January 1985

Water education grades K-6

Donald R. Daugs
C. Earl Israelsen

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WATER EDUCATION

GRADES K-6

INTERNATIONAL OFFICE FOR WATER EDUCATION
WATER EDUCATION

Grades K - 6

by

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For Water Education

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Revised February 1986
Acknowledgments

This work was made possible by funding provided by the Utah Division of Water Resources and Utah State University. Art work was done by Marianna C. (Nancy) Israelsen. The book is dedicated to the teachers of youth everywhere in the hope it will help shape informed decision making ability of citizens in the years to come.

The materials were reviewed and field tested by over 100 Utah teachers and students in the Utah State University teacher preparation program. Their suggestions and comments were most valuable. Materials were also reviewed by the following members of the Utah Water Education Committee:

Paul Summers, Assistant Director, Utah Division of Water Resources
Clark Ogden, Division Meteorologist, Utah Division of Water Resources
Kathy Loveless, Regional Public Affairs Officer, U.S. Dept. of Interior, Bureau of Reclamation
Jack Barnett, Executive Director, Water and Man, Inc.
Ed Dalton, President, National Energy Foundation
Eldon Laird, Central Utah Water Conservancy District

Virginia Jensen also reviewed the draft manuscript and made numerous suggestions for its improvement throughout the course of its development. She participated previously in the development of teaching materials for Water and Man, Inc.

Special thanks are extended to Frank Haws, Utah Water Research Laboratory, for detailed and critical review of materials, and to Douglas James, Director, Utah Water Research Laboratory, and Dean Oral Ballam, College of Education, for promoting the conditions under which such works can be undertaken.

For additional information on water education contact:

International Office for Water Education
UMC 82
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Logan, UT 84322
Conceptual Framework

The conceptual framework lists the major goals and objectives upon which the content and activities of this book have been based. They served as an organizer for the authors and may be of value to the user to identify areas of interest.

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Topic 3.1 Water is essential to human activities. (pp. 105 to 127)

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3.11 different water uses require different water qualities and quantities.

Topic 3.2 Wise utilization of water is dependent on many factors. (pp. 129 to 146)

3.21 water use decisions affect lifestyles, quality of life, and standard of living.
Preface

Water Activities for Elementary Children is based upon the assumption that children learn best by doing. In education, and especially in science, talking is not necessarily teaching. The most desirable types of learning involve direct, first hand experience, not just a teacher's interpretation of these experiences.

This set of learning experiences has been designed for teachers, teachers-in-training, and children. Each concept includes background information for the teacher and learning activities for children. Lessons are designed so that a teacher can successfully teach a unit or lesson with a minimum of knowledge, preparation, and equipment. Most of the suggested materials are common, inexpensive items that can be easily obtained. Activities include student experiments, teacher demonstrations, reference study, and field experiences. Extension activities are designed to enrich each basic lesson.

What is Water Education?

Public understanding of water, water management, and water related issues is basic to solving present and future water problems. Unfortunately, most people are only vaguely aware of the role water plays in their lives.

The long term challenge is to make people water literate, to educate citizens with respect to the problems and complexities of monitoring both ecologically and economically sound people-water interactions. The authors assume that such understandings have simple "background" beginnings. For a child, these beginnings constitute playing with water. For an adult, these beginnings consist of awareness of people-water relationships in the immediate environment.

Water literacy includes the following components:

1. Comprehension: An individual should know some of the facts about water, have an understanding of water-related concepts, and be able to express them in oral and/or written form.

2. Attitudes: An individual must have the ability and willingness to develop responsible and realistic attitudes based on what has been learned about water.

3. Skills: The ability and willingness to act in direct response to what has been learned about water, to use the skills of observation, inference, classification, and problem solving in laboratory or real life situations, and to handle and use available equipment effectively.

Water is a great excuse to do some fun and exciting things!
The activities in this manual will help students develop a scientific attitude. Children can begin to learn cause and effect relationships, increase their natural curiosity, suspend judgment, develop a desire to search for answers, and approach problems with an open mind.
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CASTOR SAYS

"BE WATER LITERATE!"

*"Castor" is the genus name for Beaver.
Objective: The learner should understand that:

1.1 Water is a naturally occurring substance with observable physical and chemical properties.
The Water Molecule

Chemically, each water molecule is composed of two atoms of hydrogen and one atom of oxygen. At normal temperatures hydrogen occurs as a very reactive gas. This means it will combine chemically with other elements. Hydrogen is explosive and can be used as a fuel. Oxygen is by far the most abundant element in the earth's crust. Free oxygen occurs as $O_2$ molecules in the atmosphere. Oxygen also combines chemically with many other elements. When cooled to $-183^\circ C$, oxygen condenses and becomes a liquid, and at $-219^\circ C$ it becomes a bluish-white solid.

The atomic weight of an element is the average weight of an atom of that element. Hydrogen has an atomic weight of 1, and oxygen has an atomic weight of 16.

Atomic number is the number of protons in the nucleus of an atom of a given element, and therefore also the number of electrons normally surrounding the nucleus. The atomic number of hydrogen is 1, and oxygen has an atomic number of 8. We could picture the nuclei of hydrogen and oxygen as:

$H^+$
$O^{8+}$

$+$ is the symbol for proton
$N$ is the symbol for neutron

Figure 1. Life as we know it could not exist without water.

Figure 2. Hydrogen and oxygen nuclei
Atom nuclei are surrounded by electrons. It is the electron structure of an atom that determines major chemical properties. Normally, the number of electrons in an atom equals the number of protons. The models for hydrogen and oxygen could be pictured:

Electrons exist in energy level rings resembling planetary orbits. The closest ring to the nucleus may contain up to two electrons. The second ring may hold up to eight electrons. From the models above it can be observed that hydrogen is short one electron in its first ring and oxygen is short two electrons in its outer ring in order to give these rings their full complements of electrons.

If one oxygen and two hydrogen atoms come close together and react, the oxygen will tend to fill its outer ring by utilizing hydrogen electrons. The atoms then share the electrons giving the water molecule remarkable stability. Large amounts of energy are released when water is formed from hydrogen and oxygen. In forming a gallon of water, enough energy is released to keep a 100 watt light bulb lit for 167 hours.

Water is an oxide. Oxides are chemical compounds that are composed of oxygen bonded to one or more other elements. In a water molecule the two hydrogen atoms bond to an oxygen atom at an angle of 104°. This bonding is determined by the interactions of the electrons in the rings. The atoms in a water molecule are held together by sharing the electrons.

Density refers to how close the molecules are packed together. Maximum packing occurs at about 4°C. Most materials contract as they cool and expand when heated. For water, this is only true down to 4°C.
From 4°C to 0°C water expands. Frozen water is less dense than liquid water. If this were not so, ice would sink to the bottoms of rivers and lakes and they would freeze solid.

The way in which the oxygen and hydrogen atoms share electrons causes water molecules to exhibit polarity. That is, the hydrogen ends of a molecule have a plus electrical charge and the oxygen end a minus electrical charge.

This causes water molecules to be mutually attractive. This molecular attraction is the property that produces many of the unusual characteristics of water, such as cohesion and adhesion.

All particles of matter, whether solid or liquid, exert an attractive force upon each other. This force is directly proportional to the product of their masses and inversely proportional to the square of the distance between their mass centers.

Quite distinct from such mass attraction is an electrochemical force known as molecular attraction. This attraction gives rise to the liquid properties of cohesion and adhesion. As shown in Figure 6, a molecule at point A, a short distance from the surface, will be attracted equally in all directions, but a molecule at point B, on the surface, will have a smaller force exerted by the fewer molecules near the surface. This difference in forces in effect "compresses" the water surface and produces a condition called surface tension. Some insects depend on this property to travel on the surface of water.
Water also has the ability to flow uphill. This property, called capillary action, contributes greatly to movement of liquids in plants. Capillary action results when water molecules respond to substances that attract them. For instance, in a small-diameter glass tube inserted in water, molecules at the surface are attracted to the glass. As they are pulled up, they also pull along other water molecules from below, and rise above the surface of the water.

Solutions and Suspensions

Water is the most common solvent in both nature and the laboratory. Energy is required to break up bonding before a material can dissolve in water.

Material dissolved in a solvent is called a solute and the resulting material a solution. When solids or gases are dissolved in a liquid, the liquid is always considered the solvent. Thus, when sugar is stirred into water, the water is the solvent. The resulting sugar solution is a homogeneous mixture. The concentration of sugar can increase until the solution becomes saturated. Saturation refers to the conditions in which no more of a solute will dissolve in a solvent. Generally the higher the temperature of the solvent, the more material dissolves. A few liquids will dissolve in each other in any proportion. For example, any amount of alcohol and water will dissolve in each other. Gases will also dissolve in water. Solubilities of gases decrease as the temperature increases. Thus, the Arctic Ocean teems with aquatic life due in part to the fact that the cold water contains larger amounts of dissolved oxygen than are found in tropical waters.

The term alkalinity refers to the content of carbonates, bicarbonates, and a few other chemicals that may be dissolved in water. Hard water is caused by the presence of calcium ions (Ca++) and magnesium ions (Mg++). Ions are electrically charged particles. Hardness limits the lathering or foaming ability of soaps and increases the tendency of a water sample to produce scale in pipes, heaters, and boilers. Other ions may also cause hardness (e.g. Sr++, Mn++, Fe+++) but they usually are not present in large amounts in most water supplies. These ions enter water as it comes in contact with soil, rock, industrial waste, and sewage.

Water hardness may be of two types: temporary or carbonate hardness, and permanent or noncarbonate hardness. Temporary hardness can be removed by boiling the water. This causes calcium carbonate to form. We see this as scale on the bottom of pans used for boiling water.

The Ca++ ions can also be precipitated out of the water by adding washing soda. Added carbonate ions, CO3-- , react with Ca++ to form soluable calcium carbonate.

Hard water impurities can also be removed by using chemical water softeners. Water softeners are large molecule exchangers. Ionic exchangers remove calcium and other divalent ions like magnesium from water.
and replace them with sodium ions. The sodium ions do not influence the lathering ability of soap. Thus, hardness of water can be removed by running hard water over an ion exchanger. Ionic exchangers must be recharged by allowing them to be in contact with a brine solution in which the sodium ion replaces the unwanted ions from the water being softened. The sodium ions are supplied by common table salt.

Dissolved material can also be removed from water by distillation. Distillation is the process of vaporizing water and then condensing the resulting water vapor. This process leaves the dissolved solids behind.

Acidity

Water molecules tend to dissociate to form ions. This reaction can be written:

\[ \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \]

The double arrow indicates that in pure water there is a balanced reaction and that H\(^+\) and OH\(^-\) ions occur in equal concentration. The concentration of H\(^+\) ions determines the acidity of the water. The pH of water is an indication of the concentration of the H\(^+\) ion. Acids all contain hydrogen ions and when dissolved in water taste sour, turn blue litmus paper red, and release carbon dioxide from carbonates.

Bases are compounds of a metal with oxygen and hydrogen. In water solution they turn red litmus blue, have a bitter taste, and feel soapy. When an acid and a base react together, they form a salt.

In water, only 1 gram in 10,000,000 liters ionizes. Since acids yield H\(^+\) ions and bases yield OH\(^-\) ions when dissolved in water, water itself could be classed as neither an acid nor a base since there is an equal distribution of H\(^+\) and OH\(^-\) ions. Pure water is therefore said to be neutral. Adding an acid to water increases the H\(^+\) concentration and adding a base increases the OH\(^-\) concentrations. The relative acidity or basicity of the solution can be measured then by determining the relative number of either H\(^+\) ions or OH\(^-\) ions in a liter of water. The most commonly accepted method is to measure the H\(^+\) ion concentration and express it as the logarithm of the number of liters of water which must be taken in order to contain 1 gram of hydrogen ions. Since the log of 10,000,000 is 7 the relative acidity-basicity or pH of water is 7. A pH of 4 would indicate 10,000 liters of water per gram of H\(^+\), an acid. A pH of 9 would indicate 1,000,000,000 liters of water per gram H\(^+\), which is a base. Remember that the pH values are logarithmic. A solution having a pH of 6.0 contains 10 times as many H ions as one having a pH of 7.0, and a solution with a pH of 5.0 contains 100 times as many H ions as a solution with pH of 7.0.
The physical properties of water are used to define a number of constants and units. The freezing point of water saturated with air at one atmosphere of pressure is set at 0°C and the boiling point at 100°C. Volume in the metric system is chosen such that 1 ml of water at 3.98°C (maximum density) weighs 1.00000 grams. A similar relationship applies to the English system. One cubic foot of water weighs 1,000 ounces. The energy units, calorie and BTU, have similar relationships.

Water has a high specific heat. Specific heat is the quantity of heat needed to raise the temperature of a unit mass of a material by one degree. Water has a specific heat of 1.0, i.e., it takes one calorie to raise one gram of water one degree Celsius. The same mass of gold only requires 0.13 calorie to raise its temperature one degree. The high heat capacity of water acts as a climate moderator in the vicinity of large bodies of water. Such bodies act as reservoirs of heat.

Ordinarily, when a body is heated its temperature rises. However, this is not true when it changes state. No matter how rapidly water is boiled, the temperature remains the same. The added heat is used to change water to water vapor. It takes 540 calories to change one gram of water to water vapor. When water vapor condenses to form water, it gives up an equal amount of energy. It takes 90 calories to change one gram of ice to liquid water.

Pressure is force per unit area such as pounds per square inch or pounds per square foot. In a fluid, such as water, the pressure is determined by the density or specific weight of the fluid and the height of the column of fluid vertically above the unit area. Since water weighs 62.4 pounds per cubic foot, a column of water 1 foot high would exert 62.4 pounds per square foot. Or in more common terms, a column of water 1 inch square and 1 foot high would exert \((62.4/144) \times 1 = 0.433\)
pound per square inch (psi). The water behind a dam 230.8 feet high would exert 100 pounds per square inch of pressure horizontally against the bottom of the dam and vertically against the bottom of the reservoir. Pressure is exerted equally in all directions. Water pressure is independent of the shape of the container and the total volume of water.
Activities

WATER, SAND, AND MUD

Objective: To investigate the influence of water on soil and sand.

Vocabulary:
- soak
- particle size
- adhere

Materials:
- dry sand
- dry soil
- water
- soda straws
- pie pans
- various water containers
- plastic dropcloth
- towels

Grade Level: K-1
Subject: Science
Art
Time: 45 minutes

Procedures:
1. Distribute pie pans containing dry soil and dry sand. Let children experience the feel of each.

2. Provide water that can be stirred into the soil and sand samples. Allow children to experiment with substances. Suggest that they use soda straws to poke in the samples. Share findings. Discuss reasons for differences between the two materials.

3. Use chalkboard to list comparisons.

Extensions:
1. Set up a playground wading pool for mud and sand experiments.

2. Experiment with adding water to various kitchen materials such as flour, salt, sugar, and corn starch.

3. Mix water with corn starch until it feels dry to the touch when in the pan, but runs when picked up. Add various food colors to different pans of corn starch and make drizzle art by drizzling the corn starch on paper.
Objective: To experimentally determine the porosity of various soils.

Vocabulary:
- porosity
- saturation

Materials:
- 500 ml beaker with 50 ml measuring marks
- 500 ml graduated cylinder
- 5 lbs. fine sand, washed and dried
- 5 lbs. coarse sand, washed and dried

Dry sand by placing it in a flat plan in a warm oven overnight. Keep the oven door open slightly.

Grade Level: 5-6
Subject: Science
Time: 35 minutes

Procedure:
1. Begin the activity by discussing the concept of porosity. Indicate that students are going to experimentally determine the porosity of two types of soil.

   Porosity is the amount of air space in any rock or sediment; it is usually stated as a percent of the total volume of the sample.

   \[ \text{Porosity} = \frac{\text{Volume of water poured into beaker}}{\text{Volume of sand}} \times 100 \]

2. Pour 300 ml of dry, coarse sand into a 500 ml beaker. Fill a 500 ml graduated cylinder with exactly 300 ml of tap water. Pour the water carefully and slowly into the beaker with the coarse sand until the water level exactly matches the surface of the sand. Measure the remaining volume of water in the graduated cylinder. Write your results in the data table. REPEAT THIS ENTIRE PROCEDURE USING THE FINE SAND. The formula is designed to determine the percentage porosity in any soil with connected pores.
3. Discuss the findings. What do you predict the porosity of clay would be? Why might it be difficult to determine the porosity of clay? How does permeability of a soil relate to porosity.

Extension:

1. Discuss the relationship of porosity to ground water supplies.

*Porosity is the amount of space between soil or rock particles. Permeability is the ability of soil or rock to transmit water.
Objective: To determine rates at which different size particles sink in water.

Vocabulary:
- particle size
- rate

Materials:
- sand
- pebbles
- soil
- tall transparent bottles
- water
- meter sticks
- graph paper

Grade Level: K-6

Subject: Science

Time: 45 minutes

Procedure:

1. Distribute sand, pebbles, soil, and bottles filled with water. Instruct students to wet finger tips, touch sand, soil, or pebbles and then put their fingers on the water surface in the bottles. The purpose of this activity is to have students discover what they can about how particulates sink in water. Discuss the results.

2. Repeat the procedure by relating particle size to distance traveled. Use a grid similar to the one illustrated. Draw dots the size of an individual particle, then measure how far the particle falls in the time it takes to say, "Sink particle, sink." The person touching the water surface should say, "Sink particle, sink," at the instant the finger touches the water. The person measuring should note how far the particle has traveled at the time the statement is completed.

Graph and discuss the results.
1. Discuss what would happen if the water were moving (flowing). Which particle would travel the greatest distance? Test the various hypotheses by using soil samples with stream table, hose and tub, or an actual stream.

2. Take a field trip to study various types of stream deposits.

*There is more to sinking than size. Don't forget the density variable.*
PARTICULATES IN WATER

Objective: To identify factors that produce turbidity in water.

Vocabulary:
- particulates
- turbidity
- sediment

Materials:
- water sample
- jars
- sand
- clay
- gravel
- white cards

Grade Level: 2-6

Subject: Science
         Language Arts

Time: 45 minutes

Procedures:

1. Collect water samples from various sources. Allow the jars to stand overnight. Measure the depth of sediment in each jar. Introduce the terms particulate and sediment. Discuss the relationships that may exist between location, rate of flow, and amount of sediment.

2. Introduce the term, turbidity. Add various amounts of sand, clay, and/or gravel to clean water samples. Shake the jars and observe the rates at which the particles settle. Put a white card behind each jar. Devise a turbidity scale for water samples ranging from white (clear) to opaque.

Discuss the secchi disk (see Chapter 6) and how it is used.

Extensions:

1. Write stories about animals that live in water having various amounts of particulates.

2. Place a jar of pond water in a warm, well lighted location. Observe any changes in turbidity over a period of weeks.
LITTLE PEOPLE'S WATER PLAY

Objective: To investigate some of the physical properties of water in play settings.

Vocabulary:
- bubbles
- evaporate
- absorb

Materials:
- soda straws
- plastic cups
- soap solution
- shallow pans (aluminum pie pans)
- plastic drop cloth
- plastic squeeze bottles
- water can

Grade Level: K-1
Subjects: Science
Art
Time: 1 hour

Procedure:
1. Distribute plastic cups containing small amounts of soap solution and soda straws. Indicate that students are going to make bubbles by dipping the straws in the solution and then blowing. (CAUTION—blow, do not suck.) Let children play.

2. Experiment with other bubble makers. Cut soda straw ends down 3 cm as illustrated. Dip soda straw in the solution.

Soap Solution Formula:
- 3/4 cup liquid soap (not dishwashing detergent)
- 1/4 cup glycerine (sugar will also work)
- 2 qts. water
Use funnels and plastic tube to make bubble fountains.

Discuss with the students what they have observed and learned.

3. Fill plastic bottles with water. Discuss what could be done with the water filled bottles. Include "should nots" in the discussion. Go outdoors and allow children to play with the filled bottles.

4. Refill the bottles. Have a design-making contest by squirting the water on a large flat dry surface.

5. Refill the bottles. Have a squirting playoff. Designate the winner as classroom fire chief. Make a small paper fire in a can outdoors and have the fire chief put it out.

Extensions:

1. Introduce the terms evaporate and absorb and conduct experiments outdoor that demonstrate both properties.

2. Provide pails of water and paint brushes. Paint the outside of the building, the sidewalk, or ???

3. Provide pails, pans, soapy water and doll clothes. Have a clothes washing session, complete with clothes lines and pins.

CASTOR SAYS

*Order Polyox resin ($3.00) from The Magication Co., P.O. Box 4021, Laramie, WY 82071. Mix with water and food color for a fantastic experience.
DRIP ME A DROP

Objective: To investigate properties of drops of water on different surfaces.

Vocabulary

- absorb
- soak
- adhere
- repel

Materials:

- medicine droppers
- water in paper cups
- waxed paper
- paper towels
- aluminum foil

Grade Level: K-4

Subjects:

- Science
- Art
- Language Arts
- Mathematics

Time: 1 1/2 hours

Procedures:

1. Distribute paper cups, medicine droppers, waxed paper, aluminum foil, and paper towel squares. Instruct students to drop drops of water on the three kinds of paper. How small a drop can be made? Make a trail of drops all the same size. Are the drops the same shape on all three kinds of paper? Can they roll the drops? Get the drops to just touch each other. What happens when a person stands on a chair and lets the drops fall on the papers? What does the point of the medicine dropper look like when it is placed in a water drop?

2. Discuss what students have learned about drops of water.

Extensions:

1. Add food coloring to the water and have students drip different colors on paper towels to make pictures. Tape the pictures on the window to dry. Follow up the next day by having students tell stories about their pictures. They may want to add some details with a pencil, such as a lion's face.

2. Have a drop-of-water race using a sloped piece of aluminum foil as a race track.
3. Create falling water music. Use streams and drops of water in pans, bottles, and on flat surfaces.

4. Have a contest to see who can pile the most drops of water on a penny.

5. Put a petri dish of water on an overhead projector. Add drops of food coloring and observe how the colors mix.

6. Record different water sounds and see if student can name them.

*If you are short of medicine droppers have children bring in droppers from empty medicine bottles.

*If you use different size medicine droppers, then take this variable into consideration as you do experiments.
THE UNIVERSAL SOLVENT

Objective: To identify some things that will dissolve in water.

Vocabulary: Material:
dissolve
solvent

Material: 6 plastic pop bottles
salt, vinegar, sugar
baking soda
distilled water
plastic glasses
soda straws

Grade Level: K-4
Subject: Science
Time: 45 minutes

Note: Prepare your mystery bottles before class time. Add 1/4 cup of salt, vinegar, sugar, and baking soda, separately to four pop bottles filled with tap water. Fill a fifth bottle with tap water only. Label the bottles A, B, C, D, E.

Procedures:

1. What is "pure" water? Discuss. Have a number of students drink some distilled water. How does it taste? Now, vigorously shake a pop bottle half full of distilled water. Does the water taste different? Discuss the term dissolve. What things might dissolve in water?

2. Place some water from the mystery bottles in plastic glasses also labeled A-E. Have students SIP the water with soda straws to see if they can discover what is dissolved in the water.

3. Introduce the terms dissolve and solvent. Discuss things that dissolve in water.

Extensions:

1. Evaporate a small amount of each mystery solution and examine the residue. Do the same with distilled water. Compare the results. Look at the residue with a magnifying glass.

2. Fill a glass with water to the brim. Ask the students if it is full. Add 1/4 cup of water to the glass. What happens? The students will conclude that you cannot add water to a full glass. Now slowly add 1/4 cup of salt or sugar to the full glass of water. What happens? Where does the salt go? Is there a limit to how much material can dissolve in a liquid?
SOLUBILITY

Objective: To investigate the solubility of various chemicals in water.

Vocabulary:
- solvent
- solute
- solution
- biodegradable

Materials:
- corn starch
- water
- 250 ml beakers
- tincture of iodine
- silver nitrate
- salt
- celery
- distilled water
- paper towels

Grade Level: 4-6
Subject: Science
Time: 1 1/2 hours

Note: Silver nitrate and tincture of iodine can be obtained at most drug stores.

Procedures:

1. Put a pinch of corn starch in a 250 ml beaker of water. Add a tablespoon of corn starch to a second beaker of water. Put 4-5 drops of iodine in each beaker. What happens? Why is one beaker darker than the other? Predict what will happen if 4-5 drops of iodine are added to a beaker of distilled water? Do it. Iodine turns blue when starch is present.

2. Put a pinch of starch and a tablespoon of starch in two 250 ml beakers of water. Label them. Add equal amounts of saliva to each beaker. Let them stand for 24 hours and then test for starch with the iodine tests. What caused the change?

3. Add a few pinches of salt to a beaker of water. Add 4-5 drops of silver nitrate. What happens? Silver nitrate can be used to test for salt content in water.

4. Put equal amounts of water in two beakers. Add 1 tablespoon of salt to one beaker. Put a piece of celery in each beaker and leave it for 24 hours. Remove the celery and dry it with a paper towel. Put the two pieces of celery in two different beakers of distilled water for 24 hours. Test the water with silver nitrate. Explain the results.
5. Introduce the terms solvent, solution, and solute. Discuss the concept of biodegradable as related to the starch.

Extensions:

1. Use a test kit to test water samples for chlorine, dissolved oxygen, or carbon dioxide.

2. Examine some copper sulfate crystals. Add enough crystals to a beaker of water to color the water. Use filter paper to filter the solution. Evaporate a few drops of the solution on a microscope slide. Observe the slide under low power. Does filtering remove all solutes?

*A solution consists of a solid, liquid, or gas (solute), dissolved in a liquid (solvent).

*Puzzle: When is a solvent a solution? Answer: When you have the problem of dissolving spilled honey. Water is the solvent and the solution to the problem.
Objective: To illustrate that gasses dissolved in water influence its chemical properties.

Vocabulary:
- gas
- dissolve
- indicator solution
- basic
- acidic

Materials:
- Feen-a-mint laxative pills
- household ammonia (non-sudsing)
- soda straws
- quart jar
- medicine droppers
- distilled water

Grade Level: 4-6

Subject: Science

Note: The indicator solution described in step 1 of the procedure should be prepared ahead of time to allow settling of the solids. Use the clear liquid portion as the indicator. The teacher should take care not to add excessive household ammonia. One (1) drop should be sufficient to produce the desired pH adjustment and should not pose any problems upon accidental ingestion or spillage. The students should be warned, however, to only blow on the straws. The chemicals in the solution would produce a very bad taste.

Procedures:

1. Dissolve 1 pill of Feen-a-mint laxative in 3-4 tablespoons of water. (Crushing the tablet will help it to dissolve; some solid material will remain. The laxative tablet contains a substance known as phenolphthalein. This substance will change color when a certain chemical characteristic of the water changes. (Pink in a basic solution, clear in an acidic solution.) This solution will be called an indicator solution because it indicates the chemical character of the water by its color change.

Put about 1/2 cup of distilled water into a quart jar or large glass. Use a medicine dropper to add one (1) drop of the household ammonia. Use another medicine dropper to add 20-25 drops of the prepared indicator solution. The water should now have a faint pink color. Have the students take turns blowing through the soda
straws placed in the water. After several minutes of blowing, the solution should become colorless.

What changes are occurring? What gas is being blown into the water? (carbon dioxide) Is this gas changing the chemical nature of the water? How can we tell? (by the change in color)

2. Introduce the concept of pH (see Background Information). Discuss other chemicals which might change the pH of water.

Extensions:

1. Experiment with the chemicals that change the pH of water. Note that a very small amount of a chemical, such as lemon juice, is needed to change the water color.

2. Relate the above experiment to the acid rain problem.

*An indicator solution uses color change to identify chemical properties of solutions.

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ACIDITY AND ALKALINITY

Objective: To determine the pH of water.

Vocabulary: pH, acidity, alkalinity

Materials: pH test kit or pH paper

Grade Level: 4-6

Subject: Science, Social Studies

Procedures:
1. Discuss the concept of pH (see Background Information).
2. Use a pH test kit or test paper to test the acidity of various water samples.

Extensions:
1. Discuss acid rain.

*Various tropical fish kept in aquaria each has a pH preference. Guppies prefer slightly alkaline water with a pH of up to 7.8. Neons will live in such water, but must have soft, very acid water to reproduce. Platies in acid water have more male offspring than female.
IT'S ALL A MATTER OF PRESSURE

Objective: To observe and describe the effect of pressure on a stream of water.

Vocabulary: pressure, vacuum, air pressure

Materials: one liter plastic pop bottle, masking tape, nail or other pointed object, water, catch pan or sink

Grade Level: 2-6

Subjects: Science, Mathematics

Time: 2 hours

Procedures:

1. Punch three holes of equal size in a plastic pop bottle as illustrated. Cover the holes with masking tape and fill the bottle with water. Remove the tape and observe what happens.

2. Retape and refill the bottle. Put the cap on the bottle. Remove the tape and observe what happens. Loosen the cap. Discuss the concepts of water pressure, air pressure, and vacuum. Relate these terms to what was observed.

*Try holding the bottle horizontally. This should clearly illustrate the pressure-depth relationship.
Extensions:

1. Relate what has been learned in the activity to the principle of a siphon.

2. Retape and refill the jug. Pull the tape from the bottom hole only. Catch and measure the amount of water collected from the bottom hole as the water level goes from the top of the jug to the first hole. Time how long it takes for the water level to go from the top of the jug to the level of the top hole. Determine the rate of flow under this pressure in cups per minute. Now, time and measure the water flow from the first hole to the second hole, then from the second to the bottom hole. Is there a difference in the rate of flow? Does the depth of water above the hole affect the rate of flow? Why?

3. Illustrate the influence of air pressure with the device pictured below. Discuss what practical application such a device might have, i.e., as a fire extinguisher.
4. Make a fire extinguisher with a dishwashing detergent bottle (transparent if possible). Pour 50 cc vinegar into the bottle, then add 250 cc of water. Put 2-3 table spoons of baking soda into a plastic bag. Do not close the plastic bag. Carefully place the plastic bag in the bottle. Screw the cap on tight and make sure the valve is closed. Shake the bottle so that the baking soda mixes with the liquid. Point the nozzle into a sink and open the valve.

5. Make a cartesian diver with a plastic pop bottle. Fill the bottle nearly full of water. Fill a small test tube about half full of water. Place your finger on the end of the test tube and carefully place the test tube, open end down, in the pop bottle. The test tube should just barely float. Replace the cap on the bottle. Squeeze the sides of the pop bottle. The "diver" should sink to the bottom and refloat when the pressure is released.

* A cartesian diver should raise questions that cannot be answered without careful observation.
SIPHONING

Objective: To explain the process of siphoning.

Vocabulary: siphon

Materials:
- 2 containers (pails, jars)
- water
- plastic tubing

Grade Level: 1-6
Subjects: Science, Language Arts
Time: 25 minutes

Procedures:
1. Fill a container with water. Fill the plastic tubing with water and place a finger over each end so that no water is lost. Submerge one end of the tubing in the container filled with water and remove your finger. Place the other end of the tubing in the empty container and remove that finger. Make sure the empty container is lower than the full container. Observe what happens.

2. Keeping both ends of the tubing submerged, raise and lower the containers and note what happens. What happens if one end of the tubing comes out of the water? What happens if both containers are at the same level?

3. Have students make a listing or write a summary of the conditions that must be met for a siphon to operate.

Extensions:
1. Discuss some practical applications of the principle of siphoning.
Density-Temperature Relationships

Objective: To observe and describe differences in the density of water at different temperatures.

Vocabulary:
- density
- temperature

Materials:
- gallon glass jar
- hot water
- 2 soda straws
- tap water
- food coloring
- paraffin or candle wax
- nail
- hammer
- block of wood
- baby food jar

Grade Level: 3-6
Subject: Science
Time: 40 minutes

Procedures:
1. Punch 2 holes in the lid of a large baby food jar so that 2 soda straws barely fit through the openings as in the diagram. (Use a nail and place the lid on a block of wood.) Seal the holes around the straws with melted paraffin or candle wax and allow to harden. Fill the baby food jar with hot water, add red food coloring to make a deep red. Gently drop the bottle of colored water into the gallon jar which has been filled 2/3 full of cool tap water. Disturb the water as little as possible.
2. Observe and describe the results.

3. Discuss the following questions:
   What makes the water move from one jar to the other?
   Where does the colder water go?
   Can you give reasons why the water acts as it does?
   Do you think water "layers" in a similar way in a deep lake?
   Leave the jar alone for several hours and observe periodically.
   What happens? Why do you think the water layers disappear?

4. Introduce the term density, and relate it to what was observed.
   Indicate that water is most dense at about 4°C.

Extensions:

1. Place an egg in a pan of tap water. Slowly add salt to the water.
   Why does the egg eventually float? Relate what happens to the concept of buoyancy. (See Background Information.)

2. Make ice cubes with water deeply colored with food coloring. Place the ice cubes in glasses of water of various temperatures and colors. Observe the results. Be sure to include a glass of water at or near 4°C. Observe and describe the results.

*Density refers to how closely packed together particles of a material are. The more mass per unit of volume, the more dense a material will be. In liquids even a slight difference in temperature will cause a difference in density.
**Layered Water**

**Objective:** To investigate water density, temperature and purity relationships.

**Vocabulary:**
- dissolve
- diffuse
- density

**Materials:**
- baby food jar
- plastic spoon
- soda straw
- 2 boxes salt
- 7 boxes food coloring
- pail of hot water
- pail of cold water
- scale
- 4 one-liter jars
- red, blue, and green food color

**Grade Level:** 3-6

**Subjects:** Science
- Art

**Time:** 2 hours

**Procedures:**

1. Begin the activity by distributing student materials. Instruct students to investigate what happens when a drop of food coloring is put into a jar of cold water. Does the color make a difference? What about hot water?

2. Distribute salt and instruct students to add a few spoonfuls of salt to a jar of water. Now repeat the procedures in step one. Discuss the differences. Introduce the terms dissolve and diffuse.

3. Make up four colored salt water solutions, each with a different concentration of salt and one liter of water:
   - a. 500 g. salt, 6 drops of red food coloring
   - b. 325 g. salt, 6 drops of green food coloring
   - c. 170 g. salt and no food coloring
   - d. no salt and 6 drops of blue food coloring

   Label each container (1-4) and list the contents on the chalk board. Use soda straws as pipettes as illustrated. Instruct students to place a straw full of one color in their baby food jars. Then draw
another color and slowly release this along the side of the jar. Discuss the results.

Have students experiment with 3 and 4 color combinations and discuss the results.

Extension:

1. Use an overhead projector and petri dishes to make food color water art. Place the dishes on the projector, add various solutions of water and drops of food coloring. Project the resulting diffusion patterns on the screen.
HEAT CAPACITY OF WATER

Objective: To show that water has a greater heat storing capacity than many other materials.

Vocabulary:

heat capacity

Materials:

cardboard box
black tempera paint
3 identical cans
heat lamp
3 thermometers
sand
water
paper
graph paper

Grade Level: 3-6

Subjects: Science
Mathematics

Time: 45 minutes

Procedures:

1. Indicate that this experiment will determine the heat capacity of water in relation to the heat capacities of some other materials. Heat capacity refers to how much heat energy a material will hold.

2. Paint the outside of the cardboard box black. The box should be large enough to hold the three cans. Add some white glue to the remaining black paint. Use this paint to paint the cans black. When the cans are dry, add sand to one can, water to another, and stuff paper in the third. Set the cans aside until the temperature is the same in all three. Place the cans in the box and let the heat lamp shine on the box for one hour. Remove the heat lamp, open the box, and record the temperature in each can. Repeat the temperature readings every minute for fifteen minutes. Graph the results. Discuss which of the materials holds the heat best.

Extensions:

1. Discuss how the heat capacity of water could influence climate.

2. Discuss how the heat capacity of water could be used to help heat a house or solar greenhouse.
SOLID, LIQUID, AND VAPOR

Objective: To identify the three states of matter.

Vocabulary:
- solid
- liquid
- gas
- evaporate
- condense

Materials:
- hot plate
- thermometer
- aluminum foil
- pyrex container
- ice
- water

Grades Levels: K-4

Subject: Science

Procedures:

1. Place an ice cube on the table. Ask the students to observe and describe what they see.

2. Discuss the properties of solid and liquid water.

3. Place some ice cubes in the pyrex container and place the container on the hot plate. Ask the students to observe and describe what they see. Where does the water go? Introduce the terms evaporate and gas. Indicate that water vapor is a gas.

4. Add a few drops of perfume to the boiling water. Have students raise their hand when they can smell the perfume. Why can they smell the perfume and not the water vapor?

5. Discuss the relationship of energy to the change from solid (ice) to liquid (water) to gas (water vapor). Students should conclude that it takes energy to cause these changes.

6. Place more ice in the pyrex container. Place the container on a table. Observe the outside of the container. Where does the water come from? Introduce the term condense.

Extensions:

1. Investigate the influence of evaporation on the temperature of an object by placing a thermometer in a wadded, wet paper towel. Is the wet towel losing or gaining energy? Place the towel in the air stream in front of a fan. What happens? Could the principle of evaporation be put to practical use for cooling? Discuss.

2. Put a dry beaker in a freezer. Remove the beaker and set it on the table. Gently breathe into the beaker. Where does the cloud come from? Relate this example to cloud formation in the sky.
Objective: To demonstrate that water expands when it freezes.

Materials:
2 baby food jars
3 plastic bags
freezer
2 elastic bands

CAUTION: Be sure the jars to be frozen are placed in plastic bags to prevent scattering of glass. The jar filled with water will break when it is frozen.

Grade Level: 3-6
Subjects: Science
Language Arts

Time: 40 minutes

Procedures:
1. Fill one baby food jar completely with water. Fill the remaining jar only 3/4 full. Place the lids on both jars and screw lids tight. Place each jar in a plastic bag and close the bag with an elastic band, and place them in the freezer. Check the jars every 15 minutes until the water is frozen.

2. Relate the results of the frozen water to the concept of density.

Extensions:
1. Brainstorm ways in which the properties observed could be helpful or harmful.

2. Write a story about a planet which has water that is most dense at 0°C. Ice would not float on such a planet.
Objective: To demonstrate the phenomenon of surface tension on water.

Vocabulary:
- atom
- molecule
- charge
- repel
- attract

Materials:
- pans
- water
- double edge razor blades
- detergent
- 2-bar magnets

Grade Levels: 5-6

Subject: Science

Time: 40 minutes

Procedures:

1. Begin by asking students if they know what water is made of. Lead the inquiry to obtain the formula $H_2O$. Ask what the formula means. Lead the discussion to explain that the formula stands for a molecule of water composed of two atoms of hydrogen and one atom of oxygen and discuss briefly the terms molecules and atoms. Indicate that these chemicals combine to form water molecules in such a way that the angle between the two hydrogen atoms is always $104^\circ$. 


Also indicate that the hydrogen ends of the molecule always have a +1 electrical charge and the oxygen end has a -2 charge. (Note: the phenomenon of "charge" is easily demonstrated with 2 small bar-magnets.)

Indicate that like charges repel each other and that unlike charges attract each other. Relate this principle to the way surface water molecules behave. Share this on the chalkboard.

2. Introduce the term surface tension. Discuss creatures that walk on water. Explain this phenomenon in terms of the "skin" caused by the attraction of water molecules at the surface of water.

3. Have students attempt to float double edge razor blades in pans of water. Add a drop of detergent to a pan with a floating razor blade. What does detergent do to surface tension?

Extensions:

1. Have students explain, in terms of the molecular and electrical nature of water, why falling water forms drops.

2. Have students investigate capillary action and explain the process in terms of the molecular and electrical nature of water molecules.

*Many of the properties of water are related to the electrical nature of the water molecule.
Objective: The learner should understand that:

Topic 1.21 The hydrologic cycle is controlled by natural laws.
Origin of the Earth's Water

Over 70 percent of the earth's surface is covered with water. The total volume of water is 326,000,000 cubic miles. This is only one millionth of the globe's volume. Table 1 indicates how this water is distributed.

Table 1. Water On Our Planet

<table>
<thead>
<tr>
<th>Location</th>
<th>Cubic Miles (x 1000)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans</td>
<td>317,000</td>
<td>97.24</td>
</tr>
<tr>
<td>Polar ice, glacier</td>
<td>7,000</td>
<td>2.15</td>
</tr>
<tr>
<td>Ground water</td>
<td>2,000</td>
<td>0.61</td>
</tr>
<tr>
<td>Lakes</td>
<td>55</td>
<td>0.017</td>
</tr>
<tr>
<td>Soil</td>
<td>16</td>
<td>0.005</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>3.1</td>
<td>0.00001</td>
</tr>
<tr>
<td>Rivers</td>
<td>0.3</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

Water is the second most abundant mineral on the surface of the earth. Some minerals contain water as water of crystallization. This means that the water is chemically bound to the other elements in the molecule. Gypsum (CaSO₄·2H₂O) and analcite (NaAlSi₂O₆H₂O) are examples of such materials. If a small amount of these materials is powdered and gently heated in a tube, water will collect on the glass. The heat drives off the water of crystallization. Other minerals contain water more firmly attached and must be heated white hot before it is given off.

When magma, molten rock, reaches the surface as in volcanic eruption, dissolved gases are released. Theory indicates that this was the original source of our water. The activity of Mount St. Helens, with its explosive eruptions, illustrates the release of gases such as water vapor into the atmosphere.
Man's understanding of the hydrologic cycle was a slow process. During the Middle Ages, people believed that water flowed magically from the center of the earth. We now know that the total amount of water on the earth, including the air, remains essentially constant. Water changes form but does not disappear. The hydrologic cycle has no starting point or end point. Water molecules you drink today may have been in the water that floated Noah's ark or may have been the same that Ben Franklin drank.

**Water in the Air**

Water in the atmosphere is called water vapor. The sun plays the major role in getting water molecules into the gaseous state. It takes energy to convert a solid to a liquid and liquid to a gas. This energy either directly or indirectly comes from the sun.

The energy sources that support evaporation differ from place to place and time to time. A large body of water may absorb and store a larger amount of heat energy than surrounding land. Thus, a large lake may be able to supply energy for evaporation later in the fall than surrounding land. So even if soil is wet, it may not evaporate as much water as a nearby warmer body of water.

The amount of water vapor or humidity in the air also plays a role in evaporation. If the air is very dry, evaporation will be more rapid than if there is a lot of water vapor already in the air. Saturated air holds all the water vapor possible for a given temperature. Air is unsaturated when the amount of water vapor is less than this limiting value.

Relative humidity is the amount of moisture in the air, and is stated as a percentage of the maximum amount of moisture that air can hold at a given temperature. The higher the temperature, the greater the amount of moisture a given volume of air can hold. One can determine relative humidity with a wet-and-dry bulb hygrometer or a sling psychrometer. In either case, one compares the air temperature (dry bulb) to the temperature as influenced by evaporation rate (wet bulb). See chapter six for instructions on how to make a psychrometer.

The greatest source of water vapor is evaporation from the oceans, particularly those that lie in warm parts of the world. The Pacific Ocean and the Gulf of Mexico are the primary sources of the water that falls as rain on the United States.

**Precipitation**

A person sitting in the shade, drinking a cold drink on a hot summer day, is aware that the outside of the glass is wet. Water condenses from water vapor in the air to form the droplets of water on the glass. This is the basic process by which rain, snow, and sleet are formed. In every case water condenses onto a solid. The condensation nucleus for a rain drop may be a dust particle or a salt crystal. Rain, snow, sleet, and
hail are all forms of precipitation. Cooling of air in contact with the earth may cause water vapor to condense in the form of dew or frost. On clear, calm evenings, the ground's surface may cool rapidly due to heat being radiated away forming a thin layer of cool air near the ground. This cool layer of air may be only a few centimeters thick. It is on such a surface that dew or frost forms. Precipitation usually results from cooling of air as it rises. If air is cooled far enough below the dew point, water vapor in it condenses. The dew point is the temperature at which air becomes saturated.

Clouds are composed of billions of minute droplets of water. Condensation nuclei may be dust particles, salt crystals, or other small particles in the air. Water droplets collect on the condensation nuclei until they become large enough to fall as drops of rain. Fog is a cloud at ground level. Cities often provide the conditions needed to promote fog. Pollutants supply condensation nuclei and various combustion processes provide added water vapor. The exhaust cloud behind a car on a cold day is mostly water vapor produced by the burning of gasoline.

Since early times people have wondered at the variety in snowflakes and the basic six-sided nature of snow crystals. The formation and proliferation of snowflakes is dependent upon environmental conditions. The six-sided factor is a result of molecular structure. Variety is determined by condensation nuclei, saturation, and temperature. At a given saturation of air with nuclei present, hexagonal plates form at just below the freezing point, followed by needles, hollow prismatic columns, a different type of hexagonal plate, fernlike stars, and hollow prismatic columns. A snowflake can also change its form as it falls to the ground.

Figure 9. The snowflake always has a basic six-sided nature, reflecting the internal arrangement of hydrogen and oxygen, but the variety of form is infinite.
Rain is precipitation in the form of liquid water drops. Clouds are the source of rain, but most clouds do not produce rain. Much of the rain that falls is the result of melted snow. Very light rain is called drizzle. If the droplets are so small that they evaporate before reaching the ground, they are referred to as mist. Sleet is frozen rain. Hail is a product of up and down air currents in a thunderstorm. Rain carried high in a thunderstorm may freeze, fall part way and get another layer of water.

The impact of raindrops releases a large amount of kinetic energy. The effect is observed in the pounding action of rain drops on exposed soil. This process is the main cause for detachment of soil particles and subsequent erosion.

Precipitation can be greatly influenced by topography. As humid air is forced up over mountain ranges, the cooling results in precipitation at higher elevations. The downwind side of such mountain ranges then experiences a drying effect and decreased precipitation. This phenomenon is well demonstrated in the states of Oregon and Washington which have a high precipitation along the west coast and in the mountains. However, the region just to the east of the Cascade Range is very dry by comparison.

Recently, in some areas attempts have been made to modify precipitation by "cloud seeding." In this process solid carbon dioxide (dry ice) or silver iodide serve as condensation nuclei, and are mixed into existing clouds to help trigger precipitation. Many states now have laws regulating cloud seeding, which is a form of weather modification.

Acid Rain

Rain and snow are often considered as nearly pure as distilled water. This is seldom the case. With modern day atmospheric pollutants all sorts of chemicals are associated with precipitation. Radioactive particles and/or salt may be found in rain and snow. Atmospheric atomic weapons testing has at times added large amounts of radioactive particles to the air. Salt is placed in the air by wave action over oceans. It is becoming increasingly apparent that some ecosystems are being injured by the chemicals in precipitation.

The pH of most rainfall is slightly acid because moisture reacts with naturally occurring carbon dioxide to form carbonic acid. The normal pH value for rain is about 5.6. As rain falls it absorbs carbon dioxide from the air. Once the carbon dioxide is dissolved in water, most of it does not remain in the form of carbon dioxide molecules, but reacts with water to form weak carbonic acid:

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]

The carbonic acid then, in turn, partially separates into hydrogen ions and bicarbonate ions. These H\(^+\) ions account for the acidity of rain water. If the value is less than 5.6, it can be assumed that the rain has been influenced by some unusual atmospheric disturbance.
Records obtained from core samples of polar ice indicate that world precipitation has been getting more acidic over the past 100 years. Records dating back to the 1950s record occasional events of precipitation with a pH of 4.5. But by 1979, the average pH of rainfall in the entire northeastern part of the United States had fallen to below 4.5 and some events are as low as 3.4 which is nearly as acid as vinegar.

The effect that acid rain has on an area depends on the ability of the soil and water to react with acid. Soil or water rich in calcium and magnesium carbonates is able to buffer the effects of an acid rain. Areas which lack these chemicals tend to experience acidification of lakes and streams, with accompanying loss of aquatic life. When the pH goes below 5, fish cannot survive; few native species reproduce at a pH of less than 6.5. Toxic metals are also released from the soil and rocks, also contributing to loss of organisms.

**Surface Water**

Any water flowing on the surface of the ground is referred to as surface water. The flow of a stream is measured by computing the volume of water passing a given point per unit of time, such as cubic feet per second (cfs). For example, if a channel one foot high and one foot wide has water flowing through it at one foot per second, it would then discharge one cubic foot of water per second.

\[
\text{Discharge} = \text{width} \times \text{depth} \times \text{velocity}
\]

The first step in measuring the discharge of a stream is selection of a suitable cross section. The measurement section should be a stable straight portion of stream where the water flows smoothly. The bottom should be free of rocks that might cause the water to swirl. The width and depth of the cross section is measured in feet and the velocity is measured in feet per second.

Gaging stations are maintained to correlate stream flow with river stages. Some gaging stations have recorders that keep a continuous record of stages. Data from gaging stations and discharge measurements are used to calculate daily, monthly, and annual stream flows.

Each stream receives water from a particular geographic area. The stream channels are in the lowest parts of the area, and the rim that separates one drainage system from another is on the highest ridge separating them. The area enclosed by such a rim is called a watershed. In a watershed, streams successively join to form larger streams. The smaller branches of a main stream are referred to as its tributaries. The pattern of joining is much like the branching of trees.
Figure 10. Stream Gaging
Stream flow is measured with a current meter.

Figure 11. A Watershed

OUTFLOW
When a stream channel overflows its banks, it is referred to as being at flood stage. The part of a valley floor covered by flood water is called the flood plain and is really a part of the river channel. Floods are a normal and expected characteristic of rivers. Most rivers exceed bankfull a number of times every year. Floods are natural events, but when human activities utilize flood plains, conflicts between man and nature are inevitable. For example, if the largest flood recorded in 50 years were of a certain volume, a flood of similar size will probably occur again in the next 50 years. If you live on a flood plain, the 50 year flood may or may not come during your occupancy, but eventually it will come.

Flood waters are characteristically muddy. The sediment carried by a stream depends on a number of factors. Particle size is one factor. The larger the particle, the more difficult it is for it to be carried by a stream. This is easily demonstrated by placing sand and clay in a jar of water and shaking it. The large particles settle out immediately while the fine clay may take days to settle out. In a moving stream, the motion of the water tends to keep the particles stirred up. The turbulent swirls in a mountain stream can keep larger particles in movement better than can the smooth flow of a big river.

The load carried by rivers varies greatly from river to river, and, in some cases, from season to season. Watersheds composed of fine soil put a large amount of sediment into a stream after every rain storm if the ground cover is poor. Such an area may lose as much as 64,000 tons from each square mile in a year. The sediment carried by major rivers is huge (see Table 2).

Table 2. Sediment load of selected major rivers.

<table>
<thead>
<tr>
<th>River</th>
<th>Countries</th>
<th>Annual Sediment Load (Million metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>China</td>
<td>1,600</td>
</tr>
<tr>
<td>Ganges</td>
<td>India</td>
<td>1,455</td>
</tr>
<tr>
<td>Amazon</td>
<td>Several</td>
<td>363</td>
</tr>
<tr>
<td>Mississippi</td>
<td>United States</td>
<td>300</td>
</tr>
<tr>
<td>Irrawaddy</td>
<td>Burma</td>
<td>299</td>
</tr>
<tr>
<td>Kosi</td>
<td>India</td>
<td>172</td>
</tr>
<tr>
<td>Mekong</td>
<td>Several</td>
<td>170</td>
</tr>
<tr>
<td>Nile</td>
<td>Several</td>
<td>111</td>
</tr>
</tbody>
</table>

Erosion occurs when water loosens and transports soil particles from one point to another. Gravity plays an important part in erosion. Splash erosion occurs when rain drops hit the ground causing soil particles to scatter.

Stream bank and bed erosion is dependent on stream depth and velocity. Velocity is dependent on the slope of the riverbed and on the shape and roughness of the channel. During floods, increased volume causes more erosion. As water moves along, turbulence causes it to dislodge particles from the stream bed and bank. Sediment picked up from the stream bed and bank become the suspended load of a stream. The bed load is the heavier material bounced along the bottom. As velocity decreases, the suspended and bed loads of the stream are deposited. Coarse sediment is dropped first and finer sediments are carried downstream.

Nearly one-half of the world's cropland is losing topsoil at a rate greater than that at which soil is replaced by natural processes. As soil is lost, productivity decreases.

The large number of lakes, ponds, and marshes on the surface of the earth contain a large volume of fresh water. Large lakes, such as Baikal, USSR, store huge amounts of water; Baikal accounts for over one-fifth of the world's fresh surface water. The Great Lakes of North America account for roughly another one-fifth of all fresh water.

Most lakes have been formed by geologic processes, such as glaciers, volcanoes, or earthquakes. The activities of man have created many reservoirs and ponds. The magnitude of this human activity is well illustrated in the western states where many large reservoirs have been constructed for irrigation and power production.

Some lakes in the temperate zones of the world experience temperature layering as seasons change. In summer the surface layers absorb heat and warm faster than deeper water. This less dense warm water floats above the cool water. By midsummer deep lakes have three distinct layers: a warm upper layer, a layer of rapid drop in temperature, and a deep cold layer. As the upper layer cools in the fall, densities between layers are equalized and a mixing of water occurs. The spring and fall turnovers are periods of increased animal activity.

Ground Water

Part of the water that falls as precipitation sinks into the ground. Soil may act like a blotter or a fine sieve. If a flower pot is filled with soil and then watered, the water fills the spaces in the soil and begins to run out the hole at the bottom. If the rate of inflow is increased, the soil may not be able to take the increased amount of water fast enough and it begins to flow off the top of the pot. This overflow is referred to as surface runoff, and the water going into the soil is referred to as ground water.
The larger the interconnecting spaces or pores between the soil particles, the faster the soil will take on water. This property of soil is referred to as permeability. Permeability of sand is much greater than permeability of clay. Thus, one would expect runoff to be greater on clay soil than in sandy soil.

The process by which water sinks into soil is called infiltration. The "filt" in infiltration means "to pass through" as in filter. Infiltration is greatly enhanced by the presence of vegetation.

![Figure 12. Arrangement, shape, and size of soil particles determines porosity. A soil like that represented on the left could hold much more water than the soil presented on the right.](image)

Water is moved by gravity through the soil and rock until it is stopped by an impervious layer or until a saturated layer is reached. Impermeable material has no interconnecting pores through which the water can travel. Permeable rock, such as sandstone, will receive water until all the pores are filled. Such saturated rock cannot hold additional water. Rock or soil areas which carry or hold water are called aquifers. The top of a saturated layer in an aquifer is the water table. As more water infiltrates an aquifer, the water table rises. If water is removed from an aquifer, the water table falls. Water tables generally slope in the same direction as the surface of the ground.

Wells must be deep enough to go below the water table in order to produce water. As a well is pumped, water is removed from surrounding materials. This removal may cause a temporary or permanent draw-down of the water table in the area depending on permeability of the soil, availability of ground water, and rate of pumping.
Figure 13.
A water table is formed as water runs into soil. A hole or well dug in the soil will fill up to the level of the water table.

Some aquifers contain water that may have fallen as rain or snow thousands of years ago and are replenished very slowly. The High Plains area of Texas is an example of such a region. The aquifer in that area appears to be cut off from some of the large supply areas to the west and north, and due to low annual precipitation the recharge is small. Pumping of water from this aquifer over the last fifty years has removed much of the existing water and lowered the water table.

Ground water under natural pressure is called artesian water. The word artesian comes from the area in France called Artesium, where, since Roman times, water has flowed to the surface under pressure. For a well to be classed as artesian, the water needs only to rise above the aquifer, but does not have to flow above the ground surface.

Springs occur where a saturated area intersects the surface of the ground. This may result in a general seepage or a large flow as in the case of springs occurring in limestone areas where the flow accumulates in underground streams and caverns.

Caves are spectacular examples of the action of ground water. Calcite, the main component of limestone, will not dissolve in pure water. However, most precipitation is naturally acid. Carbonic acid, $\text{H}_2\text{CO}_3$, is a common component of water entering the soil. In cave formation, carbonic acid combined with calcite to form calcium carbonate, which will dissolve in water. As ground water moves along cracks, this chemical process
removes limestone. Over a period of time, the crack may be enlarged to form a cave. If conditions are such that the ground water evaporates in the cave, characteristic cave deposits such as flowstone, stalactites, and stalagmites are formed.

Springs and wells which bring warm water to the surface are called geothermal or thermal. Such springs occur over wide areas of the West. These springs derive their heat from masses of magma that have come near the surface of the earth and are now cooling.

A geyser is a special type of thermal spring which ejects water with some force. Ground water that moves downward and drains into a crack or conduit that extends down to hot rock is turned to steam. As the steam expands, it pushes the water above it out of the tube, and a geyser results.

Evaporation and Transpiration

Evaporation occurs when energy loosens the bonds that keep water liquid. The main energy source that supports evaporation is the sun.
as illustrated by pouring water on a hot pavement on a summer day. The process of evaporation goes on all of the time.

Plants growing in soil that contains large amounts of water provide an environment in which much water is lost to the atmosphere. Evaporation occurs on wet plant surfaces and also inside spongy leaves. Water vapor is exchanged as a part of gas exchange required for photosynthesis. This process, called transpiration, is an important part of maintenance of plant life. Well-watered plants act much like a wet surface. For example, an acre of corn can release as much as 4,000 gallons of water in a day. A large oak tree gives off about 40,000 gallons of water in a year. We can infer from this that transpiration from plants is an important source of water vapor in the air and may produce more vapor than does evaporation from land surface, lakes, and streams.

Figure 15. Stomates, openings on the bottom sides of leaves, allow water vapor to leave the plant.

Wind and dry air will speed up this process. As the water is removed from the leaf, a cooling effect occurs, similar to that which occurs when we perspire. As the water is removed from the leaf, a gradient of water vapor concentration develops that has an effect all the way to the roots of the tree, where the water originates.

The Water Budget

The water resource planner or developer must have some way to account for the local variability of precipitation, runoff, and evaporation. A tool that can be used to understand how much water is available at a particular location and how much is used or evaporated and to assess what will happen if man-made controls are imposed on the system is the water budget. The budget is based on the simple hydrologic relation that inflow equals outflow plus change in storage. In equation form it would look like this for any given location:
I = 0 + Δs

wherein I includes precipitation, surface inflow, and groundwater inflow; 0 includes surface outflow, groundwater outflow, evaporation, and transpiration; Δs includes change in groundwater, soil moisture, snow cover, surface reservoir water, depression storage, channel storage, and detention storage.

On a worldwide basis evaporation equals precipitation, and the total system stays in balance. After precipitation occurs, some remains in the mountains as snow, while that falling as rain responds to gravity and flows downhill, either on the surface or in the ground. All does not evaporate at once. There is a time lag during which man can capture part of the flow in reservoirs, divert it into canals or pipelines and conduct it to its place of use, but it is eventually released and all returned to the atmosphere. The process is continuous and cannot be stopped unless the water is sealed in closed containers.

The accounting process for water is much like a bank account. You must know how much income you have and how much you spend and save in order to keep track of your balance. In equation form it's like this:

\[
\text{income} = \text{spending} + \text{change in savings}
\]

The big difference between a money account and a water account is in our ability to accurately measure the amounts. While a money account can be balanced to the penny, a water account can only be balanced approximately. The technology is not available to accurately measure the movement of water in liquid and vapor stages through its many and varied paths, especially underground. Estimates can be made, however, based on many point measurements, both in time and space. A budget analysis on an assumed lake as illustrated in Figure 16 follows.

![Figure 16. The Water Budget](image-url)
Assume the surface area of the lake is 100 square miles, the average annual precipitation is 24 inches, the average annual evaporation is 40 inches, the average river inflow is 80 cubic feet per second, and the average river outflow is 60 cubic feet per second. A groundwater study which defines the slope of the water table and the permeability of the soil suggests that 75,000 acre feet enter the reservoir annually. The lake level at the beginning and end of the year was the same. Note: 1 cfs = 2 acre feet per day (approximate). What would the budget look like?

**Inflow**

Precipitation \((100 \text{ sq. mi.} \times \frac{640 \text{ acres}}{\text{sq. mi.}} \times \frac{24 \text{ in.}}{12 \text{ in./ft}}) = 128,000 \text{ acre feet}\)

River inflow \((80 \text{ cfs} \times 2 \text{ acre feet} \times 365 \text{ days}) = 58,400 \text{ acre feet}\)

Groundwater (stated in problem) \(75,000 \text{ acre feet}\)

Total \(261,400 \text{ acre feet}\)

**Change in Storage**

\(0\)

**Outflow**

River \((60 \text{ cfs} \times 2 \text{ acre feet} \times 365 \text{ days}) = 43,800 \text{ acre feet}\)

Evaporation \((100 \text{ sq. mi.} \times \frac{640 \text{ acres}}{\text{sq. mi.}} \times \frac{40 \text{ in.}}{12 \text{ in./ft}}) = 213,333 \text{ acre feet}\)

Groundwater (calculated) \(4,267 \text{ acre feet}\)

Total \(261,400 \text{ acre feet}\)

The groundwater outflow is not measured, but is calculated to be 4,267 acre feet in order to balance the inflow and the outflow.

Instead of a reservoir the area could have been an area planted to crops, in which case the annual transpiration from the crops could have been estimated along with evaporation uses by industry and cities.
Activities

LITTLE PEOPLE WATER CYCLE

Objective: To identify the basic components of the water cycle.

Vocabulary:
- water vapor (steam or gas)
- condensation
- evaporation
- water cycle
- rain
- snow
- precipitation

Materials:
- water glass
- water
- ice cubes
- flat piece of glass or small mirror
- pan
- hot plate

Grade Level: K-3

Subjects: Science, Language Arts

Time: 30 minutes

Procedures:

1. Fill a glass 3/4 full of water and add 2 ice cubes. Place the glass where students can observe the moisture that collects on it. Introduce the terms water vapor and condensation.

2. Breathe onto the surface of a piece of dry glass or small mirror. Relate the condensation that is observed to the formation of clouds.

3. Pour the water into a pan and heat it to boiling on the hot plate. (Caution - be careful. Introduce the term evaporation. Hold a piece of glass over the steam until water starts to drip off.

4. Introduce the term water cycle. Explain that cycles go around and around. Distribute and discuss the water cycle picture.

Extensions:

1. Role play water evaporating, condensing, raining, snowing, or running.

2. Cut out pictures that illustrate water in various stages of the water cycle. Use them for a bulletin board display.
THE WATER CYCLE

Objective: To identify the basic components of the hydrologic cycle.

Vocabulary:
- solid
- liquid
- water vapor (steam or gas)
- evaporate
- condensation
- water cycle
- precipitation
- ground water
- transpiration
- sublimation

Material:
- ice cubes
- paper towels
- pan
- hot plate
- tin can
- perfume
- water cycle diagram
- water cycle crossword

Grade Level: 2-6

Subject: Science
- Language Arts

Time: 1 1/2 hours

Procedures:

1. Distribute ice cubes to students. Ask them to observe and describe what they see. Introduce the vocabulary solid and liquid. Identify places that we find solid and liquid water.

2. Place water in a pan. Heat the water until it is boiling actively. Discuss what is happening. Introduce the terms evaporate, steam, water vapor, and gas. Add a small amount of perfume to the boiling water. Discuss why the perfume can be smelled but the water vapor cannot.

3. Place ice cubes in a tin can. Observe the moisture that appears on the outside of the tin can. Introduce and discuss the term condensation.

4. Distribute the water cycle diagram and discuss the various parts of the cycle. Identify the ocean as a major source of water vapor. Discuss how clouds are formed as water vapor condenses on dust particles in the air. List the various forms of precipitation. Differentiate between ground water and surface runoff.
Extensions:

1. Introduce the term transpiration. Set up an experiment to demonstrate transpiration by placing a plastic bag around the above-ground part of a potted plant. Secure the plastic bag around the stem of the plant with a string. Water the plant and observe the bag.

2. Do library research on the great rivers and lakes of the world.

3. Write a story about a molecule of water as it goes through various stages of the water cycle.

4. Do the water cycle crossword puzzle.

5. Write fiction stories about all of the things a molecule of water has done or where it has been throughout history.

ANSWERS TO WATER CYCLE CROSSWORD (Page 59)
(see glossary for definitions)

DOWN:  ACROSS:
1. ground water 2. solid
2. spring 4. reservoir
3. precipitation 8. snow
5. sun 10. liquid
6. cloud 12. evaporate
7. aquifer 13. well
9. flood 15. ocean
11. ice 16. sea
13. water 17. rain
14. lake
WATER CYCLE CROSSWORD PUZZLE

DOWN:
1. Water found below the earth's surface
2. Ground water flowing to the surface
3. Rain, snow, sleet and hail
4. Energy source for the water cycle
5. Condensed water vapor, produces precipitation
6. A water carrying layer of the earth
7. Rising and overflowing of a body of water onto a normally dry land
8. Liquid precipitation
9. Condensed water vapor, produces precipitation
10. Physical state of ice
11. Source of water, produced by digging
12. Water is in this physical state between 0°C and 100°C
13. Largest body of water, very salty
14. A natural standing body of water; fed by a river or stream
15. Condensed water vapor, produces precipitation
16. Most abundant and important substance on earth
17. Liquid precipitation

EXTRA! EXTRA!

After working the crossword puzzle, alphabetize all of the words.
Write one complete sentence using each word in the crossword puzzle.
Objective: To help the student observe and describe the process of distillation.

Vocabulary:
- distillation

Material:
- Bunsen burner
- cardboard
- clay
- drinking straw or rubber tubing
- flask
- ice cubes
- ring stand
- rubber stopper
- 1 tablespoon salt
- shallow pan
- drinking glass
- water
- weights
- wire grid

Grade Level: 4-6
Subject: Science
Time: 35 minutes

Procedures:
1. Dissolve 1 tablespoon of salt in 1 cup of water and taste the solution. Pour this solution into the flask. Place the flask on a ring stand over a Bunsen burner. Use the wire grid to support the flask on the ring. Insert a straw or rubber tubing into the hole of the stopper. Seal any spaces around the straw with clay. Close the flask with the stopper, making sure the straw or tubing is above the surface of the solution. Bend the straw or tubing and insert the free end through a small hole in the cardboard. Place the cardboard over the water glass. Add weight to the cardboard to keep it in place. Surround the glass with ice in a shallow pan. Bring the solution to a boil.
2. Discuss the results of the experiment. Taste the cooled distillate and the remaining salt water.

3. Relate the process of distillation to the water cycle.

Extension:

1. Do library research on distillation and desalination of sea water.
**MINI-WATER CYCLE**

**Objective:** To demonstrate physical-state change of water and relate change to the water cycle.

**Vocabulary:**
- liquid
- gas
- condensation
- evaporation
- water cycle

**Material:**
- 2 large baby food jars
- water
- masking tape

**Grade Level:** K-4

**Subjects:** Science
Art

**Time:** 45 minutes

**Procedures:**

1. Put one inch of water in one of the baby food jars. Invert the other jar and tape both jars together, mouth to mouth. Place the jar "condenser" in a warm, sunny location or under strong artificial light and observe it over several hours. Describe the changes occurring in the jar by writing a short description.

2. Introduce the terms liquid, gas, condensation, evaporation, and water cycle. Relate the top jar, bottom jar, and water to the air, earth, and oceans. Relate the heat source to the sun and the condensed water to clouds and precipitation. Discuss what you see happening in terms of the water cycle.

**Extension:**

1. Make a solar still by digging a hole about 2 1/2 x 2 1/2 ft. and about 1 ft. deep. Place a bowl or pan in the bottom of the hole. Stretch a piece of plastic over the hole and anchor it with rocks. Seal the edges with soil. Place a small rock directly over the pan to produce a depression in the plastic. Allow the device to sit for 24 hours. Check the pan. Where did the water come from?

2. Make a water mural that depicts the many ways in which the water cycle affects our everyday life. Cut out pictures from old magazines or draw pictures which show some part of the water cycle.
FLOODWATER

Objective: To identify flood control as an important aspect of water management.

Vocabulary: dams

Materials:
Pictures of floods
Pictures of flood control structures

Grade Level: 4-6

Subjects: Science
Social Studies

Time: 45 minutes

Procedures:
1. Share and discuss experiences students have had with floods. Include some good pictures. Introduce the concept of flood control. Discuss flood control projects in your state.

2. Conduct library research on floods that have occurred in your state. Discuss ways these floods could have been prevented or damage lessened.

3. Discuss the effect of floods on soil, crops, and wildlife.

Extension:
1. Build a model community with a stream flowing through it. Use clay and sand for geographic features. Establish a normal stream flow with a slowly running hose. Create reservoirs, dikes, and diversions that would alleviate flood damage. Test them by increasing the flow.

CASTOR SAYS

*Don't build in the floodplain unless you are a beaver.
EROSION

Objective: To demonstrate that water can influence physical features on the surface of the earth.

Vocabulary: erosion, ground cover, runoff, gully, environment

Material: wading pool or stream table, hose or water can, medicine droppers, aluminum foil, gravel, soil and sand

Grade Level: K-6
Subject: Science
Time: 1 hour

Procedure:

1. Set up a stream table or wading pool with various kinds of soil and sand. Include hills and valleys and areas protected with gravel. Apply water in various ways and at various rates and observe and describe the results.

2. Place a thin layer of soil on a piece of aluminum foil. Drop water from a medicine dropper from different heights onto the soil. Describe what happens.

3. Introduce the term erosion and assign students to collect pictures that illustrate how water is changing or has changed the surface of the earth. Use the pictures for a sharing session and a bulletin board display.

Extensions:

1. Take a field trip to observe one or more of the following:
   (a) the effects of a stream on the environment
   (b) gullies caused by rain on newly planted lawn, or at the construction site of a new building
   (c) gullies caused by water running from downspouts of a new house before the grass is planted
   (d) mudslide or gully on a hillslope caused by excessive rainfall, or by water running from a paved parking lot or street
UNDERGROUND WATER

Objective: To make a model illustrating the concept of ground water.

Vocabulary:
- water table
- ground water
- runoff
- aquifer

Materials:
- clear glass pie dish
- sand
- clay
- water

Grade Level: K-3

Subject: Science

Time: 45 minutes

Procedures:

1. Fill a clear glass pie dish about half full of sand. Cover 1/2 of the surface with a flattened sheet of clay, like a pie half covered with a crust. Pour water on both the clay and the sand. Observe and describe what happens. Why does the water run off the clay? Lead the students to conclude that the sand has more spaces for the water to go into. Introduce the terms runoff and ground water.

2. Poke holes down through both the clay and the sand to the bottom of the dish. Note the visible water in each hole. Explain that the top of the ground water is called the water table, and the sand containing the water is called an aquifer. Make a chalkboard drawing illustrating these features.

Extension:

1. Set up an aquarium with various layers of soil, clay and/or sand, and experiment with forming water tables, springs, and ponds.
UNDERSTANDING GROUND WATER

Objective: To investigate factors that influence ground water.

Vocabulary: Materials:

- porosity
- permeability
- saturated
- aquifer
- unsaturated
- pumped well

sand
clay
potting soil
gravel
paper cups
glass
water
graduated cylinders or measuring cups
ground water worksheet

Grade Level: 4-6
Subject: Science
Time: 1 hour

Procedure:

1. Fill four paper cups with sand, clay, loam, and gravel. Add water to each cup until it will hold no more. Record the results, including the amount that each cup holds. Discuss findings. Introduce the terms porosity and permeability.

2. Punch a small hole in the bottom of each cup and record how much water runs out of each sample and how long it takes. Discuss the results. Students should conclude that particle size influences porosity and permeability.

3. Distribute and discuss the ground water worksheet. Introduce the concept of an aquifer, and the terms spring, pumped well, and artesian well.

4. Fill a glass with sand and add water to the halfway mark. Introduce the terms saturated, unsaturated, and water table.

Extensions:

1. Do library research on ground water use and reserves in your area.

2. Obtain permission to visit an operating well (either artesian or pumped) which supplies water for irrigation or drinking.
GROUNDWATER OCCURRENCE, RECHARGE & USE

STORM CLOUD
PRECIPITATION (Natural)
POROUS MATERIAL
SURFACE RUNOFF
RECHARGE STREAM
SOIL MOISTURE MOVING DOWN AFTER A RAIN
ZONE OF AERATION
ZONE OF SATURATION (Groundwater)
WATER TABLE
STREAM
AQUIFER

CONFINING LAYER

RECHARGE (ARTIFICIAL)
PUMP ME DRY

Objective: To illustrate relationships that exist between surface water and ground water.

Vocabulary:
- surface water
- ground water
- replenishment

Materials:
- transparent jar or small aquarium
- plastic soda straw
- sand and pebbles (gravel)
- simulated trees and plants

Grade Level: 4-6

Subject: Science

Time: 35 minutes

Procedures:

1. Place the gravel in the jar or aquarium at an approximate 45° angle. Carefully introduce tap water to the jar until the water level covers approximately 50 percent of the gravel slope. Place the pebbles and plants on the dry portion to simulate land conditions. Have the students note the interaction of the surface water (visible) and the ground water (visible only through the glass sides of the container). Drill a well on the dry (land) side of the container by pushing the soda straw into the gravel to the water table.

2. Discuss and do the following challenges:

   What would happen to the ground water if we add water to the visible pool? What natural condition does this illustrate?

   What would happen to the surface pool if we slowly poured water on the dry portion of the gravel? What natural condition does this illustrate?

   Could we remove most of the water from the jar by sucking on the soda straw? What ground water phenomenon does this illustrate?
Extension:

1. Do library research on ground water depletion in areas such as the High Plains of Texas, Houston, or Phoenix.

*Many people are aware of how badly our surface water supplies are contaminated, but few people are aware that ground water supplies are becoming increasingly contaminated as well.
ARTIFICIAL RAIN

Objective: To compare natural rainfall amounts with the amount of time and water used by a lawn sprinkler.

Vocabulary: precipitation

Materials: square or rectangular pan with vertical sides
ruler
lawn hose
sprinkler
water supply

Grade Level: K-6

Subjects: Science
Mathematics

Time: 30 minutes

Procedures:

1. Place the pan on the lawn and turn on your sprinkler at full pressure. Measure the length of time it takes to fill the pan to a depth of 1 inch. Measure the size of your yard and determine its area in square feet.

2. Calculate how many gallons of water are needed to give your lawn a one-inch equivalent rainfall.

\[
\frac{1}{12} \, \text{ft. (rainfall)} \times \text{lawn area (sq. ft.)} \times 7 \frac{1}{2} \, \text{gal.} = \text{gals.}
\]

Note: 1 cu. ft. = 7 1/2 gal.

3. How long would your garden hose have to run to deliver this much water?

Extensions:

1. Place a rain gage (a can or a bottle) in an open area of the school-yard. Record the amount of rainfall each day, then empty it, for several weeks or months. Average the amount of rainfall per month
over your study period. Determine the record high and low rainfall and average rainfall for each month from local newspapers, weather bureau, or state almanac. Compare the amount of rainfall your school had with the average and record. Make a chart to record your findings.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>OUR RAINFALL</th>
<th>MONTHLY AVERAGE</th>
<th>RECORD HIGH</th>
<th>RECORD LOW</th>
</tr>
</thead>
</table>

2. Do library research on "rain making" or "cloud seeding."

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ACID RAIN

Objective: To explore the topic of acid rain.

Vocabulary: acid rain, pH, acid

Materials: indicated references

Grade Level: 5–6

Subjects: Science, Social Studies

Time: 30 minutes

Procedures:

1. Discuss the topic of acid rain, and the meaning of pH. (See Background Material). Include the following points:

   A. Rain is naturally acid with a pH of less than 7.0.
   B. Rain with a pH of less than 5.0 contains mineral acids such as sulfuric, nitric, and hydrochloric acid.
   C. Acid rain may be caused by volcanic emissions, burning of fossil fuels, and smelting of some minerals.
   D. Some areas of the world have been greatly influenced by acid rain.
   E. Acid rain lowers the pH of lakes and streams. This removes calcium and minerals from soil and water and damages plants and animals. Many affected lakes no longer contain any fish.
   F. Acid rain damages buildings, metal statues and bridges, and automobile finishes.

2. Assign students to read and report on any of the following or similar more recent articles:

   Articles:

<table>
<thead>
<tr>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
</table>
Cowling, E. B. "Acid Precipitation in Historical Perspective"
LaBastille, Ann. "How Menacing is Acid Rain?"
Luoma, Jon R. "Troubled Skies, Troubled Waters"
Peterson, Ivars. "To Catch A Cloud"
West, Susan. "Acid From Heaven"
West, Susan. "Acid Solutions"
Environmental Science and Technology, February, 1982, 16:110A-123A
National Geographic, November 1981, 160(5):632
Scientific American, October 1979, 241:43-51

Extensions:

1. Discuss the economic and environmental implications of outlawing the burning of fossil fuels to lessen acid rain.

2. Collect rain water samples and check the pH with litmus paper or a pH test kit.

*Many Canadians view the topic of acid rain in a different way than most of us do. Find out why.

*Not all the facts are in on acid rain. Will it be too late for some areas if we wait for all the facts before we do something?
WATERSHEDS

Objective: To observe and describe the basic features of a watershed.

Vocabulary: watershed, reservoir, runoff, tributary, pollution

Materials: map worksheets, area maps

Grade Level: 4-6

Subjects: Science, Social Studies, Art

Time: 1 1/2 hours

Procedures:

1. Introduce and define the term watershed. Distribute the school grounds maps to the students. Ask them to assume that the school ground is a watershed. The students' task is to determine where water flows when it rains.

   The completed map should indicate the main water routes (beginning at the school roof drains), feeder routes, and indicate the directions of movement.

2. Discuss the following concepts:

   - What is a watershed?
   - Can you trace the path of a drop of water falling on the school roof until it leaves the school property?
   - Do you know where the water leaving the school grounds ultimately goes?
   - Could we build a dam on the school grounds to capture rainfall runoff water? Where would be the best location?
   - If we did build a dam, what uses could we make of the reservoir?
   - What could we do to keep the school reservoir clean?

TEACHER NOTE: Some school grounds have very distinctive surface features and others do not. You may have to provide some assistance.
in finding a good starting point. A good place to start in most instances is the school roof drains. The questions can be answered either as class discussion or individually and should challenge the students' imaginations. Most children have experience building dams in the street gutters in front of their homes and should be intrigued with the possibility of a school pond. Have the students think of as many uses as possible for the pond (yard irrigation, swimming, boating, fishing, drinking water, etc.). Point out some steps (such as maintaining good grass cover and keeping grounds clean) that will prevent pollution of the pond.

3. After preparing the map and answering the questions, have students examine a county or highway map of the local area to recognize the similarities and differences of the river and tributary systems to their own watershed maps. Note the existence of reservoirs and what the impounded water is used for. Also, indicate where the water falling on the school grounds ultimately goes.

Extension:

1. Take a very large sheet of butcher paper and spread it over rocks, old cans, or other items on the schoolyard so that it is very uneven. This represents watersheds on the landscape. Have the children dress in old clothes. Mix several pints of colored water or washable tempera paint. One at a time, have the children take turns slowly pouring cupfuls of the water on the paper picture from different points. The rainwater (paint) will flow with the "lay of the land" (paper) as it does naturally. After the picture has been painted, it may be displayed in the classroom (for several days) as a class "art" project.

CASTOR SAYS

*Major rivers, such as the Mississippi and Amazon have immense watersheds. The Mississippi River gathers very different pollutants than the Amazon. However, as the Amazon basin is developed this difference will change.
Cfs AND OTHER MEASUREMENTS

Objective: The student will estimate and measure stream flow.

Vocabulary

cubic feet per second

Material:

100' tape or pace-off known length stop watch, or regular one, that displays 1 second intervals

Grade Level: 5-6

Note: Appropriate caution should be used in wading in flowing water.

Subject: Math

Time: 45 minutes

Procedures:

1. Begin the activity by sharing information on measuring stream flow from Background Information. Apply sufficient detail to explain the concept of cubic feet per second.

2. At the field site pick a stretch of stream that is straight. Ask the students to estimate the volume of flowing water.

3. Place two stakes 100 feet apart, on a line parallel to the stream. Throw a stick into mid stream. Time how long it takes the stick to float from one stake to the other. Divide the time by 100. This is the stream velocity in feet per second. Now estimate or measure the average depth and width of the stream. Volume of flow = width x depth x velocity.

Extension:

1. Contact a state or federal water resource agency to arrange a visit to a stream gaging station, then write about what is learned.
Objectives: The learner should understand that:

2.11 The quantity and quality of water influence the distribution and abundance of living things.

2.12 There is a great variation in how water is used by living things.

2.13 Water is essential for life processes in all living things.
Background Information For The Teacher

Life Needs

Life as we know it could not exist without water. Most living things are largely water. In addition to the actual presence of water in all living things, water plays an important role in many chemical reactions.

Water, as a solvent, serves as a medium in which interaction between molecules can take place. Water in the cell provides a medium for the movement of molecules. Diffusion of dissolved material eventually results in a uniform distribution allowing the maximum exposure for chemical reactions.

A very important property of water is that it is relatively stable. With hundreds of reactions taking place in living matter, most of which depend on water, it would be disastrous if the water separated into hydrogen and oxygen. The process of manufacturing food in plants, photosynthesis, illustrates the role water plays in storage of energy in food. Plants use carbon dioxide and water to make sugar. Sunlight is the basic source of energy. Various processes then build these basic sugars into starches, proteins, and fats. The process is reversed in respiration and is chemically similar to burning fuel. Sugar is utilized in the presence of oxygen to produce carbon dioxide, water, and energy.

Biological Characteristics of Water

Most waters of reasonable quality have some form of biological community in them. Aquatic organisms are usually categorized by their habitat or distribution within the body of water. The usual classifications are plankton, nekton, benthos, and bacterial communities.

Plankton consist of small living organisms that float about in water currents. Phytoplankton are the plankton containing chlorophyll and are the basic source of food for aquatic organisms. They consist of various green algae, blue-green algae, diatoms, and pigmented flagellates. The zooplankton are made up of small animals including rotifers, protozoans, and small crustaceans (see Figure 17).

The nekton community is made up of larger organisms that swim freely. Organisms included in this group are fish and free swimming insects. The nekton communities are influenced by depth of water, shorelines, and other environmental factors (see Figure 18).

Benthos refers to all living organisms found on the bottom of a body of water. This includes a diversity of plants and animals (see Figure 19).
Bacterial communities may be found in all parts of a body of water. Bacteria may be planktonic or attached. Both aerobic bacteria (those that need dissolved oxygen) and anaerobic bacteria (those that do not need dissolved oxygen) are found in water. Some of these bacteria break down wastes. They are normally desirable bacteria, but may reach large numbers if water is polluted, resulting in oxygen depletion. Other bacteria play a role in the nitrogen cycle. Bacteria which cause disease such as cholera and typhoid may also be found in water.
Figure 17. Phytoplankton includes blue-green algae, diatoms, green algae, desmids, protozoa, and other floating plants and animals.
Figure 18. The nekton community. Animals are not drawn to scale.
Figure 19. Benthos
Activities

ORGANISM FIELD TRIP

Objective: To conduct a field investigation of aquatic life.

Vocabulary: plankton, nekton, benthos, bacterial community, riffle

Materials: plastic gallon jar, large pan, plankton net, several baby food jars

Grade Level: 5-6
Subject: Science
Time: 1 hour

NOTE: A stream with shallow riffles and still pools is the best site for this activity, but any body of water will do. An irrigation or drainage ditch with only a few inches of flowing water will suffice.

Procedures:
1. Before the field trip, acquaint students with the four categories of aquatic life that are discussed in the Background Information.

2. At the aquatic site, give students some time to look around. Ask them to look for different kinds of aquatic life and to make a list of what they observe. After about 10 minutes, bring the class back together to discuss what they have seen. Categorize the organisms that are seen into one of the four groups, plankton, nekton, benthos, or bacterial community. Chances are that students will have seen only the larger organisms that are easily found. Point out the importance of careful observation and tell why biologists or other scientists must be careful observers.

3. Walk around the area in a group or in several small groups. Direct students so they can observe organisms or evidence of organisms which belong to each of the four categories of aquatic habitats.

PLANKTON: Look at the color of the water in a pool. If the water is green, it is probably because there is an abundant growth of one-celled plant life called phytoplankton. If the water is not green, the phytoplankton are still there, but not in a sufficient number to color the water. Use a plankton net to collect specimens. Pour the plankton sample into a baby food jar and hold it up to the light. The tiny specks that are moving about in the water are zooplankton. Take several plankton samples to the classroom for microscopic examination.
NEKTON: Look carefully into the pools and around the edge of the water. Make a list of all the organisms that can swim freely. Don't forget to look for swimming insects. Nekton is the group most familiar to students. Some students may be able to identify the different species of fish seen. Also, look for turtles, snakes, and frogs. If your library has some good nature books or field guides, use them to identify the nekton that you see.

BENTHOS: Look first at the different kinds of plants that are growing along the stream. Notice that some of the plants which are rooted in the mud have leaves which are completely submerged and others have plant parts that grow above the water's surface. Plants that are rooted in the mud are called macrophytes. Pull some rocks from the water. Some of the rocks may have mats of green algae growing on them. (Note: Algae is sometimes called moss. It is not really moss and this point should be made to the students). If you have a microscope at school, collect samples of the algae so that you can look at the cell structure when you return to the classroom.

Collect some large rocks from a riffle area. Place them in a large pan and cover them with water. Look for different kinds of animals that live on the underside of the rocks. Many of the organisms that you will see are insect nymphs.

BACTERIAL COMMUNITY: In a pool, find an area where there is a soft mud bottom. Look at the material along the bottom. You might find dead plant materials such as leaves covering the mud. Look under the leaves. You will probably find a black material called muck. Muck is composed of fine silt and decomposed plant matter. With a stick or rock, stir up the muck and mud. Notice the odor. Dead plants and animals decay because of bacteria and other fungi that live in water. The presence of decaying plant material and the foul odor have given you indirect evidence of the bacterial community.

OTHER ORGANISMS: You have observed organisms that make up the aquatic community. The organisms are ecologically interrelated. Ecological relationships do not stop at the water's edge. Look around the body of water for land animals, foot prints or other evidence of land organisms that depend on the aquatic habitat for water and food.

4. When you return to the classroom, write the four categories of aquatic habitats on the blackboard. Ask students to list all of the organisms that they observed under the appropriate group as they discuss their observations.

Extensions:

1. Set up a classroom aquarium and attempt to maintain some organisms collected on the field trip.
2. Write a sentence about each organism collected. Describe how it may be dependent upon another organism. Relate relationships to other organisms that may have been in the same area, but not observed.

CASTOR SAYS

There would be no point in a field trip if there were no adventure involved. There is no adventure without a risk. However, where there are risks, proper precautions should be exercised. Water can be dangerous!

*An unstructured experience for students not accustomed to field trips will be of little value.
EFFECT OF WATER POLLUTION ON PLANTS

Objective: To demonstrate that some materials dissolved in water can harm plants

Vocabulary:
- pollution
- germination
- dissolve
- solution

Materials:
- 5 - 1 gallon jars of water labeled A-E
- vinegar
- salt
- sugar
- baking soda
- plastic cups or milk cartons
- potting soil
- bean seeds

Grade Level: K-3

Subject: Science

Time: Long term project

Procedures:

1. Introduce the term pollution. Discuss things that might pollute water and the influence they might have on living things in the water.

2. Add 1/2 cup salt, vinegar, sugar, and baking soda to jars A-D. Discuss where the substances go. Review the terms dissolve and solution. Allow a few students to taste each water sample. Ask them if they feel the water is polluted. Compare the taste with container E which contains only tap water.

3. Label containers of germinated seeds A-E. Water the seeds in each jar over a period of at least two weeks with water from the jar with the same label. Compare the plants. Discuss the influence various water pollutants might have on the plants.

Extensions:

1. Discuss dangers of drinking polluted water. Include the concept of water borne diseases.

2. Discuss ways to purify polluted water.
WATER POLLUTION

Objective: To identify some of the basic principles of water pollution.

Vocabulary: pollution, suspended, dissolved, solids

Materials: clean water in glass container, salt, chalkdust or talcum powder, spoon

Grade Level: 2-6

Subject: Science, Social Studies

Time: 1 1/2 hours

Procedures:

1. Stir a spoonful of salt into the water. Observe and discuss what happens to the salt. Stir a spoonful of chalkdust or talcum powder into water. Discuss the difference between what happened to the salt and to the chalk. Introduce the terms suspended, solids, and dissolved. Ask students to suggest ways to remove each substance from the water.

2. Define pollution as unwanted materials that are either dissolved or in solid form in water. The solid materials may be suspended or settled to the bottom. List some common pollutants found in water.

3. Arrange for students to contact agencies such as: local municipal water treatment plants, U. S. Environmental Protection Agency, U. S. Soil Conservation Service, U. S. Fish and Wildlife Service, State Water Pollution Control Agencies, State Fish and Wildlife services, and Municipal Pollution Abatement offices. Arrange for as many group interviews as practicably possible, with each group asking the questions outlined below. The students should be prepared to take notes during the interview in preparation for group reports to the class.

4. Discuss the following concepts:

   Does your job involve water pollution investigation or prevention? What are your duties?
Do you have any special training or education that enables you to do your job?
What are the most serious water pollution problems in this area?
What is being done to correct or eliminate the problems?

If, following the group reports, a particular local water pollution problem is apparent, the class may wish to further investigate the matter. This could be done by additional interviews, individual research, and class field trips.

3. Design a class bulletin board dealing with pollution. Titles might include:

Dirty Stuff in Our Water
Death of a River
This Water Makes Me Sick

**Extensions:**

1. The statement "Water, water everywhere, and not a drop to drink" could be true in many places. List possible reasons water might not be fit to drink even though it may be plentiful. Use the game "20 Questions" to highlight causes of water pollution.

2. As an out-of-class assignment, have students cut out newspaper articles or write summaries of radio and television reports that deal with water pollution. They must decide which category of water pollution is reported in the news item so they can post it in the scrapbook or on the bulletin board in the appropriate section. The teacher may wish to have students make a written or oral report about their news item. Keep a calendar near the current events display. Circle each day on which water pollution was reported by the media. Students will see that water pollution is a common problem which occurs somewhere every day.

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*Water too polluted to swim in may be usable for agriculture.
*A pollutant for one organism may be a nutrient for a different organism.*

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HABITAT COLLAGE

Objective: To illustrate relationships between the type of water body and the organisms found within.

Vocabulary:
habitat
community

Materials:
scissors
sports magazines

Grade Level: 3-6

Subject: Science

Time: 45 minutes

Procedures:

1. Introduce the terms habitat and community. Indicate that fresh water habitats may be divided into two major groups: (a) running water which includes all flowing streams, and (b) standing water which includes ponds, lakes, and swamps.

Organisms found in fast flowing water contain different organisms than are found in still water.

2. Use magazines such as Outdoor Life, Field and Stream, etc., to obtain pictures of various water habitats. Cut out pictures to make collages. Group pictures into the two habitat groups. Talk about the kinds of organisms that are found in each community.

Extensions:

1. Make field trips to various water habitats. Collect, identify, and compare organisms from each area visited.


3. Use cinquain poetry to describe habitats. A cinquain is written as follows:

Line 1 - One word which identifies the subject or title (noun)
Line 2 - Two words which explain the title (adjective, adjective)
Line 3 - Three words which show action (verb, verb, verb)
Line 4 - Four words which complete line three (a thought)
Line 5 - One additional word which also explains the title (noun)

Example: Water
Blue, clear
Flowing, rippling, babbling
A place fish call home
Lake
Objective: To demonstrate water-soil-habitat relationships.

Materials:
- 1/4 x 4' x 8' fiberboard
- cheap paint brush
- blue tempera
- glue (1/2 white glue, 1/2 lacquer, qt. of each, mix together well)
- collecting tools, (nets, bags, jars, spade, etc.)
- slope indicator (range poles and string)
- notebooks

Grade Level: 5-6

Subjects: Art
- Science

Time: 1 hour field
- 1 hour classroom

NOTE: This activity requires field collections. Collecting must be done in permitted areas and must be done with a minimum of damage to the environment. Be an intelligent consumer. Appropriately preserve the specimens collected for use in this project.

Procedures:

1. Study a cross section of ground from one foot into the water to seven feet inland. Carefully observe soil profiles and living things found in the cross section.

2. Collect typical plant and animal specimens from each one-foot interval. Include liberal soil samples. These samples should include soil down to below water level for all eight stations.

3. Sketch the profile and obtain the slope for the line by using range poles and a string (see Chapter 6, Range Poles).

4. On return to the classroom, place the 4' x 8' fiberboard on a table.

5. Sketch the soil-air and water surface in with chalk.

6. Cover the soil part of the sketch with the glue mixture (no rush, this stuff dries slowly).

7. Add soil samples to the glue to show a correct soil profile.
8. Add any soil organisms that may have been collected. Specimens in small jars with preservatives added will last the longest.

9. Add glue to the water area.

10. Sprinkle in blue tempera and blend to color the water area.

11. Attach any water plants and/or animals. Small fish may be placed right in the glue.

12. Attach land plants with appropriate areas of glue.

13. Let dry 2 days.

14. Display the 4 x 5 picture.

Extension:

1. Intelligent collecting should have been the rule. How much damage did this activity do to the environment? How long will it take for the area to recover? How many "Big Pictures" could be taken from the area. What advantages are there in having a "Big Picture" in the classroom.

*CIf you use mounted birds or nests for this activity, make sure you are not breaking the law.

*Since this is an expensive activity, make it a work of art.
Objective: To infer a relationship between ground water reserves and population growth.

Vocabulary:
- aquifer

Materials:
- colored pencils
- graph paper
- rulers
- data from Table 3

Grade Level: 5-6

Subjects: Math
Social Studies

Time: 35 minutes

Procedures:

1. The data in Table 3 represent historic and projected water pumpage from the Edwards Aquifer in southern Texas. The first column lists dates in ten year increments from 1950-2040. The second column is the rate at which water returns to the aquifer in thousands of acre feet. An acre foot is an acre of water one foot deep or 325,851 gallons of water. The third column is the rate at which water is pumped from the aquifer in thousands of acre feet. Share this information with the students.

2. Use this information to graph recharge and use. Use either a bar or line graph.

3. Interpret the graphs and relate them to the population growth.
Table 3.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Recharge (acre feet x 1000)</th>
<th>Discharge (pumpage) (acre feet x 1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>200.2</td>
<td>193.8</td>
</tr>
<tr>
<td>1960</td>
<td>828.8</td>
<td>227.14</td>
</tr>
<tr>
<td>1970</td>
<td>661.6</td>
<td>329.1</td>
</tr>
<tr>
<td>1980</td>
<td>350.1</td>
<td>443.0</td>
</tr>
<tr>
<td>1990</td>
<td>466.9</td>
<td>518.3</td>
</tr>
<tr>
<td>2000</td>
<td>530.7</td>
<td>636.1</td>
</tr>
<tr>
<td>2010</td>
<td>555.9</td>
<td>768.4</td>
</tr>
<tr>
<td>2020</td>
<td>395.2</td>
<td>906.4</td>
</tr>
<tr>
<td>2030</td>
<td>396.2</td>
<td>1092.0</td>
</tr>
<tr>
<td>2040</td>
<td>472.9</td>
<td>1129.4</td>
</tr>
</tbody>
</table>

4. Discuss ways to alleviate the problems depicted by these data.


*Puzzle: When is money the universal solvent? Answer: when you have to get water to flow uphill to replace locally diminished supplies.

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AQUATIC FOOD CHAINS

Objective: To identify the components of an aquatic food chain and to illustrate their importance in maintaining a balance of nature.

Vocabulary:
- food chain

Materials:
- large box of large breakfast cereal
- three different colors of cloth
- 1 sandwich bag for each student

Grade Level: 4-6
Subject: Science
Time: 45 minutes

Procedures:
1. This is a game of tag to be used in demonstrating how a food chain works in nature. Cereal will represent phytoplankton and will be spread out on the school grounds over an area approximately 60 feet by 60 feet.

   Students will play the roles of bass, minnows, and water fleas. Different colors of cloth will be used as headbands to identify the different organisms. There should be approximately twice as many minnows as bass and twice as many water fleas as minnows. Water fleas will simulate feeding by picking up the phytoplankton (cereal) from the ground and placing it into their sandwich bags. Minnows will feed only on water fleas. When a minnow catches (tags) a water flea, the water flea is out of the game and must dump all of his cereal into the bag of the minnow. Bass feed only on minnows. When a bass catches a minnow, the minnow is out of the game and the bass takes the bag of cereal which belonged to the minnow and places it in his own sandwich bag. The object of the game is for each organism to feed without getting caught.

   Begin the activity in the classroom by holding a class discussion to develop an understanding of what a food chain is. Explain the rules of the game and appoint students to serve as the different organisms.

2. Take the students to the school ground to play the game. First tell the students that you wish to demonstrate the game before everyone plays. This will be done to show students how to play, but more
importantly, it will be done to develop an understanding of the balance between producer and consumer organisms in nature.

3. Appoint 10 water fleas, 5 minnows, and 2 bass to serve as the demonstration group. Give the signal to begin the game. Allow the demonstrator group to play until all of the students in one of the consumer groups are captured. This will take only a few minutes. Ask students that were caught to join the group that have not played. Now explain that in order for an organism to survive, it must have food. Ask the players to check their bags. If they do not have food, they cannot survive and must join the other students. Ask the students if the number of survivors in the demonstration game illustrates a balance of nature and why there must be a balance of nature. Point out that in a balanced community, there are more plants (producers) than there are plant eaters (primary consumers) and more plant eaters than animal eaters (secondary consumers).

Begin the game with the entire class by releasing the water fleas first. In approximately one minute, release the minnows and finally the bass. Allow the game to go on for a few minutes but stop playing before any group of consumers is completely captured. Divide the class into survivors and non-survivors. Students who were caught or who collected no food will be non-survivors, and those who do have food will be survivors.

4. Conduct a class discussion to answer the following:

   How many water fleas, minnows, and bass survived?

   Do the results indicate a balanced community? Why or why not?

   TEACHER NOTE: If the community was not balanced, adjust the ratio of consumers and play again.

   What would happen in nature if there were not enough phytoplankton?

       (No food could be produced and all animals would die.)

   In nature, if there were no surviving water fleas, what would happen to the phytoplankton?

       (The population would grow out of control.)

   If there were no surviving minnows, what would happen to phytoplankton and bass?

       (The population of water fleas would increase, and they would eat too much phytoplankton causing its population to decrease. There would be no food for bass, and they would starve.)
Do bass need phytoplankton? Why or why not?

Yes. Without phytoplankton there would be no food for animals that bass feed upon.

Do you know of any organisms that are not a part of a food chain?

Suppose that this year there are a lot of bass and that they eat so many minnows that the minnow population decreases but does survive. How will water fleas, phytoplankton, and bass populations be affected next year? How will they be affected year after next? Why is this a part of the balance of nature?

Extension:

1. Invite a local conservation officer in to discuss aquatic food chains which sustain local fish populations.

CASTOR SAYS

*Totally removing any link in a food chain may have disastrous results on other organisms.

*Food chains are linked together in food webs.

*Food, water, shelter, and space make up a habitat. Habitats, food chains, and food webs are all linked together in a given environment.
ECOLOGICAL SUCCESSION

Objective: To demonstrate the concept of ecological succession.

Vocabulary:
- ecology
- ecological succession

Materials:
- two transparent gallon jars
- dead leaves
- pond or stream sediment
- pond water

Grade Level: 4-6

Subject: Science

Time: Long term project

Procedures:

1. Put pond sediment into two jars to a depth of 5-10 centimeters. Add 4 or 5 leaves to each jar. Fill the jars about 3/4 full with pond or river water. To one of the jars add 2 tablespoons of lawn fertilizer and label the jars "fertilized" and "unfertilized." Place the jars in a suitable location in the classroom where there is diffused light and a fairly stable temperature. After the suspended materials have settled out and the water is clear (4-24 hours), observe the color of the water and count the number and kinds of organisms living in the jars (at first, few or no organisms will be seen). Record your observations for each jar so that you can refer to them later. Make weekly observations for the first 3 weeks.

2. After about the first 3 or 4 weeks, many different organisms may be seen in the jars, so you may wish to make observations 2 or 3 times a week. Continue the activity for as long as you wish, but for at least 6 to 8 weeks. Record the date and time of each observation period and write notes on what you have seen so that you can compare the changes that take place in the fertilized and unfertilized jars.

3. A scum may develop on the surface or the water may become cloudy. This indicates an increase in bacterial growth. If the water begins to have a greenish tint, one-celled algae (plankton) are developing. Algae and/or fungi may begin growing on the sides of the jar. Larger animals and plants may then develop. If a microscope is available, look at a few drops of water during each observation period. Also,
notice the changes in color and characteristics of the sediment and the water odor in each jar. Some of the organisms that you see will be too small to make out any details without magnification. Make drawings of those organisms that are large enough and use Figure 17 or other sources from the library to identify them.

4. As water evaporates from the jars, it should be replenished with chlorine-free water. If pond water is not easily obtainable, tap water can be used if it is allowed to set in an open container for at least 24 hours.

5. After all observations are completed, conduct a class discussion to answer the following questions:

How does this activity illustrate the early stages of ecological succession in a pond?

(The discussion should center around the changes observed in plant and animal life in the jar and the changes that took place in the sediment.)

What differences were observed between the fertilized and unfertilized jars?

Where in nature might one find fertilized conditions in water?

(Below wastewater discharges into streams or reservoirs; rainfall runoff from lawns, fertilized crop land and cattle feedlots; irrigation runoff from lawns, golf courses, and crop land; urban runoff.)

When could fertilizer (plant nutrients) be considered a water pollutant?

(When they cause excessive algae blooms which cause bad taste and odors in drinking water, unsightly conditions in surface water, and fish kills.)

How do plant nutrients affect ecological succession in a pond?

(They may speed up the aging process by causing increased plant growth, thus reducing the useful life of the pond.)
DECOMPOSERS

Objective: To observe some decomposer organisms and recognize their importance in the balance of nature.

Vocabulary:
- decomposer

Materials:
- beef bouillon cubes
- gelatin
- hot plate
- pan
- baby food jars and lids
- medicine droppers
- rubbing alcohol
- paper towels

Grade Level: 4-6

Subject: Science

Time: 1 hour

CAUTION: Do not remove the lids of the culture once they have been incubated.

Procedures:

1. Sterilize 6 to 8 baby food jars and lids by washing them in alcohol. Allow them to completely dry upside down on a paper towel in air before adding culture media. Additional baby food jars for collecting samples and the medicine droppers should be sterilized in the same manner.

   MEDIA PREPARATION: (1) Dissolve 2 beef bouillon cubes in 1 cup of boiling water. (2) Allow to cool. (3) Sprinkle 2 tablespoons of gelatin into a saucepan containing the cool bouillon mix. (4) Place over low heat and stir until gelatin dissolves. (5) Pour the hot mixture into baby food jars to a depth of about one inch. Place lids on the jars and allow the media to cool and gel before use. These are now called "culture jars."

2. Using a clean, sterile baby food jar, collect a water sample from a stream, pond, or reservoir. In another jar, collect some bottom sediment and cover it with water.

3. Place the following labels on four different culture jars: Pond Water, Sediment, Tap Water, Control.
Shake the water samples: then use a sterile medicine dropper to transfer 10 drops of pond water to the appropriately labeled culture jar. Use a different sterile medicine dropper and transfer 10 drops of pond sediment suspension to its culture jar. Turn on a water faucet and allow it to run for about 1 minute, then cut the faucet off until it drips slowly. Allow 10 drops of tap water to drip into its culture jar. Do not add anything to the jar labeled "control."

4. Swirl each culture jar to cover the gelatin with the sample added. Be sure the lids are on tight, then turn the jars upside down and place them in a dark, warm spot to incubate. A hot water heater closet would be a good place, or an incubator could be made from a cardboard box and a heating pad. Incubation temperature should be 85-95°F. If a heater closet is used, do not place the culture jars directly on top of the heater because the media will melt.

5. Allow the cultures to incubate for approximately 24 hours. Examine the gelatin and count the colonies of bacteria and fungi. Do not remove the lids. Incubate the cultures for an additional 24 hours and count the colonies again. Colonies have grown from single spores or cells that were in the samples. The "control" jar is incubated to be sure our culture jars were sterile. If the "control" jar has bacteria or fungi growing in it, we will know that our jar or media was not completely sterile and that some of the growth in the other culture jars may not be from the sample. If the "control" jar is free of growth after incubation, we know that all the growth in the other cultures came from water that was added. Scientists should always have some kind of control.

Bacteria and fungi are called decomposers because as they get their food materials from dead plant and animal matter, they help to decay the dead material.

6. Discuss the following concepts.

Why are bacteria and other fungi called decomposers?

(They cause decay of dead plant and animal material.)

Why are they important in nature?

(They help to recycle elements and molecules which are necessary for other living organisms.)

What would happen if there were no decomposers on earth?

(Dead plants and animals could not decay.)

Why is it necessary to kill bacteria in drinking water?

(Some bacteria cause disease if they are taken into a human body.)
TEACHER NOTE: Dispose of the used culture jars in a garbage container. Do not remove the lids from the jars because the cultures may have an unpleasant odor and could contain disease causing bacteria.

Extensions:

1. The activity could be expanded for the class or used as a science fair type project by taking samples from several different water sources.

2. Write a short story about what it would be like on the earth if suddenly all decomposers were taken away.

CASTOR SAYS

*This earth would be a mess if there were no decomposers.

*Puzzle: How can you tell if a decomposer is cultured? Answer: When it is grown in a school of Arts and Science.

*Puzzle: How can you tell if a decomposer is a gourmet? Answer: When the recipe for its medium has more than three ingredients.
ALL LIVING THINGS NEED WATER

Objective: To demonstrate that living things need water to live.

Vocabulary: wilted

Materials: potted plants (wilted)

Grade Level: K-2

Subjects: Science, Art

Time: 45 minutes

NOTE: The plants used to begin the activity must be wilted. You will need to experiment ahead of time to determine how long the plants need to go without water in order to wilt, but still be able to recover when watered.

Procedures:

1. Display the wilted plants. Discuss reasons they look so bad. Students should be able to observe and describe the dry soil, leading to the inference that the plants look so bad because of lack of water.

2. Water the plants and observe the results. Discuss how other living things need and use water.

Extension:

1. Have students draw pictures of animals and plants using water.

CASTOR SAYS

*For a beaver, happiness is fresh, clean water.
Objective: To show that water is an important component in the life processes of plants.

Vocabulary:
- specimen
- component
- life processes

Materials:
- 5 different plant parts
- 3 flat trays
- balance or scales
- paper towels

Grade Level: 3-6

Subjects:
- Science
- Math
- Social Studies

Time: Long term project

Procedures:

1. Label and weigh each plant specimen. Record weight data. Place the plants on a tray covered with several layers of paper towels. Weigh the plants every other day over a period of two weeks.

2. Discuss the following questions:
   a. Which days showed the greatest weight loss? Why?
   b. Is there any water left in the plants after two weeks? How can you be sure?
   c. Did any of the plants get heavier?
   d. Calculate the percentage of water in each plant.

Extension:

1. Obtain a food dehydrator and dehydrate foods such as bananas, apples, or tomatoes. Compare dry weights with original weights.
Objective: The learner should understand that:

3.11 Different water uses require different water qualities and quantities.
Background Information for the Teacher

**Municipal Water Use**

Water use may be termed consumptive and nonconsumptive. In consumptive use, the water is temporarily lost to further use by man such as that used by plants in irrigation. Nonconsumptive use, as in bathing or dishwashing, may return the water to a treatment plant or a stream and it is available for further use.

Most of the U.S. population is served by public water supply systems. Cities obtain water from either rivers and lakes or from ground water. The amount of water in a stream may be too small to supply demand during low flow periods. Cities on such streams usually build reservoirs to store water to assure an adequate supply of water at all times. Drought conditions may dictate water use restrictions such as not watering lawns.

Cities that obtain water from underground supplies drill wells that penetrate water holding aquifers. Many areas of the United States that use ground water have experienced dramatic draw down of the water table. In cities of the southwest, these supplies are being only slowly replenished by infiltration. Such areas face certain future shortages unless their management schemes are altered.

Nearly all water used by cities receives some form of treatment before use. A water treatment plant may put water through a number of purification processes such as coagulation and settling, filtration, and disinfection. Untreated water containing sediment flows into the treatment plant and is mixed with chemical coagulants. Alum, aluminum sulfate, is often added as a fine powder coagulant. This causes jelly-like globs, called floc, to form. Bacteria, mud, and other sediment tend to stick to these masses. In a settling basin, the floc settles to the bottom and is referred to as sludge.

Filtration removes more particles. Water is passed through beds of fine sand and gravel to produce clear water. Sand used in filter beds is of a special size and structure. The total bed is about 30 inches deep. The water is passed through the bed at the rate of up to two gallons per square foot per minute. Then a disinfectant is added to kill bacteria. Chlorine is the chemical most often used for this purpose. Recent research has indicated that there are some potential health hazards associated with chlorine in drinking water.

Treated water is pumped into mains for distribution throughout the city. These pipes carry water to fire hydrants and smaller distribution pipes leading to every home and business.

Water may also be pumped into storage tanks that maintain water pressure due to gravity. These tanks are built on hills or placed on towers that are higher in elevation than the building using the water (see Figure 20).
Figure 20. Water and Wastewater Systems
In most areas each home has a meter to measure water use, and the householder pays for the water he uses. In areas where users are charged a flat rate, it has been found that families use more water than families where water is metered.

A water supply system must be designed to accommodate a much larger demand than for homes only. Industry may use far more water than households. The system must be able to handle fires and peak demands that occur during hot weather. Pipes must be designed to accommodate normal peak load and a major fire at the same time.

Much of the water used in homes serves the purpose of carrying away wastes. Organic wastes are subject to action by bacteria and are referred as biodegradable. The main function of a sewage treatment plant is to remove the biodegradable wastes. Oxygen plays a major role in breakdown of sewage. Raw sewage dumped into a stream will react with oxygen that is present. This process of decomposition may use up all of the available oxygen in the water and cause fish and other organisms to die. Decay then proceeds in the absence of oxygen. This process produces foul smelling gases such as ammonia and hydrogen sulfide, the rotten egg gas.

The usual stages of sewage treatment involve a first stage called primary treatment, along with secondary treatment, and possibly a third treatment. Primary treatment removes large solids such as sticks, rags, and sand. This is all that is done in some systems. The sewage is then chlorinated and discharged into a stream. This first step reduces the pollution load by about 35 percent.

Secondary treatment involves further action by spraying the sewage on beds of coarse gravel. As the sewage trickles over the gravel, bacteria further decompose the sewage. The waste is then collected in tanks for further organic action. This process may be designed to yield the valuable by-product methane, which can be used for heating. Further third step treatment, similar to that used for water supply systems, could render the water pure enough to drink.
Figure 21. Generalized Steps in Water Treatment
Agricultural Water Use

In some areas more water is used for irrigation than any other use. Most irrigation in the United States occurs in the West where summer precipitation is low. Irrigation water is measured in acre feet. An acre foot of water is enough to cover an acre of land one foot deep, and is equivalent to 326,000 gallons.

One of the major problems with irrigation is maintaining an adequate water supply during the growing season. In many areas, the annual rainfall pattern is such that water for irrigation falls during the non-growing season and must be stored for summer use.

Industrial Water Use

Industry uses more water than any other natural resource. It takes about ten gallons of water to produce one gallon of gasoline, 65,000 gallons to produce a ton of steel, and 60,000 tons to make a ton of paper. Water for these needs is drawn from lakes, rivers, municipal water systems, and from industry-owned wells. Food processing also uses large amounts of water. Fruits and vegetables must be washed before they are canned or frozen. Water is used in the production of soft drinks and other beverages. It takes 300 gallons of water to make a barrel of beer. Meat processing requires large amounts of water. Cooling of factory processes and air conditioning of factories also uses large amounts of water.

Figure 22. Did you know that it takes 136 gallons of water to make one loaf of bread and 100,000 gallons of water to make an automobile?
Only about two percent of the water used by industry is consumed. The remainder is returned largely to streams and lakes for further use. These activities produce a variety of pollutants. Some of these wastes can be degraded by bacteria. Others may combine with chlorine from municipal supply systems to form compounds that smell and taste worse than the original waste product. Even more serious is the fact that such chlorinated compounds have been implicated as cancer causing agents.

Water that has a pH of less than seven is easily polluted with metals. Lead and arsenic are common industrial pollutants. These pollutants are cumulative in their effect on organisms, so even though they may be present in small amounts, they may, over time, lead to serious illness or death.

Pollutants from other processes may include large amounts of organic fiber. When discharged into streams, this can create beds of sludge that blanket stream beds, killing clams and other organisms at the bottom of the stream. Sludge may also reduce the amount of available oxygen in the water. If the sludge breaks down without oxygen, toxic wastes such as hydrogen sulfide may be produced. Hydrogen sulfide in small amounts smells terrible and is very toxic to fish. Sugars and other soluble carbohydrates may also result in oxygen depletion.

Another form of industrial water pollution is heat. Industrial cooling processes often pass the heat gained in cooling on to a stream. The increase in stream temperature may greatly alter the stream environment.

Biochemical Oxygen Demand (BOD)

When organic material pollutes water, it generally serves as food for microorganisms. As the microorganisms multiply, oxygen in the water is depleted causing fish and other life to die. This type of pollution cannot be measured by determining the total amount of organic matter in water because not all organic matter can be utilized by microorganisms as food. Some organic matter may be nonbiodegradable. For example, sugar is a much better nutrient for bacteria than petroleum. BOD, biochemical oxygen demand, refers to the process by which both rate and quantity of organic matter is consumed by microorganisms and reflects the amount of oxygen needed to decompose organic pollutants.

The generally accepted BOD test measures the amount of oxygen used over a five day period by aerobic bacteria in a given volume of water at room temperature. A rough estimate of BOD can be achieved by adding a few drops of a weak methylene blue solution to a water sample. The rate at which the sample turns clear will be an indication of oxygen demand. An equal volume of distilled water can be used as a control.

Water Law

Most water use laws in the United States fall into two categories: riparian doctrine and prior appropriation doctrine. Other groundwater laws include: absolute ownership, reasonable use, and correlative rights.
The riparian, or common law doctrine, gives a land owner certain rights if his property is bounded or crossed by surface water. These rights include use of water for domestic and household needs, livestock watering, fishing and recreation. Rights may even include power generation. Most states have modified the law to permit owners to take water for "extraordinary and artificial" uses so long as those uses do not interfere with the riparian owners downstream, thus allowing for municipal use, industry use, and irrigation.

Prior appropriation doctrine applies in most western states. The Pioneers appropriated surface waters when they settled in Utah. Under this doctrine a party may apply to divert a specified quantity of water from a public source for a private use. When such a claim is filed, the first claimant has priority over all other later claimants. This is a "first in time, first in right" doctrine (see Figure 23).

Unlike the riparian right, the appropriation right can be lost through misuse or nonuse. The appropriation right is a property right, and as such, has value and can be exchanged. Most western states also apply prior appropriation doctrine to ground water.

Figure 23. Under Prior Appropriation doctrine later settlers cannot get any water until earlier settlers have received their shares. In dry years they may receive none at all.
Activities

HARD WATER

Objective: To identify water hardness as a factor in water quality.

Vocabulary:

<table>
<thead>
<tr>
<th>Material:</th>
</tr>
</thead>
<tbody>
<tr>
<td>hard water</td>
</tr>
<tr>
<td>soft water</td>
</tr>
<tr>
<td>calcium</td>
</tr>
<tr>
<td>magnesium</td>
</tr>
<tr>
<td>soap</td>
</tr>
<tr>
<td>detergent</td>
</tr>
</tbody>
</table>

Material:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>distilled water</td>
</tr>
<tr>
<td>epsom salts</td>
</tr>
<tr>
<td>3 quart jars with lids</td>
</tr>
<tr>
<td>liquid soap (not detergent)</td>
</tr>
<tr>
<td>ruler</td>
</tr>
<tr>
<td>medicine dropper</td>
</tr>
<tr>
<td>tap water</td>
</tr>
</tbody>
</table>

Grade Level: 4-6

Subjects:
Science
Social Studies

Time: 40 minutes

Procedures:

1. Explain that "hard water" is water which has calcium and magnesium dissolved in it; "soft water" has little calcium or magnesium. The hardness of water may affect the amount of suds produced when soap is added. The liquid soap used in this activity must be "soap" as contrasted to many detergents on the market.

2. Equally fill 2 quart jars 1/4 full of distilled (ironing) water. Distilled water contains little or no dissolved chemicals, and is, therefore, soft. Use one of the jars of distilled water to make some hard water by adding 3 heaping teaspoons of epsom salts which contain magnesium. Mark this jar "H" for hard water. Mark the other jar "S" for soft water. Fill another quart jar 1/4 full of tap water and mark this jar with a "T" for tap water. To each of the 3 jars, add 5 drops of liquid soap. Seal each jar tightly and shake vigorously for 30 seconds. Measure the depth of the suds layer in each jar from the top of the water line to the top of the suds layer.

3. Discuss the following:

Which type of water produces the most suds. How many centimeters of suds are there in each jar? What do you think caused the difference in the sudsing level? Does this difference happen naturally in water
from different areas? Does jar "T" suds more like "H" or "S"? According to the results of this experiment, do you think your tap water is hard or soft?

What would happen if people camping by a soft water stream washed their clothes in the stream? Could it be hard to wash clothes with soap if your water were very hard? When washing clothes or taking a bath, could you use less soap in a soft water area than in a hard water area? Ask the teacher or the water superintendent in your town about the hardness of the water in your area. Do the results of your experiment agree with this information?

Extensions:

1. Compare the performance of various detergents with that of soap by using the above procedures as a model.

*Water hardness affects animals other than man. The neon setra, a common aquarium fish, must have very soft water in order to reproduce. Fish from the Rift Lakes of Africa cannot live in soft water.

*Puzzle: When is soft water hard? Answer: When it is frozen.
WATER FOR RECREATION

Objective: To investigate various recreational water uses.

Vocabulary: recreation

Materials: state maps

Grade Level: 3-6

Subjects: Social Studies, Language Arts

Time: 1 1/2 hours

Procedures:

1. Begin the activity by listing on the chalkboard the different types of water sports. Have each student recopy the list by putting his favorite sport first and least favorite last. Rearrange the class so that they are grouped by favorite water sport. Have each group list the kinds of equipment and skills needed for their sport.

2. Have each group plan trips within the state to enjoy their favorite water recreation.

Extension:

1. Have a water safety message contest. The message could be in the form of a poster, poem, picture, bulletin board, or skit.

2. Plan a recreation fair at your school. Make posters for the different sports. Invite local stores to participate by displaying and demonstrating equipment. Include demonstrations on water safety, fly tying, casting, films on water skiing, etc.
WATER PURIFICATION

Objective: To investigate some of the ways in which water can be purified.

Vocabulary: purification coagulation sedimentation filtration disinfection

Materials: alum water soil two glasses or beakers spoon washed fine sand piece of cloth funnel water purification worksheet

Grade Level: 2-5

Subjects: Science Social Studies

Time: 45 minutes

Procedures:

1. Stir a spoonful of soil into each of two glasses of water, then sprinkle a spoonful of alum into one glass. Compare the two glasses over a half-hour period. Introduce the terms coagulation and sedimentation. Let the glasses set overnight, observe and discuss them the next day, then discard the contents.

2. Place a small piece of cloth over the hole in a funnel. Then fill the funnel with fine washed sand. Stir a spoonful of soil into a glass of water. Pour the muddy water through the funnel into another glass. Introduce the term filtration and discuss the results. (The water should be clearer.)

3. Provide students with the water purification worksheet. Label and discuss each component.

Extensions:

1. Develop a new method of purifying water.

2. Do library research on desalination.

3. Investigate diseases carried by water, and how they can be controlled or eliminated.
Objective: To identify the basic steps used in treating surface water.

Vocabulary:
- flocculation
- filtration
- coagulation
- sedimentation
- sterilization

Materials:
- two (2) quart fruit jars
- aluminum sulfate
- sand filter (constructed from 1 gallon jug)
- a two quart sample of any surface water (river, lake, pond)
- chlorine bleach

Grade Level: 4-6
Subject: Science
Time: 1 hour

NOTE: Students will ask if the finished water is safe to drink and probably will want someone to taste it. The water is probably safe to drink; however, since controls and tests available at modern water plants are not available in the classroom, we should not take the chance of drinking contaminated water and becoming ill. This activity works well following a water plant tour. If the class is unable to make the field trip, one or several students may wish to make the field trip and take photographs for class use and study.

Procedures:

1. Fill the clean quart fruit jars with the surface water. Have students put 5-10 grains of the granulated alum in one of the jars and take turns stirring with a tablespoon for 3-5 minutes. Look for the development of aluminum hydroxide "floc" particles. Let the jar settle for 10-15 minutes and observe the difference in water clarity in the two jars. Point out that this experiment demonstrates the coagulation and sedimentation steps in water treatment.

2. To demonstrate filtration, construct a filter by cutting the bottom from a plastic gallon jug and inverting the top of the jug over a clean quart jar. Stuff a paper towel or some cotton tightly into the throat of the jug and place 6-8 inches of clean fine sand into the jug. A portion of the coagulated and settled water can now be
carefully poured through the filter. If some of the alum floc goes over into the sand filter, it will enhance the filterability of the filter and produce a cleaner filter effluent. After a portion of the water has been filtered, have students compare the water clarity of the raw and finished water. One drop of household chlorine bleach dropped into the filtered water will complete the four step process (sterilization).

Extensions:

1. Visit a local water treatment plant.
2. Do library research on water carried diseases.

*You cannot tell if water is safe to drink by looking at it. Never drink water from a stream.

*Puzzle: When is Minneapolis' wastewater someone elses water treatment problem? Answer: Whenever Minneapolis does not adequately remove pollutants. The Mississippi River then becomes the longest sewer in the United States.
WASTEWATER TREATMENT

Objective: To establish the importance of wastewater treatment facilities.

Vocabulary:

- primary treatment
- secondary treatment

Materials:

- none

Grade Level: 4-6

NOTE: Refer to Background Information. Discuss some of the basic concepts of wastewater treatment.

Subjects: Science
Social Studies

Time: 50 minutes

Procedures:

1. Research the following questions:
   a. What type of wastewater treatment facility does your community use?
   b. Where is it located?
   c. How much wastewater is treated there each day?
   d. How much wastewater is the facility designed to treat?
   e. Does the facility have sufficient capacity to handle future waste treatment needs of the community?
   f. Is treated wastewater discharged to a stream or river? Is there a water quality problem caused by the discharge? How is the wastewater used downstream?
   g. If the treated wastewater is not discharged to a stream, how is it used?
   h. Does the treatment facility operate under a state and/or federal permit? What are the provisions of the permit regarding flow and quality of the effluent?
   i. What is the largest single wastewater treatment problem facing city officials at this time?
2. Write a fiction story telling about the TV commercial break when all the people in town flushed their toilets at the same time.

Extensions:

1. Research the use of septic tanks, composting toilets, and former day "outhouses" for the purpose of determining the implications of the various facilities on ground water quality.

2. Invent a sewage system that does not use water.

*Puzzle: When is a holiday more than a sewage system can handle? Answer: When there is a time out and a dull commercial during a nationally televised ball game.
WATER USE PICTOGRAPH

Objective: To illustrate the various ways that water is used.

Vocabulary: evapotranspiration
             aquifers

Materials: scissors
          magazines
          string
          paper
          felt pens
          work sheet

Grade Level: 4-6

Subjects: Science
          Social Studies

Time: 45 minutes

Procedures:

1. Begin the activity by reviewing the water cycle.

2. Distribute the work sheet. Discuss each component.

3. Make a very large bulletin board display using the work sheet as a labeling guide. Add pictures that illustrate each of the components.
Water Use in the United States

Adapted from Water Resources Management in America, a position paper by the Soil Conservation Society of America.
ELECTRICITY FROM WATER

Objective: To describe and discuss how water is used to generate electricity.

Vocabulary:
- reservoir
- dam
- intake
- penstock
- turbine
- outlet
- hydroelectric
- electricity
- energy

Materials:
- worksheet
- pictures of dams
- popsicle sticks (4 for each student)
- styrofoam discs (4" dia. x 1" thick)
- Electricity From Water Worksheet

Grade Level: 2-5

Subjects: Science
Social Studies

Time: 35 minutes

Procedures:

1. Begin the activity by talking about various dams students have visited. Discuss the purposes of each. Share some pictures of various dams. Identify power generation as one of the purposes of dams.

2. Place the key vocabulary on the chalkboard. Ask students to define each word. Distribute the worksheet and use it to properly identify each component by its name. Discuss the process of converting the energy of moving water to electricity. Consider the following:

   a. The water cycle is energized by the sun. The sun evaporates water that rises, then falls as precipitation to a higher position. The energy in falling water can then be changed into mechanical or electrical energy.

   b. A hydroelectric plant includes a dam with an intake and outlet. The tube down which the water flows is called a penstock. The water is directed against a water wheel called a turbine. The turbine turns a ball of wires called a generator. The generator turns in a magnetic field to produce electricity.
Extensions:

1. Use 4 popsicle sticks, 1 styrofoam disc 1 inch thick by 3-4 inches in diameter, and 1 wire clothes hanger to make a water wheel.

   Step 1. Cut all popsicle sticks in half. Tape one end of the stock. (see illustration)

   Step 2. Insert tapered sticks approximately 1 inch apart into side of illustration.

   Step 3. Insert straightened coat hanger through center of disc until equal length of wire is on either side. Bend wires around disc allowing enough room for sticks to clear. Combine wires and twist to form a handle (see illustration).

   Step 4. Place apparatus under running water allowing water to strike sticks, consequently turning wheel (turbine).

   Water provides power to turn a turbine which turns a generator and makes electricity.
ENERGY-WATER COLLAGE

Objective: To illustrate that water can be used to store energy and that water is involved in the production of many goods and services.

Vocabulary: Materials:

scissors
tape or glue
variety of magazines

Grade Level: 5-6

Subjects: Art

Social Studies

Time: 2 - 30 minute sessions

Procedures:

1. Cut out pictures illustrating water and energy related water uses. Prepare a collage of the ways water is used.

2. Can the water uses be categorized?

3. Categorize the pictures on the collage into common use areas, for example: energy, food, transportation, recreation.

4. Discuss pictured uses of water, the relationship to energy, and the criteria students used to categorize water use.

Extension:

1. Have the students explain orally or in writing several ways that water is used.
Objective: The learner should understand that:

3.22 Water use decisions affect lifestyles, quality of life, and standard of living.
Wise Utilization of Water Resources

The world's supply of water remains constant. Why then are there droughts and water shortages in many parts of the world? The hydrologic cycle, driven by energy from the sun, is largely responsible for these phenomena. It is continually, taking water from the oceans and distributing it inland in the form of snow and rain, but it doesn't do this uniformly either in time or space. As a result a particular area may experience a shortage of precipitation for a period of time, and then get an overabundance and be flooded.

It is somewhat ironic that many people, as they become more affluent, want to live in those areas that receive the least amounts of precipitation such as the southwestern United States. In those sunny areas they want to have swimming pools, air conditioning, and an abundance of lawns and trees, all of which require large quantities of water. As more and more people move into these areas, local shortages may be created for water of a particular price. However, if people are willing to pay more for the water they receive, the shortages disappear. Thus it becomes apparent that there will never be a shortage of water if people are willing to pay the price required to obtain it. It can be delivered in any amount to any location, and of the desired quality. The limiting factor is cost, not water.

As we teach the wise utilization of water, it is important that students be encouraged to consider all possible use options, and not be led to believe that conservation of use is always good. They should learn to understand the circumstances and reasons that would make water conservation desirable, and also those that might make it otherwise. If one's source of water is a pumped well, he can reduce pumping costs by using less water. On the other hand if the supply is a flowing stream, and the water not used flows directly into a terminal lake and evaporates, then conservation may not be warranted. In time of drought it would be far better to divert all the water from such a stream and store it in the soil of adjacent farmland, than to allow it to flow into the lake.

Public education can be an important factor in the wise utilization of water. For example, a large city may wish to restrict water use because of limited reservoir storage space, or because of limited wastewater treatment facilities. An educational program which presents the
facts can be very effective in encouraging water users to restrict their use, whereas trying to restrict use just by raising the price may not produce the desired result. Water users, as well as managers, should become familiar with the facts in each situation and then do what they indicate, rather than to stress conservation for conservation's sake alone.

Water Reuse

The recycling, or reuse of water, has been going on for a long time. Reuse occurs through the hydrologic cycle, groundwater recharge from septic tanks, and upstream-downstream uses of water. For example, it is estimated that water is reused seven times on the Ohio River in its journey from Pittsburgh to the Mississippi River.

Recently, large-scale controlled reuse of water has been implemented. Reuse may take many forms. Examples include agricultural and residential irrigation, impoundment in lakes for recreation and wildlife, groundwater recharge, industrial cooling, and consumption for both drinking and industrial processes.

Municipal wastewater recycled for drinking water began in southwest Africa in 1970. Municipal sewage is reclaimed by physical/chemical treatment to make up 30 percent of the public water supply. No such direct use is yet made in the United States. Customer acceptance is expected to be a major problem even if public health considerations are satisfied. Municipal waste water is being reused in the United States for industrial cooling water and irrigation water. Land treatment of waste water is really a form of reuse. A good example is Muskegon County, Michigan, where effluent provides irrigation water for crops. The crops remove the nutrient from the waste water before it is returned to the stream or ground water. Municipal waste water also can contribute to recreational lakes. An example is the Santee project in California. Industrial "closed loop," with internal recycle of water, has been performed for many years.

Agricultural irrigation reuse is common, but it may cause additional downstream use problems because of higher total dissolved solids in the water. Residential reuse (recycle) has been investigated in several demonstration projects. Treatment, storage, and reuse for toilet flushing and lawn sprinkling are considered to be economical only for problem onsite disposal areas and high water cost areas.

Recreational Water Use

We are fortunate people to have so much leisure time. Some of this time is directed at outdoor recreation in which water may play a role. Choice camping sites and picnic areas are usually on or near a body of water. The money spent for water-related recreation such as swimming, boating, water skiing, hiking, and duck hunting has a major impact on the economy. Skin diving has opened entire new vistas for the underwater recreationist.
The utilization of water for recreational purposes is dependent on three major factors: proximity to population, access, and water quality. If there are only a few quality water bodies near a population center, use will be very intensive, despite the obvious disadvantages of crowding at access points, and fluctuating water levels.

Wilderness areas play a different role in outdoor recreation. They provide a quality experience for a relatively few people. Similar experiences can often be obtained on a river near highways, farms, and towns. By its very nature, a stream can provide a thread of solitude as it winds through an area.

A large amount of water is available for fishing. Inland streams and lakes are supplemented by artificial impoundments, both large and small. Most large impoundments are managed for multiple use. Regions where water is stored for irrigation and public water supply now have reasonable access for fishing. Occasional conflicts arise even among recreationists over priorities for use. Boating and water skiing may interfere with fishing, and swimming may not be compatible with boating. All of the recreation uses may conflict with the primary purpose of an impoundment, such as public water supply, if water quality is impaired.

What About the Future?

By the year 2000, you may be drinking recycled water. Denver now has a Reuse Demonstration Plant which processed a million gallons of sewage water a day in 1983. The population growth in the Denver area has caused the need for water to reach very high levels. The only economically feasible alternative to supply the need is to recycle waste water. The waste water will be cleaned so that it is pure enough to drink.

Limited quantities of waste water have been used in various parts of the United States for agriculture and car washing, but water will have to be much cleaner for drinking. The technology is available. The process involves a lime treatment to raise the pH enough to kill viruses and then reduce the pH again. Mechanical and chemical filters are used to remove solids. Ozone is used as a disinfectant, and reverse osmosis helps eliminate dissolved minerals. Thin sheets of water are exposed to air to remove carcinogens, and the water is finally chlorinated. The end product should taste like present day drinking water.

There is no shortage of water in the sea. However, the salt content presents use problems. Many large aquifers also contain salt water. Desalination may be achieved by distillation. In this process water is evaporated with the minerals left behind. The water vapor is then condensed and collected. This process requires a great deal of energy. It has been proposed that waste heat from nuclear reactors be used as an energy source.

A number of scientists are concerned about changes in world climate. There is some concern about a greenhouse effect that may result from an increase in carbon dioxide in the atmosphere. Carbon dioxide, a product
of combustion, is increasing in the air due to industrialization, auto exhaust, and the burning of fossil fuels. The carbon dioxide tends to hold heat in the lower parts of the atmosphere. A very small increase in temperature might cause glacier and polar ice caps to melt. If this should happen, New York, Los Angeles, and similar coastal cities will have plenty of water.
EVERY DRIP COUNTS

Objective: To demonstrate some of the ways in which water is lost.

Vocabulary: Materials:
conservation glass
water supply paper
pencil ruler

Grade Level: K-4

Subjects: Science
Social Studies
Language Arts

Time: 2 hours

Procedures:

1. Place a glass under a dripping water faucet. Time how long it takes to fill the glass. Calculate how much water would be lost in a day, a month, and a year. Use this activity to introduce the concept of water conservation.

2. Discuss the merits of each of the following situations:
   A. Keeping drinking water in a refrigerator instead of letting water run from a tap until it is cold enough to drink.
   B. Taking short showers instead of filling the tub to the top for a bath.
   C. Brushing teeth using a cup of water instead of leaving water running.
   D. Watering the lawn at night instead of during the hot part of the day.
   E. Fixing leaky faucets instead of letting them drip.
   F. Washing only when there are enough clothes for a full load instead of filling a washer for a few things at a time.

Extensions:

1. Assign students to identify water loss in their homes. Devise strategies to correct these losses.
2. Add one drop of dish soap to a bottle half filled with water. Shake the bottle and then measure how much water it takes to rinse out the soap. Increase the amount of soap a drop at a time and see what happens to the amount of rinse water needed each time.

3. List on the chalkboard all the ways students use water at school. Each student should rule a sheet of paper into forty squares or rectangles, and then place his name at the top of the sheet. Each time he uses water, he is to place an "X" in a rectangle. See who has the most empty rectangles at the end of a week.

Indicate that when a person's rectangles are used up, he can't use water unless he pays extra for the privilege, like picking up five pieces of trash first.

4. Discuss the statement: "One city's waste water may be another one's supply."

CASTOR SAYS

*An intelligent steward would not waste water even if it were inexpensive and plentiful.
HOW TO SAVE MONEY AT HOME

Objective: To learn the reasons for conserving water.

Vocabulary: conservation

Materials: opaque water cooler
drinking cups of a known volume

Grade Level: K-3

Subjects: Science
Social Studies
Mathematics

Time: Extended activity

Procedures:

1. Fill a large (5 gallon) water cooler with water. Use this as the classroom source of all drinkin' water. Record how long it takes to use all of the water.

2. Refill the cooler with a measured amount of water (liters). As the water is used, subtract each amount used from the total. List the amounts on the chalkboard. Record how long the water lasts. Discuss the difference from the first example.

3. Introduce the term water conservation and discuss some of the following ways of conserving water in the home.

Do You:

1. run water while brushing teeth?
2. run water while lathering to shave, shower or wash hair?
3. run water while washing vegetables or preparing food?
4. run water while preparing dishes for the dishwasher?
5. run water while cleaning the sink or doing other house­hold cleaning?
6. use faucet aerators?
7. use water to thaw food?
8. wash only a full load in the dishwasher or the clothes washing machine?
9. have a clothes washer which has a suds-saver feature?
10. run the disposal more than once each meal preparation?
11. have native plants which require less water?
12. water your grass with more than 2 inches per week?
13. fill the bath tub full to bathe?
14. shower for longer than five minutes?
15. use a water saving device in the commode?
16. use the commode as a trash can by flushing paper, trash and cigarettes?
17. have faucets which leak? (check outside, too)
18. have commodes which leak? (check by adding a few drops of food coloring to the water in the tank and see if color appears in the bowl without flushing)?
19. water your lawn with a sprinkler rather than a soaker hose during the heat of the day?
20. encourage shallow rooting by watering?
21. use the hose to clean sidewalks and driveways instead of sweeping?
22. cut your grass too short during the summer?
23. collect and use rainwater?

4. Discuss situations which would make water conservation desirable, and those that would make it undesirable.

Extension:

1. Assign students to find examples of excessive water use in their homes. Have them plan and carry out strategies to remedy these situations.

*Little people will be tomorrow's water-use decision makers. They should understand that wise water use and the principle of stewardship can be a part of their lives.*
WATER COSTS

Objective: To show that water use has an associated cost.

Vocabulary: conservation

Materials: magazines
       glue
       scissors
       butcher paper
       small box
       water trip tickets
       crayons
       M & M's

Grade Level: K-3

Subjects: Science
       Social Studies

Time: Long term project

Procedures:

1. Find magazine pictures which illustrate various uses of water. Categorize the pictures using the following criteria:
   a. Water we use for drinking and other personal uses.
   b. Water we use for fun.
   c. Water we use for work (jobs).
   d. Water we use for transportation

   Make collages of each category.

2. Discuss the water uses depicted in each collage. Lead the discussion to the conclusion that it takes a lot of water to satisfy all of our water needs. Relate each use to an associated cost. For example, boating would even involve the cost of boat and travel.

3. Indicate that you are going to play a game which will show that using water costs money.

   First, brainstorm possible ways that students may use water during the day. For example: rest room, lunch, fountain, washing hands, etc.
Indicate that every time a student uses water, he must pay one water ticket. Students should put their names on the tickets and decorate them as they wish. Place a small box near the door. Students are to place tickets in the box each time they use water.

4. After a few days, take a count of remaining tickets. Introduce the term conservation. Discuss how students might conserve water. Allow students to purchase tickets from water conservers. Give each student five M & M's. They can use the M & M's to purchase water trip tickets.

Extension:

1. Make up a class story or play, "The Day the Money Ran Out."

*We cannot afford to not pay the price needed to maintain quality water supplies.
WATER APPRECIATION

Objective: To estimate the amounts of water required for various uses.

Vocabulary: none

Materials: none

Grade Level: 4-6

Subject: Social Studies

Time: 4 - 35 minute sessions

Procedures:

1. Give students the following situation:

As part of its Pioneer Days Celebration, your community has decided to promote a living history month. During the month, everyone will live as people did 100 years ago. To create a more realistic setting for the 30 day celebration, no cars or trucks will be used for transportation, no electricity or petroleum will be used for energy, and public water and sewage service will be discontinued.

Your class has been asked to help plan the living history month by providing water for use at your school during the celebration. In order to do this, you must know what the water needs are and how much water is required. You must also know where the sources of water can be found and what their uses could be. You must decide how to get water from the sources to the school and where to store it until it is used.

2. Divide the class into two or more groups. Let half of the groups work on Task A while the other half work on Task B.

Task A: List all the ways that water is normally used at school.

Task B: Make a list of all permanent water sources in your community. Include all wells, springs, streams, rivers, ponds, reservoirs and any other sources.

After an appropriate amount of time, call the class back together and compile a master list for each task. These lists should be available to students as they complete the remaining tasks.
3. During the class period, divide the class into groups and assign Tasks C and D.

Task C: TEACHER NOTE: Supply the groups working on this task with a list of water uses from Task A and a list of amounts of water required for household needs (see teacher note in the activity, "Water at Home").

Task C could be given to the best math students or if there is enough time, the task could be assigned to students who need more practice in working simple word problems.

a. Look at the list of water uses from Task A. Estimate the total daily water requirement for each use.

Example for a school with 360 students: Each student needs 1/2 gallon of water for drinking daily. 360 students x 1/2 gallon = 180 gallons. If each student uses the restroom 2 times each day, 360 students x 2 = 720 times per day the restroom is used. If it takes three gallons of water to flush a toilet, 720 flushes x 3 gallons = 2,160 gallons.

b. Estimate the total amount of water used each day at your school by adding amounts required for each use.

Save all calculations for use in Task E.

Task D: TEACHER NOTE: Lists from Tasks A and B should be given to the groups working on this task:

a. Based on your knowledge about the sources of water that were compiled in Task B, decide if water from each source could or could not be used for drinking. Give a reason for your answer.

b. If a source is not good for drinking, decide what use could be made of the water. Refer to the list compiled in Task A.

4. During the next class period, assign Task E to the same groups that worked on Task C. Assign Task F to the other groups.
Task E: This should be a continuation of work done by group C.
   a. Look at the list of water uses from Task A and decide which
could be eliminated during the Pioneer Days Celebration.
   b. Calculate the daily water requirements for Pioneer Days like
you did in Task C.

Task F: If it should rain during the Pioneer Days Celebration, the
rainwater could become a new source of water.

List ways that the rainwater could be collected and stored.
List ways the rainwater could be used.

Break for the day

5. During the final class period, have members of each group report on
their work, then conduct a class discussion to answer the following
questions:
   1. From what sources can we get our water for Pioneer Days?
   2. How can we get our water from the selected sources to the
school?
   3. Where or how could we store the water at school?
   4. Will we use more or less water during the Pioneer Days Celebra-
tion than we normally use?
   5. In relation to water, which way would you rather live; as we do
today, or as the pioneers did?

Extension:

1. Have students create a story or skit that depicts what water use
might be like in the year 2050.
WHOSE WATER IS IT?

Objective: To identify factors that influence water use.

Vocabulary: priorities

Materials: worksheet

Grade Level: 4-6

Subject: Social Studies

Time: 1 hour

Procedures:

1. Begin the activity by reviewing the material on water rights in the Background Information.

2. Divide the class into groups representing commercial fishermen, sport fishermen, water skiing enthusiasts, and other water recreationists, farmers, power officials, and general public. Have each group make a list of reasons water should be managed for their benefit.

3. Devise plans that would help achieve more than one group's desires.

4. Distribute the "Which Has Priority" worksheet. Assign students to answer the questions in a short essay.

Extension:

1. Obtain position papers identifying water use priorities from the following: Sierra Club, League of Women Voters, Farm Bureau, U. S. Forest Service, U. S. Bureau of Reclamation, Power Company, and Division of Wildlife Resources.
Growing demands on water supplies will result in the necessity of making choices. A 2,000 acre farm can use as much water per day as a city of 50,000. If a particular water supply cannot support both, which has priority? The city of 50,000? Or the farm that feeds that city? Why? Discuss other alternatives for solving the problem.
WATER SUPPLY RESEARCH

Objective: To investigate factors that may influence local water supply.

Vocabulary: Materials:

Grade Level: 5-6
Subjects: Science
Social Studies

Time: 2 hours

Procedures:

1. Listed below are areas for library and/or local research. Assign student groups to each topic. Allow time for gathering information and then present each topic in the order listed.

   a. Where does your city or community water supply originate, i.e., river, stream, reservoir, well? Find the source on the area map. If your town gets its water from a river, does it pass by a town upstream which also uses the river as a water supply? Does the town upstream discharge its waste into the river that supplies your town with water? If possible, determine the waste water treatment methods the upstream town uses. Are they sufficient to render the water pure for use by your town? Locate upstream towns on the map. How do they affect water quality?

   b. If your community uses well water, ask the water superintendent which aquifer is used. How deep is the aquifer? What treatment methods are used to treat the water? Is there any pollution now present, or are there any potential pollution sources?

   c. Where is the water intake for your town's water supply? If possible, visit your water treatment plant intake. Locate the intake point on a local map.

   d. Where are the city or community storage tanks located? Is there a reason for them being in a particular location? (Most are located on the highest area in the town.) Give a reason for the location. Indicate locations on the map. How much water does each of the storage tanks hold? How much do they hold altogether?
e. Where is the local sewage treatment plant? What is its elevation compared to the storage tank area? Find the wastewater treatment plant on the map. Label it. Where is the water discharged?

f. What is the destination of the wastewater from your town? If it is discharged into a river, is there a town located downstream? Note: Be sure you indicate that you know which way the river is flowing on the map. If there is a town downstream, does it use the same water as a water source? If possible, determine the methods used to treat your city's wastewater. Is it sufficient to allow safe drinking water for the city downstream? Find the downstream city on the map.

g. Do you believe your city is doing a sufficient job in supplying good quality water to its citizens? Does it protect the public and the environment, and does it follow the laws concerning water purity?

Extension:

1. Find the words to the song, "Cool, Clear Water." What is the story told in the song?

*Intelligent water use and management decisions are based on knowledge.
Background Information for the Teacher

Introduction

Two of the biggest problems facing students and teachers desiring to do field studies are cost and availability of equipment. The purpose of this chapter is to provide information on low cost equipment.

Effective field investigations cannot be carried out without the aid of appropriate instruments. Ideally, the instruments can be made by students. Many would make good projects for an industrial arts or other vocational class. Students should be informed of the purposes of field trips. Several class periods could be used to build equipment.

Personal Equipment

Dress should always be appropriate for the situation. Field studies can be hazardous. Rubber boots, waders, and other waterproof gear may be needed, but you cannot always expect students to supply such clothes. Students should be instructed with regard to water safety. Life jackets may be used for wading and are a must for boat work. Always use a buddy system.

A notebook, hard and soft pencils for labeling, note taking and drawings are desirable. Clipboards can be made from 8 1/2" x 11" pieces of cardboard and clothes pins. Pocket lens and dissecting kits are often of value.

Commonly Used Equipment

The section which follows lists and describes a various kinds of equipment and their suggested uses.

1. White Enameled Dishes or Pans. White pans are valuable for examining a fresh water catch. When the contents of a net are dumped into a pan containing a small amount of water, the animals soon come crawling or swimming out of the debris. They are then easily seen against the white background. Animals can then be lifted out with the device shown in Figure 25.

White containers for this purpose can often be obtained free from appliance stores dealing in refrigerators. When old refrigerators are traded in on new ones, the old ones are frequently thrown away. The trays from these refrigerators can be saved for school use.

2. Animal Lifter. An animal lifter can be made by folding the edges of a rectangular strip of wire cloth as illustrated in Figure 25. A convenient size is about 3 x 6 inches. The lower edge should be woven.

Figure 25. Animal Lifter
3. **Hand Screen** Figure 26 illustrates a tool that is very useful for collecting animals in flowing water. The device is held in the current by one person as another person wades or turns over rocks upstream. The current then carries the animals down into the screen. Large organisms can be picked off and smaller ones dumped into a white pan for collection.

The hand screen is made with a piece of wire cloth, and two light wood handles. A convenient size is about 1 x 2 feet. Nail the wire between two three-foot long 1" x 2" pieces of wood. Place the woven edge of the wire at the bottom. This will cover the sharp edges of the wire. Smaller-diameter handles can be used if such wood is available.

4. **Algae Substrate.** Algae are an important part of any aquatic environment. Benthic algae grow attached to a substrate. As such, many of them are difficult to remove. This situation is easily remedied by letting the algae grow on a microscope slide and then removing the slide and observing it under the microscope.

Use colored plexiglass to keep track of the microscope slides. Drill a hole near one end of two 2" x 6" pieces of plexiglass. Place a bolt with washer and wing nut in the hole, screw the nut down to hold a microscope slide in place at the other end. Place the device in the stream or pond.

5. **Range Poles.** Range poles are used to measure elevations along a stream. The device consists of two wooden poles ten feet long, a string, and a mason's level. Each range pole is marked off in one-foot intervals. The string should be tied securely to one rod and have a loop that will allow it to be moved on the other rod. A convenient length for the string is about ten feet.

With the string level, as indicated by the bubble on a mason's level, the rods will be ten feet apart and the difference in elevation between the two points will be the distance on one rod as indicated in Figure 27.
Figure 27. Using the double range pole. Point B is about 6 feet higher than point A.

A stream profile in the form of a graph as shown in Figures 28 and 29 can provide a good description of a stream. Data may include organisms, temperature, bottom type, elevation, drawing of bottom, etc.

Figure 28. Graph of a Stream Profile
6. Large Tanks. Large aquaria are often useful for conducting long-term observation of organisms. Children's plastic wading pools are a fast, easy way to provide a large tank. Aquaria can also be constructed from liners of old refrigerators. Look for a refrigerator that has a top opening into a freezer compartment. Remove the liner. Cover any screw holes with silicone rubber sealant and any large holes with a glass plate. Place a piece of plate glass in the large opening and secure it with silicone rubber.
7. Rain Gage. A simple rain gage can be made by removing the bottom of a bottle as illustrated. Cut the bottle near the base with a bottle cutter. Close with a top that will not leak. Build an appropriate stand.

The rain gage needs to be calibrated. Rain is measured in inches. An inch of rain is the amount of rain needed to fill any straight walled container to the depth of one inch. Since the bottle is only straight walled at the top, rain will be more concentrated in the neck. Use a graduated cylinder as a guide to mark off the neck of the bottle by filling the cylinder to 1 inch. Then pour this amount in the bottle and mark it with a triangular file. Continue this process to calibrate the entire rain gage.

8. Secchi Disk. The Secchi Disk is used to measure the turbidity of water. The disk works on the principle of light penetration. The depth at which the disk can be seen is affected by the amount of matter suspended in the water.

Make the disk from a 20 cm x 20 cm piece of Beaver board. A 20 cm diameter disk is a standard size. Paint the quadrants black and white as illustrated. Place a screw eye in the center of the disk. Attach a length of pipe on the under side with super glue. A snap swivel and a string marked off in feet complete the assembly.

Caring for Field Collections

Plastic and glass jars make good collecting containers. Gallon size jars are often available free from the school cafeteria or other food service places. Containers with live specimens should be left open and kept cool. An ice box may facilitate survival. Avoid overcrowding. If the long term goal is preservation, it is best to place the specimens in a 70 percent alcohol solution at the time of collection. Colors should be noted at the time of collection as there is considerable change in most preserved specimens.
When transporting fish, a good rule is not more than eight inches of fish per gallon of water. Predators such as crayfish, dragonfly nymphs, and diving beetles should be put in individual containers. All stones should be removed from containers as they may crush the soft-bodied organisms. However, it may be desirable to have plant leaves in a jar to provide resting and hiding places for specimens.

Water Quality Equipment and Methods

The chemical properties of water are usually best studied by using purchased equipment. A list of manufacturers and suppliers follows. The manufacturers listed will send catalogs to schools on request.

When purchasing kits consider refill and maintenance costs. Kits that will facilitate a number of students should be considered. Also, consider susceptibility to damage, water and dirt. Dangerous reagents and storage life of chemicals may be a cost-related factor.

General water quality is determined by concentration of three kinds of salts: carbonates, sulfates, and chlorides. Total alkalinity is a measure of the carbonate salt concentration. Sulfates and chlorides occur in fresh water in amounts ranging from a trace to several thousand parts per million. Concentrations are determined by titrations.

Ammonia, carbon dioxide, dissolved oxygen, nitrate and nitrate nitrogen, and phosphorus may also be of interest in water quality investigations. There are many types of simple test kits for determining pH.

Equipment and Supplies Manufacturers

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Address</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>Beckman Instruments, Inc.</td>
<td>2500 Harbor Blvd.</td>
<td>High Quality equipment</td>
</tr>
<tr>
<td>(714) 871-484B</td>
<td>Fullerton, CA 92632</td>
<td></td>
</tr>
<tr>
<td>Bridge Mail Division</td>
<td>Watertown, MA 02172</td>
<td>Kits, equipment</td>
</tr>
<tr>
<td>(617) 923-1020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carolina Biological Supply Co.</td>
<td>Burlington, NC 27215</td>
<td>Specimens, AV equipment</td>
</tr>
<tr>
<td>(919) 584-3771</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Scientific Co.</td>
<td>2600 Kostner Ave.</td>
<td>Broad line good service</td>
</tr>
<tr>
<td>(312) 277-8300</td>
<td>Chicago, IL 60623</td>
<td></td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
<td>City, State, Zip</td>
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<tr>
<td>Fisher Scientific Co.</td>
<td>711 Forbes Ave.</td>
<td>Pittsburgh, PA 15219</td>
</tr>
<tr>
<td>Forestry Suppliers, Inc.</td>
<td>Box 8397</td>
<td>Jackson, MI 39204</td>
</tr>
<tr>
<td>Hach Chemical</td>
<td>Box 907</td>
<td>Ames, IA 50010</td>
</tr>
<tr>
<td>Jewel Industries</td>
<td>5005 W. Armitage Ave.</td>
<td>Chicago, IL 60639</td>
</tr>
<tr>
<td>Koslow Scientific Co.</td>
<td>7800 River Road</td>
<td>North Bergen, NJ 07047</td>
</tr>
<tr>
<td>LaMotte Chemical Products Co.</td>
<td>901 Janesville Ave.</td>
<td>Fort Atkinson, WI 53538</td>
</tr>
<tr>
<td>Millipore Corp.</td>
<td>Bedford, MA 01730</td>
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<tr>
<td>NASCO</td>
<td>901 Janesville Ave.</td>
<td>Fort Atkinson, WI 53538</td>
</tr>
<tr>
<td>National Wildlife Federation</td>
<td>1412 16th St., N. W.</td>
<td>Washington, DC 20036</td>
</tr>
<tr>
<td>Novo Enzyme Corp.</td>
<td>1030 Mamaroneck Ave.</td>
<td>Mamaroneck, NY 10543</td>
</tr>
<tr>
<td>Oceanography Unlimited</td>
<td>108 Main St.</td>
<td>Lodi, NJ 07664</td>
</tr>
<tr>
<td>Sargeant-Welch Scientific Co.</td>
<td>7300 North Linder</td>
<td>Skokie, IL 60076</td>
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<tr>
<td>Sargeant-Welch Scientific Co.</td>
<td>7300 North Linder</td>
<td>Skokie, IL 60076</td>
</tr>
<tr>
<td>Turtox/Cambusco</td>
<td>8200 S. Hoyne Ave.</td>
<td>Chicago, IL 60620</td>
</tr>
<tr>
<td>Ward's Natural Science Establishment, Inc.</td>
<td>P O Box 1712</td>
<td>Rochester, NY 14603</td>
</tr>
<tr>
<td>Wildlife Supply Co.</td>
<td>Saginaw, MI 84602</td>
<td></td>
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</tbody>
</table>
GLOSSARY

Acid: Solutions with an excess of hydrogen ions.
Acid rain: Rain with a pH of less than 7.0.
Adsorption: The adhesion of a substance to the surface of a solid or liquid.
Aerobic bacteria: Bacteria that either require or can endure the presence of oxygen.
Alkalinity: In general, a compound that will neutralize an acid, having marked basic properties.
Alum: A mineral used in water treatment.
Angling: The act or skill of fishing with hook and line.
Aquatic life: All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insects, larva and zooplankton are also included.
Aquifer: A water bearing layer of permeable rock, sand, or gravel.
Artesian well: A well tapping a confined aquifer in which the water table is above the confining layer. The term is sometimes used to include all wells tapping confined water.
Bacteria: Microscopic, one celled plants.
Basic: As opposed to being acid. A solution with a deficit of hydrogen ions. Having a pH greater than 7.0.
Benthos: The entire system of life, plant and animal, found on the bottom of a body of water.
Biodegradable: That which can be decomposed quickly as a result of the action of microorganisms.
Calcium: A soft white metallic element occurring in various rocks such as chalk and limestone.
Capillary action: The phenomenon of liquid rising when it comes in contact with the surface of a container.
Colloids: Quantities of particles small enough to remain suspended in a fluid medium without settling to the bottom.
Community: A body of organisms residing in one locality.
Condensation: The changing of a gas or vapor into a liquid.
Consumer organisms: Organisms that live by consuming other living things.
Contamination: The process of becoming impure; damage to the quality of water sources by sewage, industrial waste, or other matter.
Density: Compactness; the relation of weight to volume.
Desalinization (Desalination): The process of salt removal from sea or brackish water.
Dissolve: A condition where solid particles mix, molecule by molecule, with a liquid, and appear to become part of the liquid.
Distillation: The separation of different substances in a solution by boiling off those of low boiling point first. For example, water can be distilled and the steam condensed back into a liquid that is almost pure water. The impurities (minerals) remain in the concentrated residue.
Domestic consumption (use): Water used for household purposes such as washing, food preparation, and showers.
Drainage basin: A surface area in which water drains into a stream system.
Ecology: The branch of biology that deals with the complex of relations between a specific organ and its environment.
Ecosystem: A system made up of a community of animals, plants, and the interrelated physical and chemical environment.

Effluent: Something that flows out, usually a gas or liquid discharge.

Erosion: The wearing away of the land surface by wind, water, ice, or other geologic agents. Erosion occurs naturally from weather or runoff, but is often intensified by human land use practices.

Evaporation: The process by which water becomes a vapor at a temperature below the boiling point.

Filter: A device used to remove solids from a mixture or to separate materials. Materials are frequently separated from water by using filters.

Filtration: The mechanical process which removes particulate matter from water, usually by passing it through sand.

Floc: A very fine, fluffy mass formed by the aggregation of fine suspended particles, as in a precipitate.

Gaging station: The site on a stream, lake, or canal where hydrologic data are collected.

Generator: A machine that utilizes water power, steam power, or other kinds of mechanical energy to generate electricity.

Geothermal energy: The heat energy available in the earth's subsurface, extracted from three basic sources: (1) steam; (2) hot water; and (3) hot rocks or near surface intrusions of volcanic molten rock.

Geyser: A thermal spring that throws forth intermittently escaping jets of water and steam.

Ground water: Water beneath the earth's surface.

Ground water reservoir: An aquifer or aquifer system containing ground water.

Habitat: The region in which an animal or plant naturally lives, or the place where a thing is usually found.

Humidity: A moderate degree of wetness in the air or on a surface.

Hydroelectric: Having to do with production of electricity by falling water.

Hydrogen sulfide: A flammable, poisonous gas, \( \text{H}_2\text{S} \), with the characteristic odor of a rotten egg.

Hydrology: The study of water in all its phases above, on, and beneath the earth.

Hydrologic cycle (water cycle): The cycle of water movement from the atmosphere to the earth and back to the atmosphere through various processes. These processes include precipitation, runoff, infiltration, percolation, storage, evaporation, transpiration, and condensation.

Ice: Water in the solid state.

Impervious: A term denoting the resistance to penetration by water.

Impoundment: A surface storage area created by a dam, dike, floodgate or other barrier. It is used to collect and store water.

Indicator solution: A solution which indicates the chemical character of the water by its color change.

Infiltration: The gradual downward flow of water from the surface into soil.

Intake: The place at which a pipe or channel takes in a fluid.

Irrigation water: Controlled water supplies applied to lands for producing crops.
Kinetic energy: The energy of a body which results from its motion.
Limestone: A sedimentary rock composed of calcium carbonate (lime) and sometimes containing fossil remains.
Meteorology: The science of the atmosphere; the study of atmospheric phenomena.
Methane: An odorless, gaseous hydrocarbon, resulting from decomposing matter in marshes and mines.
Methylene blue: A blue solution which indicates the chemical character of solution by its color change.
Minnow: Any of a large number of usually small fresh water fish, used commonly as bait.
Nekton: Free swimming water creatures.
Organism: Any living thing, either plant or animal.
Osmosis: The passage of a material though a membrane.

pH: A way of expressing both acidity and basicity on a scale of 0-14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity.
Parts per million (ppm): The number of "parts" by weight of a substance per million parts of weight. This unit is commonly used to represent pollutant concentration. Large concentrations are expressed in percentages.
Penstock: A gate or sluice used in controlling the flow of water. A tube or trough for carrying water to a water wheel, or a pipe carrying water to an electric turbine.
Percolation: The movement of water through fractured rock or soil.
Permeability: The ability of a water-bearing material to transmit water.
Pesticide: An agent (as a chemical) used to destroy a pest, such as insects, weeds, rodents, etc.
Plankton: A collective term for the organisms, large and microscopic, that float or drift at random in a body of water.
Pollution: The presence of matter or energy whose nature, location or quantity, produces undesired effects upon the normally existing environment.
Porosity: The ratio of the volume of voids within a material to the volume of its mass.
Potable water: Drinkable water.
Precipitation: A deposit on the earth of hail, rain, mist, sleet, or snow. It is the common process by which atmospheric water becomes surface water.
Primary treatment: A first step in purification of waste waters and sewage.
Prior appropriation: A doctrine for appropriating water which recognizes the right of early appropriation as having priority over those who appropriated later -- "First in time is first in right."
Purification: The process in which one gets rid of impurities or pollution.
Rain gage: Any instrument used for recording and/or measuring the amount of rainfall.
Recharge: The addition of water into a ground water system.
Relative humidity: The ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature.
Reservoir: A pond, lake, tank, or basin (natural or human made) where water is collected and stored. Large bodies of ground water are called ground water reservoirs; water behind a dam is also called a reservoir.

Riffle: The movement of water across a shallow bar in a river.

Riparian water right: The legal right held by an owner of land bordering on a natural stream or lake, to take water from the source for use on that land.

Runoff: The portion of rainfall, melted snow, or irrigation water that flows across the land surface and eventually runs into streams.

Salinity: The concentration of salts or dissolved solids in water.

Saturation, zone of: The zone below the water table in which all pore spaces are filled with water.

Sediment: Transported and deposited particles derived from rocks, soil, or biological material.

Sedimentation: The removal, transport, and deposition of detached soil particles by flowing water or wind.

Septic tanks: Underground tanks used to hold domestic wastes when a sewer line is not available to carry them to a treatment plant.

Sewer: A line of underground pipes to carry off waste material.

Siphon: A bent tube used for carrying liquid out over the top edge of a container through the force of atmospheric pressure upon the surface of the liquid.

Sludge: Precipitated solid matter produced by water and sewage or mineral treatment processes.

Solution: The act or process of dispersing one or more liquid, gaseous, or solid substances into another, usually a liquid, so as to form a homogeneous mixture.

Strata: A homogeneous layer of material deposited by water.

Stream gaging: A process of determining the rate of flow, or the discharge, of streams.

Subsurface water: All water which occurs below the ground surface.

Surface tension: The compressed layer produced at a liquid surface by the unbalanced downward pull exerted by molecules underlying the layer of surface molecules.

Surface water: Water on the earth's surface exposed to the atmosphere, e.g., rivers, lakes, streams, oceans, ponds, reservoirs, etc.

Tributary: A stream or other body of water which contributes its water to another and larger stream or body of water.

Turbine: A propeller or wheel device driven by the pressure or velocity of a liquid or a gas.

Upstream: In the direction against the direction of flow of a stream.

Vaporization: The change of a substance from a liquid or solid state to the gaseous state.

Velocity: The rate at which water flows, often expressed as feet per second.

Waste water: Water for which disposal is more economical than use at the time and point of its occurrence.

Water cycle: The process by which water travels in a sequence from the air (condensation) to the earth (precipitation) and returns to the atmosphere (evaporation). It is also referred to as the hydrologic cycle.
Water table: The upper surface of a zone of saturation; the upper surface of the ground water.
Water vapor: Gaseous water in the atmosphere.
Watershed: The area drained by a river or river system.
Zooplankton: Plankton consisting of animals.
Activities by Grade

Kindergarten


First Grade


Second Grade


Third Grade

Activities by Subject

Art

Water, Sand, and Mud (K-1) - 9, Little People's Water Play (K-1) - 15, Drip Me a Drop (K-4) - 17, Layered Water (3-6) - 31, Mini Water Cycle (K-4) - 62, Watersheds (4-6) - 74, 4 x 8 Ecology (5-6) - 90, All Living Things Need Water (K-2) - 102, Energy-Water Collage (5-6) - 127.

Language Arts

Particulates in Water (2-6) - 14, Drip Me a Drop (K-4) - 17, Siphoning (1-6) - 28, Give Me a Break (3-6) - 35, Little People Water Cycle (K-3) - 55, The Water Cycle (2-6) - 56, Water for Recreation (3-6) - 115, Every Drip Counts (K-4) - 134.

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