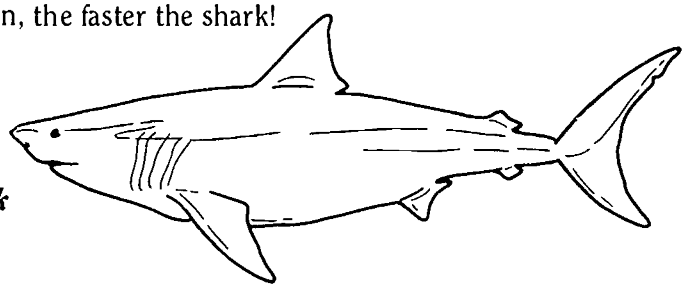
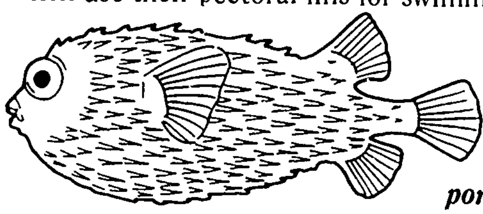
FINS

The **CAUDAL FIN**, or tail fin, is of the greatest importance in most fish for swimming at sustained speeds, and for all fish where bursts of high speed are important. Among bony fish, those with a narrow connection of tail to body tend to swim constantly, while those with a broad base to their tail swim with brief bursts of speed. Sharks generally use their caudal fin for power. The interesting thing is that the size of the shark's second dorsal fin relates to its swimming speed. The smaller the second dorsal fin, the faster the shark!



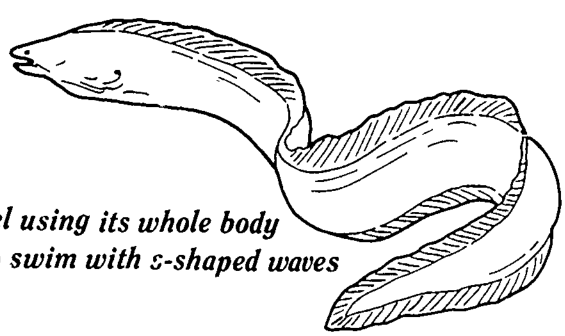
great white shark

The **PECTORAL FINS** and **PELVIC FINS** (each of which are paired), are important for climbing, diving, banking, turning, and stopping in those fish that swim with their caudal fins. Some fish use their pectoral fins for swimming too, paddling their way through the water.

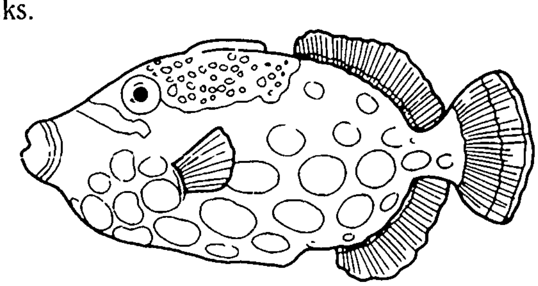


porcupinefish

The **DORSAL FIN** and **ANAL FIN** serve mainly as keels which keep the fish upright in the water. In some fish these fins also are used for swimming. Waves pass down both fins in a s-shape, pushing the fish through the water. Fish that swim this way can go backwards as well as frontwards which means they can easily swim in and out of cracks.

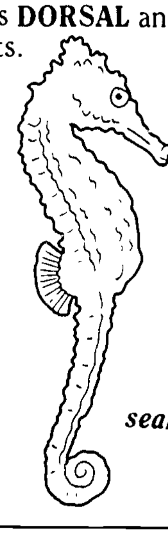


eel using its whole body to swim with s-shaped waves



triggerfish

The seahorse is unusual in that it swims upright, using its **DORSAL** and **PECTORAL FINS.** This slow way of swimming helps the seahorse hide among plants.



seahorse

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ACTIVITY 24
AT THE RACES!

Name ______________________________

Length of the race course is ______________________________.

FISH NUMBER ONE is a ______________________________.

It uses its ______________________________ fin(s) to swim.

Its body shape is ______________________________.

Time it took this fish to swim the race course in seconds:

1. ____________ 2. ____________ 3. ____________

Average speed ______________ (remember this is distance per unit time)

FISH NUMBER TWO is a ______________________________.

It uses its ______________________________ fin(s) to swim.

Its body shape is ______________________________.

Time it took this fish to swim the race course in seconds:

1. ____________ 2. ____________ 3. ____________

Average speed ______________ (remember this is distance per unit time)

What body shape and swimming method did the fastest fish in the class use?

____

____

____

What was the shape and swimming method of the slowest fish anyone found?

____

____

____

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ACTIVITY 27 Name ____________________

A LIGHT SNACK

What question might you answer by doing this experiment? ____________________

____

____

Record your results here:

	dissolved oxygen at beginning in ppm	dissolved oxygen after 24 hr in ppm	difference
low light			
high light			

Average the differences from all of the high light samples and low light samples for the class. The averages are:

High light: ________ ppm

Low light: ________ ppm

Based on these results, what statement can you make about the importance of light in producing oxygen during photosynthesis?

____

____

____

____

If you were an aquatic plant, where would you want to live and why?

____

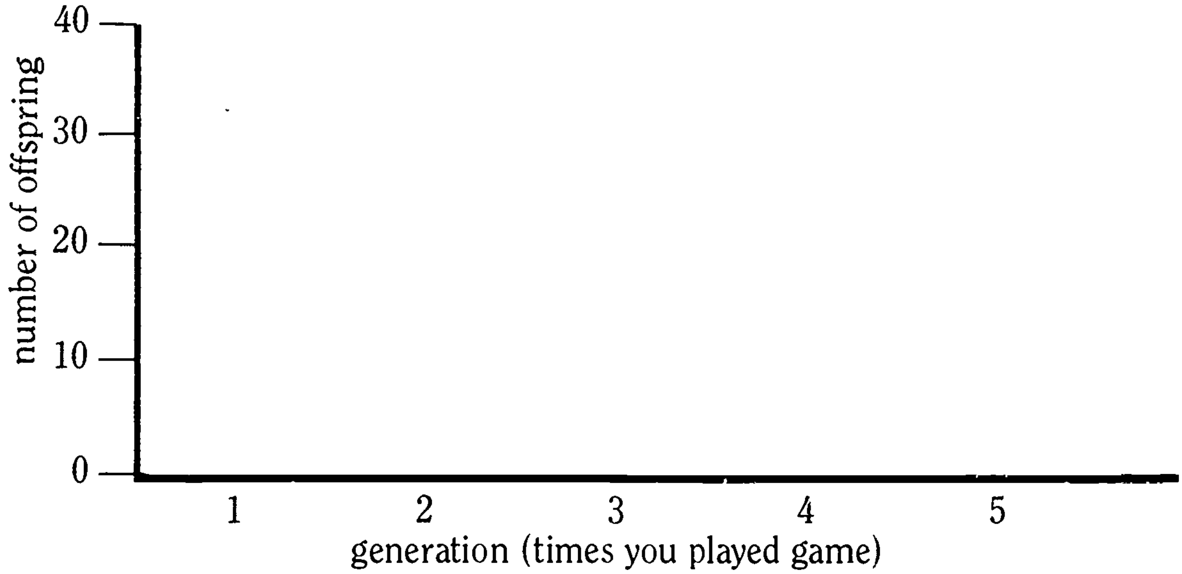
____

____

ACTIVITY 28
COMPETING FOR FOOD

Name ______ ______

Graph the number of zooplankton offspring you got each time you repeated the game.



Calculate the average number of offspring in the population by adding the numbers from each generation together and then dividing by the number of generations you had.

The average number of offspring was ________.

Draw a line across the graph to show the average. How do the actual numbers compare to the average?

______

______

______

What change could you make in the game that would make the number of offspring go up?

______

______

______

DATA SHEET FOR ACTIVITY 28

Generation number ________

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
_____	fewer than 9	none	0
_____	9, 10 or 11	1	_____
_____	12 or 13	2	_____
_____	more than 13	3	_____
Number of parents _____ number of offspring in next generation _____			

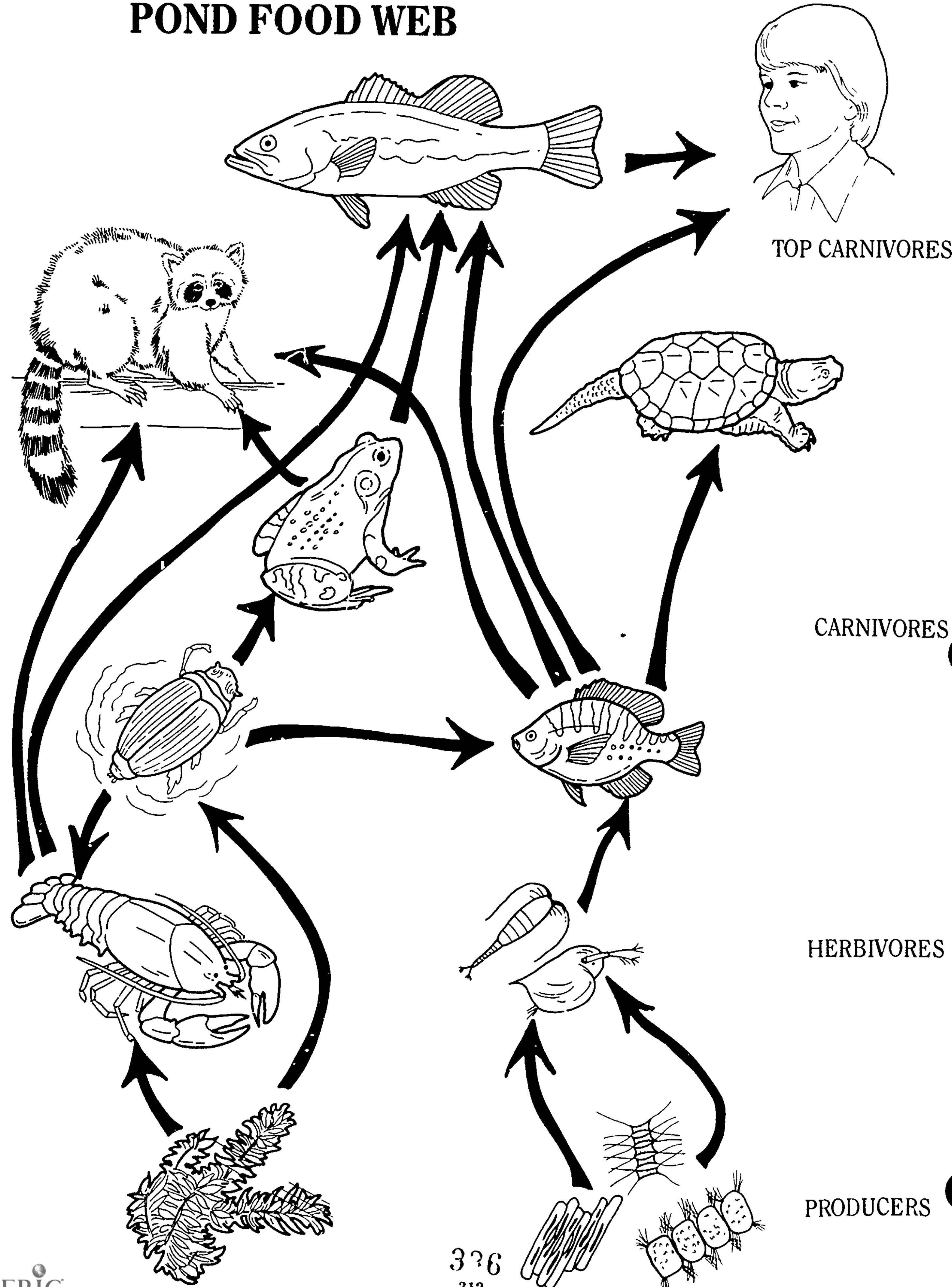
Generation number ________

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
_____	fewer than 9	none	0
_____	9, 10 or 11	1	_____
_____	12 or 13	2	_____
_____	more than 13	3	_____
Number of parents _____ number of offspring in next generation _____			

Generation number ________

adults getting this number	number of food items captured	number of offspring each has	total offspring these have
_____	fewer than 9	none	0
_____	9, 10 or 11	1	_____
_____	12 or 13	2	_____
_____	more than 13	3	_____
Number of parents _____ number of offspring in next generation _____			

POND FOOD WEB



DATA SHEET FOR ACTIVITIES 29 AND 30

First run

feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores				
carnivores				
top carnivores				

results ______________________________

Second run

feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores				
carnivores				
top carnivores				

results ______________________________

Third run

feeding level	no. live at beginning	no. eaten	no. that starved	no. alive at end
herbivores				
carnivores				
top carnivores				

results ______________________________

DATA SHEET FOR ACTIVITY 31

Name ____________

Write depth (in cm) next to position where lines cross.