Exploring Water Habitats: Wetlands, Streams, Oceans

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Section 1: Water Connections

1. Sun Power: Coaching for Inquiry

Content Objectives

Learners will be able to do the following:

■ Explain some effects that energy from the sun causes to objects on Earth
■ Understand that heat is the transfer of energy from an object with a higher temperature to an object with a lower temperature
■ Understand that energy from the sun causes evaporation, a part of the water cycle

Scientific and Engineering Practices

National Academy of Sciences (2012), A Framework for K-12 Science Education

❏ Asking questions
❏ Developing and using models
❏ Planning and carrying out investigations
❏ Analyzing and interpreting data
❏ Constructing explanations
❏ Engaging in argument from evidence
❏ Obtaining, evaluating, and communicating information

Background

The sun is the major source of energy in our atmosphere. This energy reaches the planet in the form of radiation. (Is all radiation bad? From sci-fi movies and cartoons, learners may have the misconception that people should never be exposed to radiation.)

Radiation is the transfer of energy by electromagnetic waves. On Earth, we experience the sun’s radiation as light and heat. Heat is the transfer of energy from an object with a higher temperature to an object with a lower temperature.

What happens to the energy that enters Earth’s atmosphere? Clouds and the atmosphere absorb about 20 percent of the energy and reflect another 25 percent back into space. Earth’s surface absorbs about 50 percent of the energy and reflects about 5 percent back into space. One reason life on Earth is possible is the delicate balance our unique atmosphere produces between the energy Earth receives and the energy it loses. The atmosphere on Venus is composed of thick gasses and clouds that trap radiation, similar to a closed car on a sunny day. The atmosphere on Mars is so thin that radiation escapes. The atmospheres of Venus and Mars cannot support life as we know it.

Water is one of the requirements of life found on Earth. Water moves between the atmosphere and Earth in the water (hydrologic) cycle. The sun provides the energy that “powers” the water cycle. Radiation from the sun causes evaporation of water from lakes, rivers, and oceans, and transpiration from plants. When radiation is absorbed by water, this energy heats the water. As the water warms, its molecules move farther apart from each
other. In the process of evaporation, the warmed water changes from a liquid to a gas, called water vapor.

Water vapor rises in the atmosphere, eventually forming clouds. Clouds are made up of many tiny water droplets. The water droplets collide with each other in the cloud and form larger drops. The water molecules move closer to each other as they cool. When the drops grow so large that they can no longer stay suspended in the cloud, they fall back to Earth as precipitation (rain, snow, or hail). Once back on Earth, the water drops may take a variety of paths to the ocean and then return to the clouds in this endless process that is the water cycle. The lesson Rosa Raindrop’s Water Cycle will explain the process in more detail.

In addition to powering the water cycle, light energy from the sun is captured by green plants (plants that contain chlorophyll). Photosynthesis is the name of the process plants use to change light to chemical energy, which is used to create food (carbohydrates) from carbon dioxide and water. Plants use the carbon dioxide found in air and release oxygen as a waste product. Thus, plants provide two essential components of much life on Earth: oxygen and food for humans and other animals.

**Materials**

- One copy of the Sun Power Activity Sheet for each team of learners, following the lesson or
- Have older learners design their own data sheet to support the experiment they design for a more open inquiry
- Thermometers
- Clear plastic cups
- Water source
- Supply of construction paper in both light and dark colors
- Supply of plastic wrap and aluminum foil
- Tape

**Preparation**

Leaders should review the following:

- Background section on page 3
- 4-H Science Inquiry in Action Model Flowchart (Appendix, page 94)

**Procedure for Inquiry**

It is easier to use curriculum guides with scripted lessons that have standardized sets of data to collect an expected result or “right” answer. But, this type of lesson format does not always encourage learner curiosity. Leaders can conduct activities based on the lesson’s information and allow learners more flexibility in the questions they ask and the methods they use to collect data. This method has the advantage of engaging the learners in designing their own learning experience.

This set of lessons uses the Inquiry in Action flowchart (Appendix, page 94) to support
including inquiry in appropriate lessons. You may find it helpful to make copies of the Inquiry in Action flowchart for yourself and your learners.

Begin the activity by asking the learners some questions to determine what they know about how Earth receives energy from the sun (Flowchart boxes 1 and 2). Have any of them ever had a sunburn? How is a sunburn (radiation) different from a burn you might get from a hot object such as a stove top or candle flame (conduction)? A sunburn can be a “bad” result of radiation Earth receives from the sun. What are some good results? Have any of the learners ever made sun tea? Lead a discussion based on the information provided in the “Background” section. Adapt the information to the age of the learners.

After the introductory discussion with the learners, organize them in teams of three to five persons each. Follow the steps outlined in the 4-H Science Inquiry Flowchart. Ask learners how they might measure the changes to objects on Earth when the objects receive energy from the sun (Flowchart Box 3).

Have each team select a question. Coach the teams to select questions that can be answered by a simple experiment. Some examples are:

- Do objects of different colors absorb energy differently?
- How warm does water have to become for evaporation to start?
- Does the water in a pond get warm when the sun shines?
- Does the temperature of a pond change throughout the day?
- Does water evaporate from a pond?

Encourage older learners to use an “If. . . . ., then. . . . .” hypothesis format for their questions. The question, “Does water become warmer in the sun?” becomes the hypothesis, “If we leave water in the sun, then it will become warmer.”

Once all the teams have selected a question, ask them to share their question with the group. It is best if each team poses a different question or hypothesis. In this way the whole group will learn more about sun power by the end of the lesson. Also, at that time the leader can determine if the learners have asked a question they can answer with the available materials.

Now they are ready to design an experiment and a data sheet. (Flowchart boxes 4 and 5). Have the materials suggested in the list available for learners to use in collecting data. If needed, explain how to use the materials or equipment. They may think of additional items they wish to use for their experiments. Provide these if you have them. Take the materials outside and have learners collect the data they believe they need to answer their selected question (Flowchart Box 6).

After they have collected the data, ask each team to analyze and interpret their results (Flowchart Box 7) and provide a summary report to the rest of the group (Flowchart Box 8).
Once all the groups have reported their findings and explanations, lead a discussion to identify what has been learned about “Sun Power” from the investigations (Flowchart Box 9). Are there new questions the group would now like to ask about how objects on Earth change when they receive energy from the sun (Flowchart Box 10)?

**Extend the Learning**

**FOR OLDER LEARNERS**

We have learned that some radiation from the sun is absorbed by the atmosphere and Earth. The heat can be transferred by radiation, conduction, or convection. Ask learners to look up how each of these processes transfers energy. What effect do these processes have on the atmosphere and weather conditions?

**REFERENCE**

The Sun Power lesson is adapted from *Mud, Muck and other Wonderful Things*, National 4-H Council.
Sun Power Activity Sheet

Water Temperature Experiment

<table>
<thead>
<tr>
<th>From the tap — beginning temperature of the water</th>
<th>Glass of water in the sun</th>
<th>Glass of water without sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 minutes later — temperature of the water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

My own experiment

I am going to do: ____________________________________________________________________________________
________________________________________________________________________________
What I think will happen (my hypothesis): ________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
What happened: ____________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
Why I think that happened: __________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

Archival copy. For current version, see: https://catalog.extension.oregonstate.edu/4-h3805l
2. Water Cycle: Rosa Raindrop

This is an interactive water cycle demonstration where everyone in the group has a part to play.

Content Objectives
Learners will be able to do the following:
■ Name the three forms of water found on Earth (solid, liquid, gas)
■ Demonstrate the water cycle

Scientific and Engineering Practices
National Academy of Sciences (2012), A Framework for K-12 Science Education
   ❏ Developing and using models
   ❏ Constructing explanations

Background
The chemical formula of a water molecule is H₂O. This means there are two atoms of hydrogen attached to one atom of oxygen. The hydrogen and oxygen in the molecule are attached to each other by very strong bonds called covalent bonds. There are also weaker bonds between the oxygen and hydrogen of adjacent water molecules. This loose arrangement of molecules gives water its fluid nature and other remarkable properties.

When water freezes at 32 degrees F or 0 degrees C, it changes from a liquid to a solid. Water boils at 212 degrees F or 100 degrees C.

Learners probably know that when water boils, it produces steam. If they participated in the Sun Power lesson, they know that water can evaporate from a cup of water with a temperatures below 100 degrees C. In the process of evaporation, the warmed water is changed from a liquid to an invisible gas called water vapor. As the water warms, its molecules move farther apart from each other. Another way to say this is the water becomes less dense. When water vapor condenses to liquid water, it is becoming more dense. The water cycle involves the process of liquid water changing to a gas and then back to liquid water.

The water—or hydrologic—cycle is an endless process in which water is circulated around the surface of the earth through soil, plants, animals, and the atmosphere. The amount of water moving through the cycle has been approximately the same throughout 3.5 billion years. On average, a single water molecule is evaporated once every 5,000 years and has moved through the cycle about 700,000 times.

Materials
■ One set of Water Cycle Activity Cards (Appendix, page 99). There are 21 main-heading cards. If you are working with more than 21 learners, you may assign up to seven additional cards as follows:
“Water vapor evaporating from the ocean” (cards 2b, 2c, 2d, 2e), for one to four additional participants
“Rain” (card 4b), for one additional participant
“Soil infiltration” (card 8b), for one additional participant
“Slushy melting snow” (card 13b), for one additional participant
A Basic Water Cycle, Illustration 1
Rosa Raindrop’s World Water Tally, Illustration 2
Blackboard and chalk or flip-chart with pens (optional)

Preparation
Photocopy the Water Cycle Activity Cards from the masters on page 99 onto card stock.

Procedure
Show learners Figure 1: “A Basic Water Cycle” (page 10). Pass out the first seven Water Cycle cards. These are cards 1, 2a, 3, 4a, 5, 6, and 7. As you hand a card to each learner, have him or her read the “FACT” on the card to the group, then take his or her place in the Basic Water Cycle circle. When the first seven learners are in place, ask them to read again the title of their card to the group. Ask the remaining learners if there are any ways not mentioned that water exists or moves on Earth. Record the list of answers on the board or flip-chart paper.

From the remaining Water Cycle cards (8 through 21), pass out the ones from the answer list learners suggested. Add all the remaining cards from the set, and, if needed, cards 2b, 2c, 2d, 2e, 4b, 8b, and 13b. As you hand each card to a learner, have him or her read the FACT on the card to the group, then take his or her place in the Water Cycle circle. The learner with card 21 (Rosa Raindrop) joins the demonstration after all the other learners have taken their places in the Water Cycle circle.

Make a copy of the “Rosa Raindrop’s World Water Tally” (Figure 2, page 11). Ask the learner with the Rosa Raindrop card to travel around the “water cycle,” pausing as each learner again reads his or her card’s title. At each location with a world water supply percentage listed, Rosa “collects” this water. Record the water supply percentage in each blank on the World Water Tally.

Rosa Raindrop’s World Water Tally
Lakes 0.017%
Oceans 97.54%
Soil moisture 0.005%
Groundwater 0.62%
Rivers/streams 0.0001%
Ice caps/glaciers 1.81%
Atmospheric water 0.001%
When Rosa has completed one cycle through the Water Cycle, ask learners to raise their hand if they represent a part of the water cycle in which water:

- Is a gas
- Is a liquid
- Is a solid
- Moves
- Is fresh
- Is salty

Remember, only one learner, the ocean, represents salt water. However, the majority of the water on Earth is found in the oceans. Remind learners of this using the World Water Tally. They should not be confused by the greater number of learners who represent the many forms of freshwater.
### Rosa Raindrop's World Water Table

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage of total water (approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakes</td>
<td></td>
</tr>
<tr>
<td>Oceans</td>
<td></td>
</tr>
<tr>
<td>Soil Moisture</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
</tr>
<tr>
<td>Rivers/streams</td>
<td></td>
</tr>
<tr>
<td>Ice caps/glaciers</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Water</td>
<td></td>
</tr>
<tr>
<td>Total +/-</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2
3. Watersheds: Rain Coming and Going

CONTENT OBJECTIVES
Learners will be able to:
■ Define a watershed
■ Explain where rain falls most and least in Oregon
■ Locate some of Oregon’s major watersheds

SCIENTIFIC AND ENGINEERING PRACTICES
National Academy of Sciences (2012), A Framework for K-12 Science Education
口 Analyzing and interpreting data
口 Using mathematics and computational thinking
口 Constructing explanations
口 Engaging in argument from evidence

METHOD
Part 1
Leaders will make a simple watershed model of newspaper and a plastic garbage bag to demonstrate water flow in a watershed.

Part 2
Using the “Rain Coming and Going” worksheet, learners will locate and label major Oregon mountain ranges and rivers in watersheds and discuss the reasons for Oregon’s rainfall pattern.

BACKGROUND
A watershed is the entire land area drained by a stream or river. Watersheds are the part of the water cycle where surface water is channeled into a series of streams and rivers on its return journey to the ocean.

A watershed can be compared to a bathtub. All the water that falls inside the walls of the bathtub travels under the influence of gravity toward a common point, the drain. In fact, the land area that drains into a river is often called the river’s drainage basin. For example, the land area from which surface water flows toward the Willamette River is called the Willamette River Drainage Basin.

Continuing with the bathtub analogy, water that falls OUTSIDE the bathtub, onto the floor, is falling in a different “watershed.” The bathtub wall is the divide between the two watersheds. High elevation places such as mountain ridges divide water flow into watersheds.

In Oregon, the deep snow pack that builds up each winter in the mountains provides fresh melt water in the spring and summer that is important to recreation and irrigation. Wetlands can be important contributors to the watershed function as well. In the wet
season, wetlands soak up water like a giant sponge. This may prevent or reduce seasonal flooding. In the drier season, this water is slowly released to the watershed, maintaining water quality downstream.

Oregon has many large river basins that begin as a series of smaller watersheds in the mountains. The largest river basin associated with Oregon is the Columbia River Basin. The Columbia River Basin drains water from as far north as Canada and as far east as the Idaho headwaters of the Snake River. Its major tributaries from Oregon are the Umatilla, John Day, and Deschutes rivers in eastern Oregon and the Willamette River in western Oregon. The Grand Ronde, Malheur, and Owyhee rivers of far eastern Oregon drain east to the Snake River. The Snake River flows into the Columbia near Pasco, Washington. Much of the rain that falls on Oregon could eventually return to the ocean in the Columbia River.

**Materials**

**Part 1**
- A supply of old newspapers
- One white (not clear or black) plastic bag
- Small container of soil
- One container of green decorating sugar
- Water spray bottle labeled “cloud”
- Optional: A copy of the Rosa Raindrop’s Water Cycle diagram

**Part 2**
- One copy of the Rain Coming and Going Oregon Map (Figure 3) for each learner

**Preparation**

It is best to do the Part 1 activity outside. Create a model watershed by crumpling several sheets of newspaper in various ways to form raised areas for ridges and low areas for valleys. Lay the white plastic bag over the newspaper form. Adjust the newspaper and the plastic bag as needed so that at least one depression in the model will create a “lake” when water is added. In the demonstration the water spray bottle labeled “cloud” will be used to “rain” on the model watershed.

**Procedure**

**Part 1 — The Watershed Model**
Gather the learners around the model watershed and discuss how a watershed is defined. Spray some water on the watershed. Ask learners to notice where the water falls in the watershed and where it moves from where it falls. Remind the learners to remember what they learned about the water cycle. How is the water cycle related to a watershed?

Ask one learner to sprinkle a small amount of the soil on one raised area of the watershed. Ask learners, “When it rains again, what will happen to the soil?” Rain on the watershed and discuss observations about the effect on the soil. Have learners seen places where soil was being moved into surface water? What effect has the soil had on the model lake in the watershed?
Show the learners the green sugar crystals; explain that the sugar is fertilizer used on a
golf course. Ask one learner to sprinkle some of the green sugar crystals on one part of the
watershed. Ask learners what they think will happen when it rains. Rain on the watershed
again. Where does the “fertilizer” go?

Part 2—Rain Coming and Going
Pass out copies of the Oregon map (Figure 3). Have learners locate the rivers and lakes
on the map nearest to their home community. Point out the mountain ranges on the
map. Discuss which way some of the major rivers are flowing. The rivers which join the
Pacific Ocean flow from east to west. The Willamette River and all the rivers that enter the
Columbia along Oregon’s northern border flow from south to north. Along Oregon’s eastern
border the rivers flow from west to east to join the Snake River. Ask learners to draw a line
encircling the river and watershed where they live.

Remind learners of the Rosa Raindrop activity they completed. How does rain get to Baker
City? The annual average rainfall in inches for the Oregon cities on the map is provided
below. Provide learners with the information for the first nine cities one at a time. Ask them
to write the rain totals next to each city’s name.

<table>
<thead>
<tr>
<th>City</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astoria</td>
<td>67.3</td>
</tr>
<tr>
<td>North Bend</td>
<td>64.9</td>
</tr>
<tr>
<td>Portland</td>
<td>43.5</td>
</tr>
<tr>
<td>Eugene</td>
<td>46.1</td>
</tr>
<tr>
<td>Hood River</td>
<td>31.3</td>
</tr>
<tr>
<td>Bend</td>
<td>11.4</td>
</tr>
<tr>
<td>Pendleton</td>
<td>12.7</td>
</tr>
<tr>
<td>John Day</td>
<td>13.0</td>
</tr>
<tr>
<td>Ontario</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Discuss Oregon’s rainfall pattern. Where is it most wet or most dry? Why? (To pass over
the Coast Range and Cascade Mountains rain clouds must rise. This causes cooling and the
clouds lose some of their moisture as rain.)

Write the rainfall totals provided below, without the city names, on a paper or board where
all the learners can see them. Ask learners which cities on their map they believe has each
listed annual rainfall.

11 inches (answer: Baker City)
39.7 inches (answer: Salem)
67.2 inches (answer: Newport)
14.2 inches (answer: Klamath Falls)

After discussion and agreement on the correct answers, have learners complete their map.
Ask learners to keep their maps for use in the How the Ocean Affects Temperatures on
Land lesson.
4. Water Words

Objectives
Learners will be able to do the following:
■ Use vocabulary needed to discuss the properties of water
■ Describe the processes that are part of the water cycle.

Materials
■ Copy the “Water Words Vocabulary” page (page 17), one per learner.
■ Copy the “Water Word Search” worksheet (page 18), one per learner.
■ “Water Word Search” answer key (page 19) provided at the end of the lesson

Procedure
Pass out the “Water Word Search” worksheet and “Water Words Vocabulary” pages. Review the vocabulary words with the learners. Ask the learners to complete the “Water Word Search” worksheet.
Water Words Vocabulary

**Water vapor:** Water in its gaseous form is called vapor. Water can evaporate (change from a liquid to a gas) at any temperature. This process is called evaporation. Water will always become vapor when it reaches its boiling point. We see water vapor over a pot of boiling water as steam.

**Atmosphere:** The name given to the gas (air) directly over the earth’s surface that is acted on by the gravity of Earth.

**Condensation:** The process of water changing from vapor (gaseous form) to liquid. Small drops of water join together to become bigger drops. The bigger drops form clouds. We cannot see water vapor, but we can see clouds.

**Ice:** The solid form of water. When water freezes, it expands, but the weight remains the same. This is why ice cubes float on water.

**Gravity:** The downward force exerted by the earth. Gravity is the “down energy” of the water cycle; it causes water to flow downhill.

**Infiltration:** The process of a liquid (water) soaking into a dry material (soil). Water may infiltrate only the upper layer of soil, or it may soak deeply into the soil.

**Percolation:** The process of water moving through several layers of soil, sometimes reaching the water table.

**Water table:** The upper surface of water stored underground. This is the first water reached when a well is dug. Often this is the top surface of the ground water.

**Watershed:** A watershed is the entire land area drained by a stream or river. The boundaries of a watershed are called divides, because they divide the direction that water on these slopes will flow. Small watersheds contribute to larger watersheds.

**Glacier:** A mass of ice formed from compacted snow. Snow falling in the Cascade Mountains may become part of the snow pack, which may melt in the spring, or it may become part of a glacier.

**Transpiration:** The process of water vapor leaving a plant, generally from pores on the leaves.

**Photosynthesis:** The process green plants (chlorophyll-containing) use to change light into (chemical) energy, which is used to create food (carbohydrates) from carbon dioxide and water. Oxygen is released as a waste product of this chemical reaction.

**Estuary:** A coastal wetland area where salt water from the ocean blends with fresh water draining from the upland watershed(s).
Water Word Search

E I C A G I T P H G W A P E S C V A
T N E V A P O R A T I O N R V O N W
A F V O T R N M F T R C O L A N T A
V I A I M T A D O R A R E S G D E T
N L I L O R E I C A L G E A W E S E
P T G A S A T S N N T O S C P N T R
P R Y H P H O T O S Y N T H E S I S
R A I Y H E N T A P I P U H T A R H
E T O A E T R H G I D C A S O T V E
L I R C R V A P O R E T R O D I E D
I O S T E R P G C A A E Y R C O A W
R N Y R O A I W Y T S V I T I N R E
N S O V S U N A T I H F I K A M S T
P E R C O L A T I O N A C T G C O M
W F M K Q N S E P N I H W V Y D I C
H C L O U D H R F E K Z O P M V L Q

Look for the following words sideways, downward, diagonally, or backward:
1. Estuary
2. Vapor
3. Gas
4. Ice
5. Rain
6. Water
7. Percolation
8. Watershed
9. Glacier
10. Photosynthesis
11. Transpiration
12. Infiltration
13. Gravity
14. Atmosphere
15. Condensation
16. Evaporation
17. Ocean
18. Cloud
19. Soil
20. Sun
Section 2: Freshwater Ecosystems

5. Wetlands Functions: Water, Soils, and Plants

Well-functioning wetlands are vital components of healthy watersheds. Wetlands are found in many locations where the soil is saturated and other conditions are right to support their development. Typical locations include:

- Along rivers and streams
- In depressions on floodplains and at higher elevations
- On hill slopes where water seeps out of the ground
- Along the shores of lakes and estuaries
- On flats, such as vernal pools in southern Oregon or peat bogs near the coast

Although the lessons about wetlands are in the Freshwater Ecosystems section of this book, it should be noted that estuaries include wetlands, where there is a combination of both fresh and salt water found in coastal lowlands.

If you look around, you may see many wetlands in your area that have suffered from neglect or changes in the landscape—roads that interrupt drainage patterns, soil filled over wetlands to provide building sites, and stream diversions that cut off the water supply to wetlands. Approximately 4 percent of Oregon's original wetlands have been altered or converted to other uses since European-Americans arrived.

These changes greatly diminish the watershed support functions of the wetlands. With increased care and attention, however, some degraded wetlands can be rehabilitated, thereby increasing their capacity to support fish, wildlife, and human needs.

What is a Wetland?

Marshes, bogs, swamps, fens, sloughs and wet meadows are some of the more common names for different kinds of wetlands. These terms conjure up an image of ecosystems that aren't quite aquatic and aren't quite terrestrial. In other words, they are “transitional.”

Many wetlands fit this image of being part of a continuum between upland and open water ecosystems. Other wetlands, however, are isolated from open-water habitat and are maintained purely by groundwater and precipitation.

Three features of wetlands are common in most definitions:

- The presence of enough water to cause saturation of the upper 12 inches of soil for at least 2 weeks during the growing season
- Soils that are typical of saturated or ponded areas
- Plants that can tolerate such conditions

Wetlands are ecological “hot spots,” playing a role disproportionate to their size in supporting endangered species and maintaining biodiversity. Wetlands play other roles too: they usually help remove excessive nutrients (such as fertilizers and animal waste) and
other contaminants from water, store flood waters, release water during low flow periods, and provide food and shelter for salmon, trout, animals, and pollinators. The two lessons in this section introduce learners to how soils and plants function in wetlands to support these roles.

### Wetlands: What’s Soil Got to Do With It?

**Content Objectives**

Learners will be able to do the following:

- Name three types of soil: sand, silt, clay
- Understand how percolation rates differ with soil type
- Name two characteristics of wetland soils

**Scientific and Engineering Practices**

National Academy of Sciences (2012), *A Framework for K-12 Science Education*

- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations

**Methods**

**Part 1:** Learners will take on the role of soil particles to demonstrate the behavior of different soil types in an imaginary flower pot.

**Part 2:** Learners will learn how to identify soil types by how they feel and behave in their hands when moistened with some water.

**Part 3:** A guided inquiry will show learners how water percolates through different soil types. Through experiment and discussion, learners will understand how characteristics of wetlands (i.e., storing surface water, recharging groundwater) are related to soil type.

**FYI**

This lesson will introduce some of the characteristics of soil and how these characteristics affect wetland function. Review with learners what they have been taught so far. They have learned about the water cycle and how watersheds are interconnected. They know that water is stored in lakes and wetlands.

However, lakes and wetlands could not exist to store water where soils are very sandy. A sandy soil texture does not allow it to hold water at the surface. The exception to this is sandy soil in estuaries and coastal areas where water is located in low-lying pockets at the water table. Sandy soil may have a rapid percolation rate that allows quick recharge of groundwater supplies; yet in these same soils, water may move so rapidly that plants cannot take up the water they need to thrive.
Soils are classified by the size and number of their mineral grains into four groups: Sand, silt, loam, or clay. Loam is the term used to describe a combination of sand, silt, and clay.

Sand has the largest particles. They can be seen with the naked eye. Clay particles are extremely small and can be seen only with high-powered microscopes. Silt is between sand and clay in size.

Most soils are a combination of sand, silt, and clay. Soil scientists can be very precise about soil texture (Figure 4). For instance, a “sandy clay loam” soil contains 25 percent clay particles, 20 percent silt particles, and 55 percent sand particles.

**Materials**

For Parts 2 and 3, pass out copies of the “What’s Soil Got to Do With It?” worksheet (pages 26-27), or have learners design their own data sheet.

**Part 1**

Soil Texture Cue Cards to be made (see preparations)
- Sand
- Silt
- Clay
- Sandy clay loam = 55 percent sand (16 of 30 students) + 20 percent silt (6 of 30) + 25 percent clay (8 of 30)

**Part 2**

- Soil samples of sand, a clay soil, and a local soil (see preparations)
For each team of learners:
- Three petri dishes or plates
- A squeeze bottle filled with water, or a cup of water and an eye dropper

**Part 3**
One set to use as a demonstration or one for each team of learners for an interactive lesson:
- Soil Tube Percolation Test Assembly (see preparations)
- Soil samples of sand, a clay soil and a local soil
- One 1-cup measuring cup
- Three 2-cup measuring cups
- Timer or watch or clock with a second hand

**Preparations**

**Part 1**
Make four Soil Texture Cue Card signs:
- Sand
- Silt
- Clay
- Sandy clay loam = 55 percent sand (16/30) + 20 percent silt (6/30) + 25 percent clay (8/30)

The number in parenthesis is the number of learners in a group of 30 learners needed to give the correct composition for sandy clay loam. Adjust this number for smaller or larger groups of learners.

**Part 2**
To provide samples of sand and clay soils, you may need to purchase some materials.
- For sand, purchase sand-box grade sand at a “big box” toy store or garden nursery.
- If clay soil is not found locally, you can create a clay soil by adding clay to your local soil.
- Purchase “Mason's Clay” or “Mortar Clay” from a masonry supplier.

For each learning group (two to four learners), make up three petri dishes or plates containing one sample of the sand, clay, and local soil in each plate.

**Part 3**
For this part of the lesson, you will need one Soil Tube Percolation Test Assembly to use as a demonstration or one for each team of learners for an interactive lesson. The Soil Tube Assembly is a wonderful inquiry tool. The construction is fairly easy, once you have shopped for the parts. Please see the Soil Tubes Construction Instructions at the end of this lesson.

To set up the soil tubes for use, you will need to make three signs, one for each tube: “sand,” “clay,” and “local soil.” Fill the tubes approximately three-fourths full, one sample type in each tube. Be sure the amount of soil in each tube is the same. Tap the side of the tube gently to help the soil settle in the tube. However, do not pack the soil samples down. Place a 2-cup measuring cup under each tube to collect the water that percolates through the tube. The 1-cup measuring cups will be used to measure the amount of water added to each tube.
**Procedure**

**Part 1—The Flower Pot**
This activity can be done in any open area making use of natural boundaries or painted lines on the playground. The leader may also use sidewalk chalk to draw a flower pot outline big enough for the whole group to stand in.

Take the Soil Texture Cue Cards to the location of the activity. Ask the learners to stand in the designated flower pot area. Have one learner step out of the flower pot to take on the role of “Rosa Raindrop” for the activity. If this is a popular role, you can have a different learner be “Rosa” in each round of the activity.

Post the Soil Texture Cue Card for sand. Ask the learners remaining in the flower pot to become sand particles by standing with their arms outstretched and their hands clenched. They should stand so that they can GENTLY turn in a circle and just be touching each neighbor's knuckles.

When all the learners/sand particles are in position, ask them to freeze in place. Now ask Rosa Raindrop to begin at the top of the flower pot and percolate down through the sand (between the learners), and out the bottom of the pot. How hard was it for Rosa Raindrop to infiltrate and percolate through the sand?

Post the Soil Texture Cue Card for silt. To simulate silt particles, learners will stand with their hands on their hips and their elbows extended. They should stand so that they can GENTLY turn in a circle and just be touching each neighbor's elbows. Again, ask the learners to freeze in place while Rosa percolates through the pot. Discuss her travels; learners should notice it was a slower percolation with the smaller silt particles in the pot.

Post the Soil Texture Cue Card for clay and repeat the exercise. To be clay, learners will stand with their arms down their sides with their hands pointing away from their bodies. When they turn now, they will touch their neighbor's fingertips. Ask learners to notice how much of the pot they now occupy. Ask Rosa Raindrop to percolate down through the clay; it will be much harder this time! How do the clay particles compare to sand and silt for ease and speed of percolation?

Post the Soil Texture Cue Card for sandy clay loam. A sandy clay loam is made of 25 percent clay, 20 percent silt and 55 percent sand. With 10 learners, a sandy clay loam will be divided as 3 clay particles, 2 silt particles, and 5 sand particles. If needed, remind learners how to “become” their assigned particle size. Mix the learners up in the flower pot area. Ask Rosa Raindrop to infiltrate and percolate once again. Ask learners to discuss and compare Rosa's progress through the “sandy clay loam” to how the water drop was able to move through each soil type alone.

**Part 2—Texture by Feel**
Provide one copy of the “What’s Soil Got to Do With It?” worksheet page 1 to each learner. Give each learning group a set of three petri dishes or plates containing the samples of sand, clay, and local soil.
Ask learners to observe the soil samples. They may touch them, but don't add water yet. Ask learners to find the Texture by Feel section of the worksheet and to fill in the prediction column under each of the listed soil types. How do they think each soil type will behave when water is added?

To test for soil texture, one learner from each group will place a small amount of soil in the palm of their hand and add a few drops of water. After mixing the water into the soil, they will feel its texture. Can it be made into a ball? Can they make a rope? Can they bend the rope into a ring? Does it feel gritty or sandy? Does it feel smooth, like flour? Does it feel gritty, but NOT sticky? If too much water is added on the first test, ask them to try a second sample with less water. What results do they get for the three soil types? Ask them to fill in the results column on the chart. Lead a discussion to help learners complete the remaining sections of the worksheet.

Part 3—Percolation Test
Provide one copy of the “What's Soil Got to Do With It?” worksheet (page 26) to each learner or have them design their own inquiry and data sheet. Provide learners with a copy of the Inquiry Model Flow Chart from the Appendix (page 94) if learners are designing their own inquiry activity. Even in a guided inquiry or demonstration, leaders can ask learners to predict how the soil in each tube will behave when water is added. Use the “If, then….” model for prediction. For example: “If 1 cup of water is added to the sand and the clay, then more water will flow out of the sand tube than the clay tube AND it will flow faster through the sand tube.”

Be sure the 2-cup measuring cups are under each tube before learners begin. They should measure both the amount of water added to the tube and the amount that exits it.

Discussion
How did learners’ prediction of percolation volume and rates compare to the results? Did water stand on top of any soil type? If so, why? Could learners tell when the soil became saturated? What did they observe? Did water flow out of any soil at the same rate it was poured in to the top of the tube?
What’s Soil Got to Do with It? Worksheet

Texture by Feel

1. Fill in the Prediction column in the chart below for each type of soil before adding water to the samples.

2. Have one member of the group put some of the sandy soil sample on his or her palm. Add a drop or two of water, and try to form a ball. Add another drop or two of water as needed to make the sample moist but not muddy. Fill in the chart below.

<table>
<thead>
<tr>
<th>Can you?</th>
<th>Sandy Soil</th>
<th>Clay Soil</th>
<th>Local Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediction:</td>
<td>Observation:</td>
<td>Prediction:</td>
</tr>
<tr>
<td>... form a ball?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>... form a ring?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>... feel grit or sand?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>... feel a smooth texture, like flour?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>... feel any grit or stickiness?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3. Finish each sentence below to describe each soil’s characteristics.

a. I would know I had a sandy soil sample if it __________________________________________________________

b. I would know I had a clay soil sample if it __________________________________________________________

c. I think our local soil sample is most like (choose one) Sand Clay Neither one

Percolation Test with Soil Tubes
4. Before adding water to any of the tubes, predict how each soil will behave.

In the sandy soil, if we ________________________________________________________________________________
then ____________________________________________________________________________________________

In the clay soil, if we ________________________________________________________________________________
then _____________________________________________________________________________________________

In the local soil, if we ________________________________________________________________________________
then _____________________________________________________________________________________________

5. Pour a half cup of water into the top of each soil tube. Pour slowly so no water is lost over the edge of the tube. How long does it take for the half cup of water to soak into each soil type? Record this on the chart.

6. If water is not yet dripping from the bottom of any tube, add more water, a quarter cup at a time, until it does. Record the volume of water added in each tube on the chart.

7. If water is not yet standing (ponding) on the top of the soil in any tube, add more water, a quarter cup at a time, until it does, or until the group agrees that a type of soil will not “pond” water. Record the amount of water added before water sits on top of the soil in each tube on the chart.

<table>
<thead>
<tr>
<th></th>
<th>Sandy Soil</th>
<th>Clay Soil</th>
<th>Local Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time for a half cup of water to soak into soil:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total volume of water added before water dripped from the bottom of the tube:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of water added before water sat on top of the soil in the tube:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compared to the other soils, the percolation rate of this soil is (choose one)</td>
<td>❑ Faster</td>
<td>❑ Faster</td>
<td>❑ Faster</td>
</tr>
<tr>
<td></td>
<td>❑ Medium</td>
<td>❑ Medium</td>
<td>❑ Medium</td>
</tr>
<tr>
<td></td>
<td>❑ Slower</td>
<td>❑ Slower</td>
<td>❑ Slower</td>
</tr>
<tr>
<td>When the soil was saturated, the volume* of water held in this soil was:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Volume = (Amount of water poured into the tube) – (Amount of water collected in the cup below the tube)

8. What type of soil would you expect to find in a wetland?
Soil Tubes

Parts
30" of 3/4" Schedule 40 PVC pipe
One 3/4" Schedule 40 PVC coupling
Two 3/4" Schedule 40 PVC 90° elbows
Two 3/4" Schedule 40 PVC tees
Three #12 hose clamps
Three #24 hose clamps
One small can PVC cement
One 48" clear plastic fluorescent light tube cover
Three end caps for above
Nylon stocking material or cheesecloth

Tools
5/16" nut driver
Hack saw (for cutting PVC)
Sharp knife (for cutting tube)
Tape measure or ruler

Assembly
__1. Cut Schedule 40 PVC pipe into the following sizes.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 1/2&quot;</td>
<td>Cross Piece</td>
</tr>
<tr>
<td>2</td>
<td>8&quot;</td>
<td>Legs</td>
</tr>
<tr>
<td>1</td>
<td>3&quot;</td>
<td>Support</td>
</tr>
</tbody>
</table>

__2. Cement the coupling to one end of the support—see Figure 1. Push the pieces together quickly because the cement sets up very fast.

__3. Cement a 90° elbow to one end of each leg—see Figure 2.

__4. Cement the cross piece to one of the 90° elbow and leg assemblies—see Figure 3.
5. Lay the cross piece and leg assembly on a flat surface. Cement the other end of the cross piece to the other leg assembly so both leg assemblies lay on the flat surface—see Figure 4.

6. Cement a tee to each leg—see Figure 5.

7. Cement the support to one of the tees—see Figure 6.

8. Measure and cut the fluorescent tube cover in half.

9. Measure and cut each of the halves in half.

10. Open the three #12 hose clamps completely.

11. Place a mark on the cross piece 3/4" from each end—see Figure 6.

12. Measure and mark the center of the cross piece—see Figure 6.

13. Fasten the #24 clamps to the cross piece using the #12 clamps—see Figure 7 for proper orientation of the clamps.

14. Insert the fluorescent tube covers and hold in place with the #24 clamp. Do not overtighten clamps.

15. Cut three pieces from the nylon or cheese cloth approximately 2" square.

16. Place a square on the bottom of each tube and press the tube cap on to hold it in place.
6. Wetlands: In the Water, In the Plants

CONTENT OBJECTIVES
Learners will be able to do the following:
■ Understand the capacity of wetlands to cleanse water through storage of soluble substances in plant material
■ Understand that the wetland's capacity to store substances can be exceeded when there are too many contaminants in the ecosystem

SCIENTIFIC AND ENGINEERING PRACTICES
National Academy of Sciences (2012), A Framework for K-12 Science Education
   ❑ Asking questions
   ❑ Developing and using models
   ❑ Planning and carrying out investigations
   ❑ Analyzing and interpreting data

METHOD
Learners will observe the ability of plants to absorb soluble substances from water.

FYI
Wetlands play an important role in maintaining water quality. Water enters the wetland from surface runoff or from groundwater. These water sources may bring with them fertilizers and other waterborne contaminants.

Many things may be dissolved in the water that moves through plants. If the water carries pollutants, these pollutants may be deposited in the plant's tissue. If the plant is used for food, then the pollutants may get into animals or people who eat it.

In the spring and summer, when wetland plants are actively growing, they absorb contaminants along with water-soluble nutrients. In the fall and winter, when plants die back, nutrients are released as some of the plant's tissues decay. In the winter there is a lower concentration of nutrients in water from runoff and groundwater; ecosystems downstream make good use of these released nutrients.

Wetlands have been called nature's “water treatment operations.” In a time when humans introduced fewer pollutants and less silt to the waters entering wetlands, they were very efficient indeed.

Today heavy metals, petroleum products, and fertilizers are more abundant in the environment. Wetlands’ capacity to purify water can be exceeded, resulting in degradation of other parts of the ecosystem. As you study the ability of plants to remove contaminants from a system, remind learners that the ultimate answer is to reduce the amount of pollutants humans put into the environment.
**Materials**

- A copy of the Inquiry in Action flowchart for each team (Appendix, page 94)
- A set of two clear glasses for each team. Plastic “party” cups work well.
- One ruler per team
- Several bunches of celery, stalks cut to the same length, no longer than 11 inches each.
  - Each team will need two stalks.
- One knife per team for older learners, or leader can cut the celery stalks
- Access to water supply
- For teams to design their own inquiry, provide supplies of edible items, such as:
  - Red or blue food coloring
  - Salt
  - Vinegar
  - Two or more different food flavoring extracts

*NOTE: Caution learners not to taste the extracts undiluted from the bottle.*

**Procedure for Inquiry**

This set of lessons uses the Inquiry in Action flowchart (Appendix, page 94) to support including inquiry in appropriate lessons. You may find it helpful to make copies of the Inquiry in Action flowchart for yourself and your learners.

Begin the activity by asking learners some questions to determine what they know about how plants absorb water and nutrients. If you have completed the soil lesson with them, learners will know a little bit about how soils function in a wetland. What questions do they have about how plants contribute to wetland functions?

Introduce the edible items for learners to use to test if celery, our sample plant, absorbs soluble materials from water. Each team will have 2 cups of water with food coloring in it and two stalks of celery. The food coloring will provide a visible indication of the movement of fluid in the celery stalks. The experimental pollutant will be one of the other edible items. The items need to be edible because one learner will taste the celery to verify how far up the stalk the experimental pollutant travels. Refer the teams to the Inquiry in Action flowchart and ask them to form a hypothesis about how one of the edible experimental pollutants will interact with a stalk of celery (Box 3).

Once all the teams have formed a hypothesis, ask them to share their question with the group. Coach the process so that each team selects a different experimental pollutant to test. Be sure each team has proposed a hypothesis that can be tested with the available materials.

Next the teams will be ready to design their investigation and create a data sheet (Boxes 4 and 5). Be sure that learners give the celery a minimum of 4 hours up to a maximum of two days to absorb fluids. If it is more convenient, you may have all the teams test their celery after a set period of time.
Ask learners to evaluate the condition of their celery stalks before they begin to slice them. Is the stalk firm as when it started, or has something changed? Ask them to record their observations. To evaluate how the solutions moved in their celery stalks, each team will slice each stalk at half-inch intervals, examining for food coloring. They should note how far up each stalk the food coloring has traveled. One team member will be the taster for the celery in the edible experimental pollutant solution. They should start tasting their celery slices from the top and work their way down to where they taste the “pollutant.” Remind learners that there are many science experiments they could do that should NOT be tasted!

Provide time for all the teams to share their findings with the full group.

**DISCUSSION**

If a pollutant was in the water that had no color, no odor, and no taste, how would we know it was there?

**EXTENSION DEMONSTRATION**

Demonstrate transpiration in plants in this way: Place a celery stalk containing leaves in a glass of colored water. Over the leaves at the top of the stalk, place a plastic sandwich bag. Secure the bag around the stalk with a rubber band. After a period of time, water droplets will collect in the bag. What color are the water droplets? Where did they come from?
7. What’s in a Stream?

**Content Objectives**
Learners will be able to do the following:
- Diagram and explain the interrelationships of a food chain and a food web

**Scientific and Engineering Practices**
National Academy of Sciences (2012), *A Framework for K-12 Science Education*
2. Developing and using models
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**Background**
In addition to fish, many living things make up a pond or stream habitat. As a way to understand their relationship, the interactions among the organisms that populate a stream can be arranged in a food chain. A food chain is a model to depict energy flow through an ecosystem. Any ecosystem is much more complicated than a single food chain or even a group of food chains—called a food web—can demonstrate. However, a food chain is a useful model for learners to begin to understand the interrelationships in ecosystems.

A food chain in an aquatic habitat might seem to begin with phytoplankton or algae, which create energy through photosynthesis. However, these plants need nutrients too. Decomposers—bacteria and other microbes—break down dead plants and animals so they are recycled back into the aquatic system as nutrients. In salmon streams, the decomposing bodies of spawned-out salmon are crucial for returning nutrients to the ecosystem. These nutrients are important not only to the stream, but to the surrounding uplands as well.

In an aquatic food chain, small animals called zooplankton, which feed on phytoplankton, might come next. Salmon fry, which have absorbed their yolk sacs, feed on the zooplankton. The salmon fry may be eaten by a variety of predators, including trout, raccoons, and belted kingfishers.

Salmon are an example of how complicated ecosystem study can become. Pacific salmon do not spend their lives in the home stream of their birth. They live in the whole watershed, traveling down to the Pacific Ocean and then returning home to spawn. All the ecosystems within the watershed and the ocean affect salmon on their journey.
MATERIALS

Part 1
- “What's in a Stream?” worksheet, one copy for each learner

Part 2
- “Stream Web of Life” cards (Appendix, page 106), one set
- Two lengths of poly-rope, two different colors if possible

PREPARATION
- Copy the “Stream Web of Life” card masters onto card stock

PROCEDURE

Part 1
Pass out a copy of the “What's in a Stream?” worksheet to each learner. Using the information in the “Background” section, lead the learners to define a stream habitat. What are some of the nonliving things that are part of an aquatic habitat? Ask learners to list these on the four lines provided around the outside of the oval on the worksheet. Learners might list water-quality characteristics, such as the temperature or amount of oxygen; the amount of water; the types of stream-bottom coverings, such as boulders and gravel; and the logs and sticks that would make up other components of stream structure and provide pools and places for fish to hide.

In the center of the oval, ask learners to write down three to four components of a simple aquatic food chain. A food chain typically begins with a plant and then moves to an animal that eats that plant, followed by an animal that eats the first animal, and so on.

Two examples of food chains follow:

- (1) phytoplankton, (2) zooplankton, (3) juvenile salmon, (4) belted kingfisher
- (1) algae, (2) snails, (3) crayfish, (4) raccoon

See the “What’s in a Stream?” answer key for one example of how to complete the chart.

When learners have completed the worksheet, discuss their answers. What other organisms might be added to create a stream food web?

Part 2
For this activity, you will need a large area where learners can spread out. There are 30 cards in the Stream Web of Life set. If you have fewer learners, remove some of the cards from the set. Be sure you use all six of the habitat component cards each time you demonstrate the activity. (Habitat component cards are the Sun, Salmon carcass, Riffles/runs/gravel, Woody debris, Silt, and Water quality.)
Young learners may have trouble with the vocabulary used on the cards. The leader may need to read the cards for the learners as the activity proceeds.

Ask learners to stand in a circle. Pass out one Stream Web of Life card to each learner. Ask the six learners with habitat component cards to take two steps back from the main circle of learners. Position the six learners so they will be able to hold one of the lengths of poly-rope in a circle around the outside of the remaining circle of learners. Ask each learner with a habitat component card to read his or her card aloud in turn as you pass the rope around the habitat component group. It is helpful to begin and end this outside circle with the Sun, as it is the logical starting point for the next part of the activity addressing learners on the inside circle.

Hand one end of the second length of rope to the learner with the Sun card. This learner now holds the beginning and ending sections of the first rope and the beginning of the second length of rope. Now, ask the Sun to pass the second coil of rope to a learner with a plant card. For example, Sun might pass the rope to Phytoplankton.

The Phytoplankton reads its card to the group, then passes the rope on to one of the components listed on the card. In the case of the Phytoplankton card, these are zooplankton, salmon, aquatic insects, and snails. Learners may pass the rope to any other learner who is a component listed on their card. They may pass the rope to something they eat or use or to something that eats or uses them. As each learner receives the rope, he or she reads the card aloud to the group.

Each learner continues to hold his or her section of rope until all learners are holding a piece of rope and a web design has been created in the middle of the circle. Be sure the rope is passed across the circle to form a web, not just around the edge. It is easiest for the leader to facilitate this activity from the center of the circle.

Ask learners where people fit in the web. (People eat crayfish, frogs, and salmon.) What would happen to the web if there were no more insects? Ask learners who have insect cards to drop their section of the rope. What happens to the web?

Lead a discussion with learners about what habitat components they might find in a local pond or stream. From what they have learned in previous lessons, which animals and insects would live in a pond or stream? Where might learners find other habitat webs? Do forests or meadows have webs of life? Older learners may do research and report on webs found in other habitats.
What’s in a Stream?

Habitat Component

Habitat Component

(1) ____________ (2) ____________ (3) ____________ (4) ____________

(1) ____________ (2) ____________ (3) ____________ (4) ____________

Habitat Component

Habitat Component
What’s in a Stream?

Habitat Component

Sun

Phytoplankton
Algae
Woody debris

Habitat Component

Riffles/runs/gravel

Zooplankton
Snails
Silt

Habitat Component

Juvenile salmon
Crayfish
Belted kingfisher
Raccoon
8. Water Quality Tests: pH, Dissolved Oxygen, Temperature, Sediments, and Aquatic Invertebrates

**Content Objectives**

Learners will be able to do the following:

- Name a minimum of two and up to five water-quality factors that can be tested
- Demonstrate how to test for water quality
- Explain why water-quality factors can affect aquatic animals, invertebrates, and plants
- Understand that each water quality measurement must be within a tolerable range for aquatic life to thrive

**Scientific and Engineering Practices**

National Academy of Sciences (2012), *A Framework for K-12 Science Education*

- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**Background**

The pH, temperature, dissolved oxygen, and sediment in water have a direct effect on the aquatic animals, invertebrates, and plants that can live there. In an artificial pond, these factors may be changed by changing how the pond is managed. For instance, fountains and waterfalls mix (aerate) water, which might increase the dissolved oxygen content; they also can cause the water to become warmer, which can decrease the water's ability to hold dissolved oxygen. The relationships among the factors and their effects on aquatic life are complicated. It is not necessary for adult leaders and learners to understand all these interrelationships. What is important is to understand that they each must be within a tolerable range for aquatic life to thrive.

**pH**

In the chart “pH Ranges that Support Aquatic Animal and Plant Life” (page 41), you can see that animals we might consider “desirable”—such as trout and the aquatic insects they feed upon—find a narrow pH range between pH 6 to 8 acceptable. The pH scale ranges from 0, which is acid, to 14, which is called basic. Both very high and very low pH readings are detrimental to aquatic life. A pH of 7 is called neutral. Rain in the western United States averages a pH of 6.5. In the eastern United States, rain can have a lower pH reading (thus, it is called “acid rain”).
Dissolved Oxygen (DO)

All aquatic animals need oxygen to survive. The amount of oxygen dissolved in water can be affected by altitude (pressure), temperature, plants, light exposure, aeration, and sediments suspended in the water. Temperature has a direct effect on the amount of oxygen in water. Colder water can hold more oxygen.

Dissolved oxygen (DO) is measured in parts per million, written “ppm” (milligrams per liter of water is written as mg/l). A DO range of 5 to 6 ppm is acceptable for most aquatic life.

Temperature

Temperature is very important to water quality. Temperature has a direct effect on the amount of dissolved oxygen in water. In addition, temperature can affect the rate of photosynthesis by aquatic plants and the sensitivity of organisms to parasites and disease. Salmon and trout generally prefer water temperatures between 40 to 65 degrees F.

Aquatic Invertebrates

Aquatic invertebrates are adult or juvenile insects, and relatives of insects, that live in water for all or part of their life cycle. These invertebrates are also an indicator of water quality. On the “pH Ranges that Support Aquatic Animal and Plant Life” chart we see some invertebrates listed. On the “Quick Reference Guide to Aquatic Invertebrates” cards (page 121), the first information provided after the name is the pollution tolerance of each species. Learners should refer to that information as they collect and identify macro-invertebrates.

Materials

- Quick Reference Guide to Aquatic Invertebrates cards (Appendix, page 121), one set per team
- Loose-leaf binder rings, one for each set of Aquatic Invertebrates cards
- Chart: “pH Ranges that Support Aquatic Animal and Plant Life” (page 41), one per team
- Water Quality Test Kit—at minimum the kit should test for pH and DO.
- LaMotte makes several student water test kits which can be ordered from science supply companies. The kits use “TesTabs” and plastic test tubes to measure a range of parameters. In addition to DO, these may test for pH, nitrates, or phosphates. More expensive kits include tests for coliform bacteria and biochemical oxygen demand (BOD). If you do not wish to buy the complete kit, you can buy the following individual tests:
  - pH (pH test paper)
  - DO
  - Temperature (standard thermometers)
- 4-H Water Data Sheet (pages 42-43), one for each learner or team of learners (from the 4-H Natural Science Project Record, 4-H 303LR)
- Aquatic invertebrate collection materials: aquarium nets, plastic collection bowls, hand lenses
**Preparation**

Order the water-quality testing materials of your choice. Practice using them before demonstrating them to learners.

Make photocopies of the 4-H Water Data Sheet (pages 42-43), and the pH Ranges that Support Aquatic Animal and Plant Life chart (page 41).

Make photocopies of the Quick Reference Guide to Aquatic Invertebrates cards (Appendix, page 121) onto card stock, one set per team. Punch a hole in one corner of each card and insert a loose-leaf binder ring through each set to keep them together.

**Procedure for Inquiry**

This set of lessons uses the Inquiry in Action flowchart (Appendix, page 94) to support including inquiry in appropriate lessons. The Introduction provides information on facilitating lessons using Guided Inquiry and Open Inquiry. You may find it helpful to make copies of the Inquiry in Action flowchart for yourself and your learners.

Lead a discussion with learners to determine what they know about water pollution and water quality. Share information with learners based on the “Background” section. Adapt the information to the age and interests of the learners. If learners have questions that are not answered by the information provided, have them do some library or Internet research to find answers.

One objective of this lesson is for learners to know how to use water-quality test kits. Demonstrate how to use each test in the water-quality test kits you purchase.

Lead a discussion about water-quality monitoring programs. Pass out the 4-H Water Data Sheet. (Note: The 4-H Water Data Sheet calls aquatic invertebrates “macro-invertebrates.”) Using the knowledge they now have about water-quality tests, ask learners to design a plan for monitoring the quality of the water and numbers and types of invertebrates in the pond or stream they will study. Ask, “If we do not monitor the quality of our pond’s or stream’s water, how would we know if the pond water was becoming polluted?”

Coach learners to ask a question or form a hypothesis that they can investigate and test over time using the water-quality monitoring tests they have learned. Follow the steps outlined in the 4-H Science Inquiry Model. Create a timeline of the project. This could be a week, a month, or the entire year.

At the end of the investigation phase, learners should organize and summarize their data. They can use the Quick Reference Guide to Aquatic Invertebrates cards and the pH Ranges That Support Aquatic Life chart to help them analyze and interpret the data.
### pH Ranges That Support Aquatic Animal and Plant Life

<p>| | | | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Most acid</td>
<td>1</td>
<td>Battery Acid</td>
<td>2</td>
<td>Lemon juice</td>
<td>3</td>
<td>Vinegar</td>
<td>4</td>
<td>Cola</td>
<td>5-5.6</td>
<td>Normal</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Pure water</td>
<td>8</td>
<td>Sea water</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>11</td>
<td>Ammonia</td>
<td>12</td>
<td>Bleach</td>
<td>13</td>
<td>Most basic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Snails, clams, mussels**
- **Largest variety of animals: trout, mayfly nymphs, stonefly nymphs, caddisfly larvae**
- **Bass, bluegill**
- **Carp, suckers, catfish, aquatic worms, insects such as midge larvae and black fly larvae**
- **Plants (floating, rooted) and algae**
- **Bacteria**

**Notes:**

Figure 5

Archival copy. For current version, see: https://catalog.extension.oregonstate.edu/4-h3805l
### 4-H Water Data Sheet

A record is part of your 4-H project. Keep your record neat, clean, and up-to-date. It's best to use a pencil. Write clearly. If you need help, ask your parents or leaders. If you need more space, add notebook paper to your record.

**Date_________________**  
**Crew members ________________________________________________**

**Location ___________________________**  
**Plot no. _____**  
**Elevation _______**  
**Percent of slope _____**

**Season_________________**  
**Temperature _______**  
**Annual precipitation _____**  
**Soil type ___________**

#### Type of water study area (check one)
- [ ] Temperate forest
- [ ] High desert forest
- [ ] Coastal grassland/meadow
- [ ] Temperate grassland/meadow
- [ ] High desert grassland/meadow
- [ ] Coastal mountain grassland/meadow
- [ ] High desert shrub land
- [ ] Other:

Record the amount of stream vegetative cover (all species), dissolved oxygen (DO), pH, width, depth, velocity, and temperature. These relate to the overall ability of the system to maintain aquatic life, slow stream flow, and decrease excessive stream bank erosion and incising. You will need a camera, 100-foot measuring tape, water quality kit, clipboard, data logger or thermometer, pencil, and this check sheet.

- **Stream type**
  - Perennial (year-round) ______  
  - Intermittent (seasonal) ______

- **Photo station**
  - Perpendicular ______  
  - Oblique to stream ______

- **Current precipitation year**
  - Wet ______  
  - Normal ______  
  - Dry ______

- **Channel type**
  - Entrenched: Slightly ______  
  - Moderately ______  
  - Deeply ______
  - Confined: Poor ______  
  - Moderately ______  
  - Well ______

- **Channel pattern**
  - Straight ____  
  - Slightly sinuous ____  
  - Meandering ____  
  - Braided ____

- **Stream gradient**
  - Steep (>10%) _____  
  - Moderate (4–10%) _____  
  - Gentle (<4%) _____

- **Vegetation**
  - Typical riparian, perennial, water-loving species dominate
  - Typical riparian, perennial, water-loving species infrequent
  - Typical riparian, perennial, water-loving species absent
  - Typical riparian, perennial, water-loving species replaced by upland species

List the three most abundant macro-invertebrates found.

__________________________

__________________________

List other species found (such as fish, snails, crayfish).

__________________________

__________________________

Water turbidity (sediment/muddy)  
- Clear _______  
- Moderate _______  
- Extreme _______
### Stream flow data record
To determine stream flow (cubic feet per second = \( \text{ft}^3/\text{sec} \)), observers should take measurements at three different sites along the section of stream they are studying. The measurements will include width, depth, velocity, and streambed roughness. Use the following table to help with your calculation.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Width (w)</th>
<th>Depth (d) (average of 5 locations across stream)</th>
<th>Velocity (v)</th>
<th>*Streambed roughness (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Streambed roughness — rubble, gravel, or plant: a = 0.8; smooth mud, silt, or bedrock: a = 0.9

To calculate stream flow rate (\( r \)), use the information on the above data chart. Use the average value of each measurement at the three sites in the formula: 

\[
r = w \times d \times v \times a
\]

Stream flow = _______ x _______ x _______ x _______ = _______ ft\(^3\)/sec

### Temperature data record

<table>
<thead>
<tr>
<th>Air temperature</th>
<th>Water temperature</th>
<th>Note:</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>°F</td>
<td>Time</td>
</tr>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\frac{9 \times (\text{°C} + 32)}{5} = \text{°F}
\]

\[
\frac{5 \times (\text{°F} - 32)}{9} = \text{°C}
\]

### pH data record

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Dissolved oxygen (DO) data record

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Average</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. The Home Water Detective

**Content Objectives**
Learners will be able to do the following:
- Explain where their home's drinking water supply comes from and where their home's wastewater is treated
- Understand how much water is used in their homes
- Determine if less water could be used in their homes

**Scientific and Engineering Practices**
National Academy of Sciences (2012), *A Framework for K-12 Science Education*
- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking

**Background**
Become familiar with the drinking water and wastewater disposal systems in your community. Do your learners get their drinking water from a well on their home property or a municipal source, or both? Does the wastewater that leaves learners' homes go to a septic tank or a municipal waste water management system, or both? Use online resources to learn about your nearest municipal drinking water and wastewater systems.

**Materials**
- Flip chart paper and pens
- The Water Detective worksheet, one per learner (page 46).

**Preparation**
Write the title words Home Water Source at the top of one piece of flip chart paper. Under the title, make a chart with two columns. In the left column, list each type of drinking water supply learners in your community may have. These may be springs, city, county, small community system, private well on the home property, share well, or other sources. Below the drinking water sources, write a list of wastewater disposal systems found in your community. When you lead the discussion, you will fill in the second column with each learner's information.
**Procedure**

Pass out the worksheet and lead a discussion about where people get their drinking water and how wastewater is treated and disposed of. Fill in the chart. Learners may not know where their water comes from or where it goes. That is OK. They should write what they think they know on the worksheet in Section I, and ask their parents or guardians when they go home.

Read through Section II of the worksheet to be sure that learners understand their assignment to collect information on their homes. Remind learners to bring their completed worksheet to the next session, where you will discuss everyone’s results and compare them to the hypotheses in Section I.
The Water Detective

Section I: In your learning group, discuss the questions below and develop a hypothesis about your water use at home.

1. My family gets its drinking water from ______________________________________________________________

2. My home's wastewater is treated by: ___septic tank ___municipal waste water system
   Other:___________________________________________________________________________________________

3. I think I use this many gallons of water each day at home: ________________________________________________

4. I think my family uses this many gallons of water each day at home: ________________________________

5. I think there are this many leaky or drippy faucets at my home (Remember to check both inside and outside):
   ______________________________________________________________________________________________

Section II: Test your hypotheses at home

1. Home water supply: Ask your parents/guardian where the drinking water in your home comes from. Record the answer here:
   ______________________________________________________________________________________________

2. Home wastewater system: Ask your parents or guardian where the wastewater from your home goes when it leaves your house. Record the answer here:
   ______________________________________________________________________________________________
3. Keep a record of your personal water use over a 24-hour period. Tally your use on the chart below for each type of water use each time you use it.

Start Date and Time: _______________________________  End Date and Time: _______________________________

<table>
<thead>
<tr>
<th>WATER USE</th>
<th>TALLY</th>
<th>TOTAL TALLY</th>
<th>GALLONS PER USE</th>
<th>GALLONS PER DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flush toilet</td>
<td>X</td>
<td></td>
<td>7 gallons</td>
<td>= (a)</td>
</tr>
<tr>
<td>Wash hands</td>
<td>X</td>
<td></td>
<td>1 gallon</td>
<td>= (b)</td>
</tr>
<tr>
<td>Brush teeth</td>
<td>X</td>
<td></td>
<td>2 gallons</td>
<td>= (c)</td>
</tr>
<tr>
<td>Take shower</td>
<td>X</td>
<td></td>
<td>30 gallons</td>
<td>= (d)</td>
</tr>
</tbody>
</table>

Total gallons per day = \( \frac{a+b+c+d}{e} \) = (e)

4. My family's water use. Use the total gallons/day amount from (e) on the water-use chart to determine the water used by you and your family members.

Number of family members: ________ X (e) _________ gallons/day = ________________

5. Take a tour inside your home and outside in the yard. How many faucets or hoses can you find that are dripping? Record the answer here:

__________________________________

6. If your home uses water from a public water system, your family probably pays a bill each month for the amount of water they use. The monthly bill is generally based on the number of cubic feet of water used as recorded on the water meter at your house. Ask your parents or guardian how much they pay for each cubic foot of water used in your home. A cubic foot of water equals 7.5 gallons of water. How much money could your family save each year if all the leaky faucets were fixed?

What other ways could you and your family reduce your home water use?

7. How did your hypotheses of the water used by you and your family compare to the actual use? Fill in the chart below.

<table>
<thead>
<tr>
<th>MY HYPOTHESIS</th>
<th>ACTUAL USE</th>
<th>MORE OR LESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>My water use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My family’s water use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 3: Marine Ecosystems

10. Oregon’s Weather and Ocean Climate Chemistry

Introduction

We hear a lot from the news media about climate change. What are they talking about anyway? No matter where you are on the planet every day you experience some type of weather. But climate is different from weather. Climate is the average weather for a given location in each season of the year over many years. Climate influences the plants and animals that live in an area.

In the Northern Hemisphere, where the United States of America is located, weather is generally warmer in the summer and cooler in the winter. The farther north you go, the cooler the winters get, on average. The farther south you go, the warmer summers get, on average, but there might be warm or cold days—that's weather!

Climate

Climate is important to many aspects of our lives. We grow plants for food in specific areas of the country because these plants grow best in a specific climate. The United States Department of Agriculture developed a map to help farmers and home gardeners plant the correct plants for their climate zone (Figure 6). You can see a larger interactive version of this map at www.usna.usda.gov/Hardzone/ushzmap.html.
Can you see in Figure 6 how the light brown colored zone 8a and dark brown colored zone 8b are located along the United States’ southeast coast, along the Gulf Coast, across Texas, into the Southwest, California, and on northward into Washington State? The map key tells us that plants in zone 8a may be exposed to low temperatures of 10—15 degrees Fahrenheit in winter. Zone 8b is a little warmer at 15—20 degrees Fahrenheit (Figure 7).

<table>
<thead>
<tr>
<th>Zone</th>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Example Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a</td>
<td>10 to 15 degrees</td>
<td>-9.5 to -12.2 degrees</td>
<td>Tifton, GA; Dallas, TX</td>
</tr>
<tr>
<td>8b</td>
<td>15 to 20 degrees</td>
<td>-6.7 to -9.4 degrees</td>
<td>Austin, TX; Gainesville, FL</td>
</tr>
</tbody>
</table>

Figure 7

The Pacific Ocean on the United States’ West Coast and the Atlantic Ocean on the East Coast have a modifying effect on the weather in our country. Locate the area of light purple zone 4a and dark purple zone 4b on the map. This is an area with very cold minimum winter temperatures in the central part of our country (Figure 8). This area is too far away from an ocean to experience the milder temperatures of zones 8a and 8b. Note that the north/south trends in average temperatures in the center of the United States are greater than near the oceans. Oceans matter!

<table>
<thead>
<tr>
<th>Zone</th>
<th>Fahrenheit</th>
<th>Celsius</th>
<th>Example Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>-30 to -25 degrees</td>
<td>-31.7 to -34.4 degrees</td>
<td>Minneapolis MN, Lewistown, MT</td>
</tr>
<tr>
<td>4b</td>
<td>-25 to -20 degrees</td>
<td>-28.9 to -31.6 degrees</td>
<td>Northwood, IA, Nebraska</td>
</tr>
</tbody>
</table>

Figure 8

When scientists talk about climate change, they mean that the patterns of weather used to develop this map may experience more differences than the average on recent record for a season. Winters may be warmer or colder than average. There may be less precipitation, leading to drought, or more precipitation, causing flooding. Summers could also be warmer, cooler, drier, or wetter.

**The Oceans and the Atmosphere**

Climate is affected by both chemistry and physics. You know that on a warm day you can move out of the direct sun into the shade to cool off. When you are in the sun you are absorbing incoming energy from the sun. Trees, buildings, the earth around you, and the oceans also absorb some of the sun's energy. This energy is called radiant energy. The energy gets redistributed in the atmosphere and in the oceans by huge circulating currents. The large bodies of air and water on our globe move in relation to heat from the sun, the earth and from each other. There are many variables in the global system.

The movement of water in evaporation, precipitation, and storage in oceans and on land is called the water cycle. This movement also redistributes energy. For more information and an animation on the water cycle, see [www.epa.gov/climatechange/kids/index.html](http://www.epa.gov/climatechange/kids/index.html), Let’s Learn about the Water Cycle.
In the oceans, this redistribution of energy is called The Global Conveyor Belt. For more information on currents and The Global Conveyor Belt see http://oceanservice.noaa.gov/education and click on Currents.

In the atmosphere, redistribution of the sun's energy is affected by naturally occurring “greenhouse gases.” Greenhouse gases are water vapor, carbon dioxide, ozone, methane, and nitrous oxide. They are what make life as we know it on Earth possible. You may have heard that Mars gets very cold at night. This is because there is no blanket of gases holding in the heat. Activities by humans have increased the amount of greenhouse gases in the atmosphere. The name of these gases refers to their property of trapping energy. Like the glass in a greenhouse, Earth's atmosphere holds the sun's energy and does not allow it to reflect back into space.

Scientists believe this increased energy is causing changes in average global temperatures and raising the temperature of the oceans. Even small increases in ocean temperatures can influence climate and may be harmful to the animals and plants which live there.

**The Carbon Cycle**

Carbon dioxide, CO$_2$, is a greenhouse gas which has increased in the atmosphere as a result of human activity. In a very simple carbon cycle, we know that we breathe in oxygen and we breathe out CO$_2$. Then plants use CO$_2$ in a process called photosynthesis, to produce carbohydrates and release oxygen. Humans are a part of the carbon cycle.

Living plants contain stored carbon. Fossil fuels are plant energy stored in the earth; burning these stored sources of carbon increases the CO$_2$ in the atmosphere. Combustion of fossil fuels and deforestation are leading causes of rising CO$_2$ levels in the atmosphere.

For web-based information and animations designed for youth on the carbon cycle, see the EPA's Let's Learn about the Carbon Cycle website at http://www.epa.gov/climatechange/kids/index.html, and NASA's Climate Kids site at http://climatekids.nasa.gov.

**Where’s the Chemistry?**

When CO$_2$ dissolves in sea water, it reacts to form carbonic acid (H$_2$CO$_3$). The chemical formula looks like this:

$$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$$

The pH scale is used to rank acids and bases with the numbers 1–14. The numbers 1–6 are acids. The numbers 8–4 are bases. The number 7 is neutral; it is neither a base nor an acid. In the experiment, you will determine if CO$_2$ changes the pH of sea water.
Activity 1: How the Ocean Affects Oregon's Land Temperatures

Content Objectives
Learners will be able to do the following:
- Understand that the average July high temperatures are lower on the coast than inland in Oregon
- Understand that the ocean moderates the temperatures on the coast

Scientific and Engineering Practices
National Academy of Sciences (2012), A Framework for K-12 Science Education
- Asking questions
- Developing and using models
- Analyzing and interpreting data
- Constructing explanations

Materials
- Pads of self-sticking notes
- Oregon map

Procedure
Ask learners to work in pairs. Give each pair a copy of the Oregon map (page 15) and a stack of self-sticking notes. The worksheet provides learners with the average July minimum and maximum temperatures for 10 cities across Oregon. Learners should write these temperatures on the self-sticking notes and place them on the map by each city. When they have completed this task, lead a discussion of the questions in item 2 on the worksheet. For item 3, ask learners to predict the average July minimum and maximum temperatures for four additional Oregon cites by using the data they have on their maps. Ask learners to work in pairs to complete the tasks in item 3. When the teams are done, ask them to share and defend their answers before providing the real data.

Item 4 answers
July averages in degrees Fahrenheit for given cities:
Astoria: average maximum 67.5 degrees F; average minimum 52.4
Salem: average maximum 81.6; average minimum 50.7
Bend: average maximum 82.5; average minimum 52.7
Ontario: average maximum 93.8; average minimum 57.5
## How the Ocean Affects Temperatures on Land Worksheet

1. Find the cities listed below on an Oregon map. Use a self-sticking note to post the listed July average maximum and minimum temperature (in Fahrenheit) for each location.

<table>
<thead>
<tr>
<th>City</th>
<th>July Average Max.</th>
<th>July Average Min.</th>
<th>July Temp. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newport</td>
<td>65.7</td>
<td>49.5</td>
<td></td>
</tr>
<tr>
<td>North Bend</td>
<td>73.1</td>
<td>53.5</td>
<td></td>
</tr>
<tr>
<td>Portland</td>
<td>81.5</td>
<td>50.7</td>
<td></td>
</tr>
<tr>
<td>Eugene</td>
<td>81.7</td>
<td>52.8</td>
<td></td>
</tr>
<tr>
<td>Medford</td>
<td>90.5</td>
<td>55.2</td>
<td></td>
</tr>
<tr>
<td>Hood River</td>
<td>82.5</td>
<td>60.8</td>
<td></td>
</tr>
<tr>
<td>John Day</td>
<td>94.0</td>
<td>55.0</td>
<td></td>
</tr>
<tr>
<td>Klamath Falls</td>
<td>88.8</td>
<td>44.1</td>
<td></td>
</tr>
<tr>
<td>Pendleton</td>
<td>87.8</td>
<td>58.0</td>
<td></td>
</tr>
</tbody>
</table>

2. Which two cities have the smallest average temperature range? In which part of the state are they located?

Which two cities have the largest average temperature range? In which part of the state are they located?

3. Locate the last four cities listed above which do not have any data included. Analyze the data on the Oregon map and predict the average July maximum and minimum temperatures for each location. Record your predictions on the chart. Your leader will provide the actual maximum and minimum data for you to complete your chart. How close were your predictions? Were you more accurate or less accurate for cities farther away from the coast? What do you conclude about how the ocean affects temperatures on land?
Activity 2: Climate Chemistry: Can I Change the Oceans?

Content Objectives

Learners will be able to do the following:

- Explain how increased CO$_2$ levels in water change the pH of water
- Understand that a decrease in the pH of the oceans is harmful to water quality and plant and animal life

Scientific and Engineering Practices

National Academy of Sciences (2012), *A Framework for K-12 Science Education*

- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Materials

- pH paper
- Vinegar
- Baking soda
- 16-ounce soda bottle
- Straw with bendable end
- Screwdriver
- Masking tape
- 1 package rapid-rise yeast
- ½ cup warm water
- 1 tablespoon sugar
- Clear plastic cups
- Bromothymol blue solution, or you may substitute Red Cabbage Jiffy Juice available from Steve Spangler Science, Inc.

Activity 2A

Provide each team of learners with 3 cups of Bromothymol blue solution, or complete this part of the activity as a demonstration. Discuss the pH of the solution. Test the pH. Ask learners to predict how the solution will react to the addition of vinegar and baking soda. Add vinegar to 1 cup of solution and have learners record the results. Test the pH and record it. What color is the solution? Add baking soda to another cup of solution and have learners record the results. Test the pH and record it. Be sure that learners understand which solution is an acid and which is a base. What color is each solution?
Activity 2B

When we make bread we use yeast to cause the bread to rise. The gas produced by the yeast is CO$_2$. Design an experiment using yeast as the CO$_2$ source. Alternatively, learners may place a straw in the Bromothymol Blue solution and blow CO$_2$ into it; be sure they do NOT drink the liquid!

You can make a “closed system” for the yeast using a 16-ounce soda bottle and a straw. A small screwdriver can be used to carefully make a hole in the cap of the soda bottle. Put the short end of a bendable straw in the hole. Seal the straw into the hole with masking tape.

Place your Bromothymol Blue solution in a clear plastic cup. Ask all the teams to write a hypothesis of how the solution will react to the addition of CO$_2$ from yeast.

Place the yeast, warm water and sugar in the bottle and cap tightly. Gently swirl the liquid in the bottle to mix it. Place the long end of the straw in your solution of Bromothymol Blue until the end of the straw is submerged. What happens? Record your observations.

Use the background information or web pages recommended to complete the discussion of the effects of increased carbon in the atmosphere and in the oceans.
11. The Ocean Tides Discovery Lessons

**Content Objectives**

Learners will be able to do the following

- Explain the causes of tides and influences on them

**Scientific and Engineering Practices**

National Academy of Sciences (2012), *A Framework for K-12 Science Education*

- Asking questions
- Developing and using models
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**Background**

Tides are the response of the ocean’s waters to many interrelating forces. The primary forces are the pull of the moon’s gravity and, to a lesser degree, the sun’s gravity. The sun, even though it is much larger than the moon, has a smaller effect because of its greater distance from Earth (Figure 9).

![Figure 9](https://catalog.extension.oregonstate.edu/4-h3805l)
Go to the NOAA Education Website http://oceanservice.noaa.gov/education/tutorial_tides/. If this link does not work try http://oceanservice.noaa.gov/education, and scroll down to the tutorials list links.

At this link you will find links to information including animated graphics on tides to share with learners. The links include:

- What are Tides
- What Causes Tides
- Gravity, Inertia, and Bulges
- Changing Angles and Tides
- The Frequency of Tides
- Tidal Variations
- Types and Causes of Tidal Cycles
- Monitoring Tides
- How Tides are Measured

To assist learners to complete the Reading a Tide Table worksheet, go to http://hmsc.oregonstate.edu/weather/tides/tides.html and print off a tide table for a current month.

Predicting tides has always been important to people who look to the sea for their livelihood. Commercial and recreational fishermen use their knowledge of the tides and tidal currents to help them improve their catches. In addition, knowledge of the tides is important in planning a trip to the beach or tide pool area for recreational beachgoers.

**MATERIALS**

**Activity 1**
- Hula-Hoop
- String: 4-foot segment and 15-foot segment
- Sample tide table
- Globe or world map

**Activity 2**
- A copy of the Earth, Sun, Moon, and tidal bulge model page for each learner
- A supply of
  - Crayons
  - Scissors
  - Glue
  - Two brass brads (paper fasteners) per model
  - Rulers
  - Pencils
  - Sheets of tagboard or stiff paper

**Activity 3**
- A current tide table from http://hmsc.oregonstate.edu/weather/tides/tides.html, one copy per person or pair of learners
- Reading a Tide Table worksheet (page 63), one copy per learner
Procedure

Lead the learners in a discussion of their experiences with tides. Ask them what they know about the forces that cause tides to change. Some children may have gone clamming and will know that clam beds are exposed at low tide. Others may have noticed the change in tide level as they played on the beach. Large ships must wait for a high tide to move safely in and out of some harbors.

The causes of tides is a complex topic. To assist in visualizing the effect of the forces that create tides, ask learners to imagine they are looking at Earth's North Pole from space. Imagine that Earth is completely covered with a layer of water—there are no continents visible.

The layer of water covering the earth responds to the gravitational pull exerted by the moon and the sun. The sun, even though it is much larger than the moon, has a smaller effect because of its greater distance from the earth. The water also responds to the centrifugal force caused by the rotation of the earth. Remember that the tide has a high point and a low point. In Figure 9, the Moon and Sun are on the same side of Earth. Two tidal “bulges” are present on opposite sides of Earth. Because there are two bulges, there generally are two tides per lunar day. A lunar day is 24 hours and 50 minutes. The earth makes one complete rotation relative to the moon each lunar day. Because Earth is turning in relation to the tidal bulge, any particular location on the Oregon Coast will move through both of the tidal bulges in a lunar day.

The earth, the moon, and the sun are moving constantly in relation to each other. The moon orbits the rotating Earth. Both the Moon and Earth orbit the sun. The path of the orbits is an ellipse, not a circle. In addition, Earth's axis is tilted with respect to its orbit about the sun. The moon's orbit is also at an angle to Earth's orbit. The relationships of the earth, the sun, and the moon are constantly changing in a predictable pattern.

Activity 1: Hula-Hoop Tides

Select three learners to help enact the formation of tides. One will be the earth, one the moon, and one the sun. The layer of water covering the earth will be represented by a Hula-Hoop. Have Earth stand in the center of the Hula-Hoop.

Cut the string into a 4-foot segment and a 15-foot segment. Tie the shorter segment to the Hula-Hoop and have the learner who will be the moon hold the other end. Since the moon is closer to the earth than the sun, it exerts a much stronger gravitational pull. Water on Earth responds to the pull and forms a bulge. This is high tide.

Cut the string into a 4-foot segment and a 15-foot segment. Tie the 15-foot segment of string to the Hula-Hoop and have the learner who will be the sun hold the other end. Initially, have both Sun and Moon stand on the same side of Earth (see Figure 9). Earth, meanwhile, should hold the Hula-Hoop with one hand near the strings and the other hand on the opposite side. Have the sun and moon pull the strings gently while Earth counteracts the pull by pushing out on the opposite side of the Hula-Hoop. This will elongate the Hula-Hoop, creating an oval. The two sides of the Hula-Hoop farthest from Earth are the two
high-tide bulges. The narrower part of the Hula-Hoop oval represents the low tides. The high tide on the side away from the moon and the sun is caused by centrifugal force. The range between the high and low tides is extreme. This is called a Spring Tide (see Figure 10, page 59).

For some learners, this may be a good place to stop the lesson or to go on to the Model Building activity. The next demonstration concerns the movement of the moon and the sun in relation to the earth. This may be difficult for learners to visualize.

Have the sun and the moon so that they are at right angles to the earth. Both the sun and the moon should pull gently on their strings. The sun and the moon are both exerting a gravitational pull on the earth's oceans, but they are working against each other. The high tide bulges are not as high and the low tide bulges are not as low as in the Spring Tide. This is called a Neap Tide (see Figure 11, page 59).

Refer to the tide table and note that every other week there are extreme tides, the Spring Tides, followed by a week of not-so-extreme tides, the Neap Tides.

Place the Hula-Hoop on the floor, but have the earth, sun, and moon continue to stand. Ask questions about the movement of these bodies. How often does the earth rotate? (Once every 24 hours.) How long does it take the moon to go around the earth? (28 days.) How long does it take the earth to go around the sun? (365 days.) In the course of one day, will the moon move much? (No.)

Have the earth turn around once while the moon moves one step in the same direction around the hoop. Now imagine that the tidal bulge stays pointed toward the moon. Count how many high tides and how many low tides the earth-learner's right shoulder goes through as it rotates once more. (Two of each.) It might help for you to pin a sign that says, “Oregon” on the earth's right shoulder. Will the tides be at exactly the same time every day? (No.) Why not? (Because the moon is moving a little bit each day.)

Continue the demonstration until the group can describe how the movement of the earth and moon dictate the height of the tide at any given time and place. Some learners may be able to figure out approximately how long each tide lasts, and whether the tide will be earlier or later each day. Have the learners consult a tide table to confirm their predictions.
When there is a full and new moon, Earth, sun and moon are in line. These tides have the most extreme range between the high and low tides.

When the moon is at the first and third quarter, the moon and sun form a right angle with Earth. These tides have the least range between the high and low tide.
Activity 2: Model Building

This model will show how the earth rotates through the tides, and the orientation of the tidal bulge toward the moon. It will not show fluctuation in the height of the tide. The leader should construct a model before the lesson for learners to see a finished model.

Distribute the supplies for Activity 2 to the learners (Figure 12). Have them color the earth, sun, moon, and tide figures and then cut them out. The earth figure is shown as it would look from space over the North Pole. Using a ruler, cut a strip from the long side of the tagboard that is 15 inches long and a half-inch wide. Cut another strip the same width, 4 inches long. Glue the cutout figures on to tagboard and cut them out again.

Glue the tidal bulge to one end of the 4-inch strip with the long sides of the tidal bulge's oval along the length of the strip. Pierce the center of the moon and the end of the 4-inch strip opposite the tidal bulge. Using a brad (paper fastener), fasten the moon to the 4-inch strip.

Glue the sun to the end of the 15-inch strip.

Stack the figures so that the earth is on the top, the tidal bulge with the moon attached on the 4-inch strip is in the middle, and the 15-inch strip with the sun on the end is on the bottom. Pierce a hole through the four layers at the center of the earth and insert a brad (paper fastener).

The earth figure can now be rotated through the tidal bulge. Ask learners to arrange the figures to show a Spring Tide and then a Neap Tide. Remember to rotate the light side of the moon toward the sun.
Figure 12: Illustration of tidal bulge formation due to the gravitational pull of the Moon on the Earth.
Activity 3: Reading a Tide Table

Using the questions on the Reading a Tide Table worksheet as a guide, introduce learners to the tide table. Remind learners that whenever they plan a trip to the ocean, they should consult a tide table before planning their activities.

Reading a Tide Table Worksheet Answers
1. Where can you find a tide table before planning a trip to a coastal area?
   Online at the Hatfield Marine Science Center’s website

2. What do the numbers in the first left-hand column indicate?
   The date of the month on the chart.

3. Where are the high tides and low tides listed on the tide chart?
   High tides are on the left, low tides are on the right.

4. How are morning tides, or AM, written differently from afternoon, or PM, tide times?
   PM in is bold. Sometimes minus tides are indicated with a blue highlight.

5. In most rows for specific dates on the tide chart TIME and HT(ft) are listed four times. What do these mean?
   There are two high tides and two low tides on these days.

6. In some dates, rows on the tide chart TIME and HT(ft) are only listed three times. Why is this?
   There will be only three tidal changes on these days.

For the answers to these questions consult the chart you are printing for the learners before beginning the activity. The answer to 7 and 9 will be the same. The answer to 8 and 10 will be the same.

7. On your tide chart, on which date is the highest tide of the month?

8. On your tide chart, on which date is the lowest tide of the month?

9. If you are a surfer, what would be a good date to go surfing?

10. If you like to look at tide pools, what would be a good date for that activity?
Reading a Tide Table Worksheet

1. Where can you find a tide table before planning a trip to a coastal area?

2. What do the numbers in the first left-hand column indicate?

3. Where are the high tides and low tides listed on the tide chart?

4. How are morning tides, or AM, written differently from afternoon, or PM, tide times?

5. In most rows for specific dates on the tide chart TIME and HT(ft) are listed four times. What do these mean?

6. On some dates, rows on the tide chart TIME and HT(ft) are only listed three times. Why is this?

7. On your tide chart, on which date is the highest tide of the month?

8. On your tide chart, on which date is the lowest tide of the month?

9. If you are a surfer, what would be a good date to go surfing?

10. If you like to look at tide pools, what would be a good date for that activity?
**Activity 4: Graphing the Tides**

Graph the tides for one month. Make copies of the Graphing Tides Worksheet for each group member. Divide the days of the selected month up amongst the group members and ask each of them to record the tide information on a graph page. When all the graphs have been completed, tape them together in sequence of the calendar dates. On the top of each page, add the phases of the moon. Can you see how the tidal height changes as the moon goes through its phases?

**Graphing Tides Worksheet**

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<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
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<th>2</th>
<th>1</th>
<th>0</th>
<th>-1</th>
<th>-2</th>
<th>-3</th>
<th>-4</th>
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**Time of Day**
12. Waves and Tsunamis

Content Objectives

Learners will be able to do the following:

■ Explain the characteristics of waves
■ Explain why waves “break” on a beach
■ Understand some causes and characteristics of tsunamis
■ Understand how to respond to a tsunami warning

Scientific and Engineering Practices

National Academy of Sciences (2012), A Framework for K-12 Science Education

- Asking questions
- Developing and using models
- Analyzing and interpreting data
- Obtaining, evaluating, and communicating information

Background

■ International Tsunami Information Center, a part of UNESCO, has resources at http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=1075&Itemid=1075&lang=en. You will need to download: Tsunami, The Great Waves. This 12-page brochure provides information on what tsunamis are, how fast and how big they can be, and what causes them.

■ The website How Stuff Works has a good tutorial about waves in general, which includes information on tsunamis at http://science.howstuffworks.com/nature/natural-disasters/tsunami3.htm.

■ San Diego County has a video on YouTube with a youth-friendly animated short film where a crab teaches tsunami characteristics and preparedness at www.youtube.com/watch?v=UzR0Rt3i4kc. Preview the YouTube video before sharing it with youth.

■ The National Oceanographic and Atmospheric Administration (NOAA) has a page with links for kids at http://www.tsunami.noaa.gov/kids.html; their page for adults is at www.tsunami.noaa.gov.


Waves on oceans or lakes are a churning or disturbance at the water’s surface. The wind causes most wave action. Waves are made up of crests and troughs. The crest is the
highest part of the wave; the trough is the lowest part. Waves can be described by their characteristics; they all have a wavelength (λ), wave height, an amplitude, a frequency or period (P), and a velocity (V).

**Wavelength** is defined as the distance between two identical points on a wave, such as the waves’ crests. Normal ocean waves have wavelengths of about 100 meters. Tsunamis have much longer wavelengths, usually measured in kilometers.

**Wave height** refers to the distance between the lowest part of the trough of the wave and the highest part of the crest of the wave.

**Wave amplitude** is the height of the wave above the stillwater line. The still-water line is equal to half the wave’s height. The still-water line is shown as a dashed line in the illustration.

A wave’s **frequency** or **period** (P) is the amount of time it takes for one full wavelength to pass a single stationary point.

**Wave velocity** (V) is the speed of the wave. Velocities of normal ocean waves average about 90 kilometers per hour. Tsunamis have velocities up to 950 kilometers per hour—which is about as fast as a jet flies! The formula for wave velocity (V) is the wavelength (λ) divided by the wave period (P), or \( V = \frac{\lambda}{P} \) (See Figure 13).

Normal ocean waves have very little forward movement. Waves appear to be coming in to shore but the water in the wave is actually moving in a circular motion. The larger the wave, the larger the circular movements of the water. The water moves forward, down, and then backward as the energy is passed through the water.

When a wave encounters water shallower than one-half of its wavelength, such as at a beach, the wave is said to “feel bottom.” As the water becomes shallower, the circular motion at the bottom of the wave is altered. The water at the bottom of the wave slows down. At the surface, the circular motion is still moving rapidly. The upper portion of the wave moves faster than the bottom so that the top spills over, creating a breaker.

Earthquakes are the most common cause of tsunamis. Tsunamis are unlike wind-generated
waves in that they are characterized as shallow-water waves, with long periods and wavelengths. The wind-generated swell one sees at a beach might have a period of about 10 seconds and a wavelength of 150 meters. A tsunami, on the other hand, can have a wavelength in excess of 100 kilometers and a period on the order of 1 hour.

**Activity 1: Wave in a Bottle**

**Materials**
- Clear plastic bottle of approximately 1-liter volume
- Clear mineral oil
- Rubbing alcohol
- Blue food coloring

Fill a clear, 1-liter bottle approximately half full with rubbing alcohol. Add a few drops of blue food coloring to the bottle and mix gently by swirling the bottle around. Fill the remaining space in the bottle with the mineral oil. Fill the bottle to the top of the neck and replace the cap without allowing air bubbles to be trapped inside. Turn the bottle on its side and rock it gently back and forth to simulate the action of waves (Figure 14).

**Activity 2: Tsunami Sand Bin: A Desktop And Coastal Engineering Lesson**

**Website**
http://nees.org/resources/7216. The website includes all materials, including a PowerPoint presentation and supporting videos.

**Introduction**
Tsunamis can affect coastal communities worldwide with sudden inundation. With little warning, whole communities can be washed out to sea. Coastal engineers work to protect coastal communities and their infrastructure from coastal hazards such as tsunamis. At the Oregon State University Tsunami Research Facility, engineers use models to help coastal communities. This activity will connect modeling to coastal engineering while having learners "play" the role of coastal engineers and attempt to protect a coastal community from a tsunami wave, all in a small under-bed sweater box, using Lego houses and common materials.
This activity introduces learners to how civil and coastal engineering and design can address problems and enable people to consider choices through cost-benefit analysis to help communities prepare for natural disasters such as tsunamis.

**Learning Objectives**
Learners should understand the engineering design cycle, the destructive nature of tsunamis, and simple cost-benefit analysis.

**Vocabulary Words**
Inundation, resilience, design cycle, engineering, tsunami

**Background**
Tsunamis are a problem for coastal communities worldwide and their destructive powers do not discriminate between developed and developing countries, as the events in Indonesia and Japan have shown us. Oregon is at risk for a large, locally created and destructive tsunami. The Cascadia Subduction Zone lies 50 to 100 miles off the Oregon coast, where the Pacific Plate (oceanic plate) meets the Juan de Fuca Plate (continental plate). Every 300 to 500 years, this plate boundary “fails” and creates a large earthquake and ensuing tsunami. The last Cascadia Subduction Zone tsunami was in 1700. Tsunamis present a large and imminent problem. There is an ever-increasing chance of another large event on the Oregon coast.

Go to the Oregon State 4-H Natural Science Projects home page at http://oregon.4h.oregonstate.edu/natural-science. Scroll down the the PowerPoint presentation “Surviving Tsunamis on the Oregon Coast” Save this presentation and review it before using with youth.

**Engineers**
Engineers work to provide solutions to problems in everyday life. Coastal engineers are constantly working on solutions to help create tsunami resilience within communities. Resilience refers to the community’s ability to respond and recover after a natural disaster. The engineering design process is what research engineers do to try to find solutions for problems. The engineering design process includes the steps of:
1. Identify the problem
2. Propose or design potential solutions
3. Test solutions
4. Evaluate solutions—define how well the solution worked and what its cost was (cost-benefit analysis)
5. Report results
6. Refine solution (as necessary)

Not all solutions that would be effective are reasonable or practical. Every solution must be critically evaluated from many perspectives. For example, a large wall might stop a tsunami but it would also be expensive, potentially environmentally hazardous, and limit access to
the coast. It is part of engineering analysis to consider all of the aspects of a solution when analyzing its potential.

Engineers use models to study both the hazards caused by tsunamis (for example, large shipping containers hitting buildings) and the solutions. Typically, engineers who work at the Tsunami Research Facility, the Hinsdale Wave Research Lab at Oregon State University, combine computer and physical models to better understand the complex nature of tsunamis. Engineers often build and use physical models to generate data to verify computer models so they may apply the models to real-world situations.

This lesson draws on both the tsunami hazard models and ways to create resilient communities. Some of the solutions that might work in the sand bins might not be practical for real communities. The practicality of proposed solutions is a good topic of discussion because engineering is a complex field where many aspects of the problem and solution need to be considered.

**Scientific and Engineering Practices**

National Academy of Sciences (2012), *A Framework for K-12 Science Education*

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics, information and computer technology, and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**Materials needed per set-up**

- Sweater box (A container about 35 by 16 by 6 inches is recommended. This exercise was developed using the Sterlite model 1960)
- Fine sand
- About 20 Legos (to build small houses with)
- Six 2-inch-square pieces of plywood,
- 10 wood skewers, cut in half, sharp ends cut off
- 10 2-inch narrow dowels
- 10 straws
- 1 cup gravel
- 10 3- to 4-inch-diameter pieces of cobble or river rock
- plywood (or other suitable material) for a paddle to generate waves

**Table-Top Tsunami Box Preparation**

1. Prepare Table-Top Tsunami Box
   a. Build small “houses” out of 4–5 Lego bricks
b. Make the wave-maker paddle out of plywood or other suitable material cut to the width of the box, and 2 to 4 inches taller than the box (Figure 15).

c. Add sand to the sweater box (plastic tub) and build the beach (Figure 15). The box should be a third to half full of sand with a beach sloping toward the middle.

d. Add water. The water should be just below the flat part of the beach. The lower the water is, the smaller the maximum "tsunami" will be. The higher the water, the larger the wave (Figure 16).

e. Use the wave maker to make waves. Place the wave maker in the box crosswise at the end away from the sand, and then move it all the way down toward the sand in one swift motion to make a tsunami (Figure 17, No. 1) or back and forth to make wind-driven waves (Figure 17, No. 2). Note that the “splash” can be considerable; this activity is best conducted outside.

Figure 15: A sweater box partially filled with sand with a wave maker, a piece of wood cut to fit the size of the box.

Figure 16: The sweater box now partially filled with water and with Lego houses positioned on the sand.
**Procedure**

This lesson can be a several-day lesson or shortened to a 1- or 2-hour lesson depending on the amount of time available. The procedure is written for a 2- or 3-hour lesson, with additional items added as optional steps.

1. Have one sand bin set up and 4 to 5 houses on the flat part of the beach.
2. Show learners the “Surviving Tsunamis on the Oregon Coast: Engineers Think Inside The Box” PowerPoint sections that they may not understand or that are relevant to the learning goals. (30 minutes)
3. Follow up the PowerPoint presentation with a guided discussion reinforcing the tsunami and engineering design cycle content. (15 minutes)
4. Discuss with learners how tsunamis are a problem and how the learners will be practicing to be engineers by trying to solve the problem. (10 minutes) (Optional: Have them set the “building codes” or rules for how the beach and houses must be modified. Otherwise, the teacher can establish these rules.)
5. Demonstrate how a tsunami will wash the houses away. (5 minutes) (Optional discussion: How is the model useful, what are the assumptions?)
6. Divide the learners into teams of four. (Note: four is not a magic number for this lesson, but it's the largest number recommended for the teams. Teams are important because all engineers work in teams.) (5 minutes)
7. Show them the materials they will use to help build a community resilient to the tsunami (plywood squares, skewers, straws, small gravel, cobbles, etc.).

8. Depending on the skill and maturity of your learners, have them set up the bins or have them prepared. (5–15 minutes)

9. Have teams follow the engineering design cycle:
   - Identify the problems that a tsunami can cause.
   - Propose or design potential solutions to mitigate the problem.
   - Test solutions (e.g., build tsunami-resistant structures, build structures that can dissipate or redirect the wave and its energy, have faster warning systems and greater accessibility, establish well-marked and easily accessible escape routes).
   - Evaluate solutions and define how well the solution worked and what its cost was (cost-benefit analysis).
   - Report results.
   - Refine solution (as necessary).

10. Optional step: Have learners propose a final design for the “city planning committee” (class or teacher) to approve.

11. Provide teams a budget by either giving everyone the same materials or putting a price on the materials and giving learners a specified amount of funds. (Optional: Learners could use a spreadsheet program to track their spending or they could graph how well each design does versus money spent.)

12. Once learners have a final design, they need to report their findings. They can use the worksheet attached. (Optional: Groups could report their findings to the group).

13. If you would like to add a simple math component to this activity, you can “charge” for materials. You can do this in one of three ways.
   - **Option 1:** Set a limited budget. Each team gets $100 and must pay for each item. Price items according to how useful they are. For example, the plywood squares and cobbles would be most expensive, say $10 each, and the skewers and straws would be $3 each.
   - **Option 2:** Allow “unlimited” funds, but still charge for materials. Use final cost as part of the assessment and discussion.
   - **Option 3:** Give each team a set amount of materials and see how creative each group can be. There is an included worksheet for calculating costs, but this could also be done in a spreadsheet as an additional activity.

**Conclusion and Evaluation**

In the end, learners should understand that engineers use a specific process to develop and design solutions to problems. Learners should also understand that engineering problems are complex and there are no quick and easy answers. Learners should also understand that the Oregon Coast is due for a large and potentially devastating tsunami event.
**Resources:**

https://nees.org/shakeout
*Lists tsunami and earthquake resources*

http://www.tsunami.noaa.gov/
*National Oceanographic and Atmospheric Administration Tsunami website*

http://www.ready.gov/tsunamis
*Information on current tsunami readiness*

http://www.oregongeology.org/sub/earthquakes/earthquakehome.htm
*Oregon tsunami and disaster mapping*
Ocean Literacy Standards

Ocean Literacy Principle #6: The ocean and humans are inextricably interconnected.

Questions for a guided discussion
BEFORE learners start to design and build
Note these questions are aimed for eighth- to 10th-graders; adjust as necessary.

1. How is the sand bin model like the Oregon Coast and how is it different? What are the assumptions of the model?
   a. This has many correct answers. Below are some samples. This should be a good discussion topic for your learners. There are fewer right or wrong answers, but many shades of gray)

   ❑ Similarities: The components of the model are similar to the coast, water, sand waves, and houses, but on a smaller scale.
   ❑ Differences: It is very simplified; there is no “bathymetry” (shape to the seafloor).
   ❑ Assumption: the wave made is a simple but accurate representation of a tsunami. The friction of the bottom of the box is similar to that of the seafloor.

2. How do you think the wave we make is similar to a tsunami and how is it different?
   a. It has a “run-up” like a tsunami. It goes far inland, over the beach, and into the houses. But it is much more simple and doesn’t have all the complex forces.

3. What do we need to consider when building reinforcements to a beach town? Why?
   a. Again there are many possible answers—inundation height, lay out of the houses, possible environmental effect, beach or coast access, and cost.

4. What sort of forces will there be on the model from the tsunami? (Here is a video that highlights some of these forces: http://watch.discoverychannel.ca/daily-planet/march-2012/daily-planet---march-09-2012/#clip635345)
   a. There are four types of forces that engineering designs will have to resist. If you have ever stood in running water, the ideas won’t be hard to understand conceptually.

   ❑ Hydrodynamic Forces: The water running and the forces it applies. A good example is water running against your legs when you stand in the surf.
   ❑ Hydrostatic Forces: The force of the water pushing inwards. A good example is water pushing in on your legs when you walk into a pool.
   ❑ Buoyant forces: The uplifting forces of water.
   ❑ Impact forces: When items carried in the water impact structures. An example is shipping containers in Japan.

5. Which are the dominant forces for our model? Which one is most likely to cause damage to the structures? In our, model, hydrodynamic forces and buoyant force are dominant.

6. What are some different building techniques you could use to reduce these different forces?
Tsunami and Sand Bin Worksheet
An exercise in the engineering design cycle

In this exercise you will learn about the engineering design cycle while trying to protect a coastal village from being swept away by a tsunami. Here is a quick review of the engineering design cycle:

- Identify the problem.
- Collect information and determine your constraints.
- Propose and design potential solutions.
- Test solutions.
- Evaluate solutions—define how well the solution worked and its cost (cost-benefit analysis).
- Report results.
- Refine solution (as necessary).

1. Set up your desk with the tsunami sand bin according to your teacher’s instructions.
2. Build four to five small houses out of the provided Legos.
3. Arrange the houses on the flat part of the beach.
4. Place the “wave-maker paddle” into the sand bin, and make your first wave! (Your teacher will show you how to do this.)
5. Record what happened:

6. Identify one problem posed by the tsunami your team would like to solve.

7. Find the materials you can use to solve your chosen problem.

8. List the constraints involved in solving the problem.

Hydrodynamic forces on a building

Figure 18
9. Work with your team to develop and test two to three potential solutions. Document them on a separate sheet of paper. To document your solutions, you should draw, describe, and take photos of your solutions. Also, test these solutions against three tsunamis and record the results. How well did each design perform in solving your stated problem?

<table>
<thead>
<tr>
<th>Tsunami</th>
<th>Design #1</th>
<th>Design #2</th>
<th>Design #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave #1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave #2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave #3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. Evaluate your solutions and choose the best overall solution. Consider time, materials, and impact on the community. For example, how was access to the ocean affected? Views of the ocean?

<table>
<thead>
<tr>
<th>Design</th>
<th>Costs (\text{Materials, limitations, community impacts})</th>
<th>Benefits (\text{How does this design address the problem? What are the positive aspects of this design?})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which solution did you choose? Why? What were the benefits and what were the costs? Did you agree with your group?
13. Marine Debris

CONTENT OBJECTIVES
Learners will be able to do the following:
■ Explain how trash is carried by rivers and streams, becoming marine debris
■ Understand their role in reducing marine debris
■ Understand the length of time that marine debris can persist in the environment

SCIENTIFIC AND ENGINEERING PRACTICES
National Academy of Sciences (2012), *A Framework for K-12 Science Education*
❏ Asking questions
❏ Developing and using models
❏ Analyzing and interpreting data
❏ Constructing explanations
❏ Engaging in argument from evidence
❏ Obtaining, evaluating, and communicating information

BACKGROUND
Please use the following National Oceanic and Atmospheric Administration links for background information:
Great Pacific Garbage Patch: http://marinedebris.noaa.gov/info/patch.html
Wind Driven Surface Currents: http://oceanservice.noaa.gov/education/kits/currents/05currents3.html

Marine debris is trash that enters our streams, rivers, and oceans. Littering is a major cause of marine debris. The most common types of marine debris are disposable items that we use every day. In September 2011, nearly 600,000 volunteers participating in the annual International Coastal Cleanup picked up more than 9 million pounds of trash from 20,776 miles of shoreline and inland areas around the world. The top 10 items found during the annual cleanup were:

1. Cigarettes and cigarette filters
2. Plastic beverage bottles
3. Plastic bags
4. Caps and lids
5. Food wrappers and containers
6. Cups, plates, forks, knives, spoons
7. Glass beverage bottles
8. Straws/stirrers
9. Beverage cans
10. Paper bags

If you did the Rosa Raindrop or the Watershed lessons with learners, they should already understand that we all live in a watershed. For trash, a watershed acts like a vehicle; trash can travel hundreds or even thousands of miles through the watershed. A piece of litter dropped on a city street can be blown by wind or washed by rain into a nearby waterway, and begin its journey to the ocean.

Most marine debris starts out on land. Small towns, big cities, rural areas, and urban areas are all considered land-based sources of marine debris. Urban areas, however, tend to produce more trash and litter because they are more densely
populated. Once the trash enters the urban watershed, it may eventually be transported to the sea and become marine debris.

There are also ocean-based sources of marine debris. Boats and ships, oil drilling rigs, fish farms, and other structures at sea can be sources of marine debris. Garbage can be dumped, accidentally blown, or washed overboard. Common ocean-based items include food waste and wrappers, fishing nets and gear, and shipping cargo. Wrecked or abandoned boats, buoys, and other equipment also create marine debris.

On March 11, 2011, a devastating 9.0 earthquake and tsunami struck Japan. The disaster claimed nearly 16,000 lives, injured 6,000, and destroyed or damaged countless buildings. As a result of the disaster, a portion of the debris that the tsunami washed into the ocean had begun to reach the United States along the Oregon and Washington coasts in late 2012. For current information see the NOAA link at http://marinedebris.noaa.gov/tsunamidebris.

The Harmful Effects of Marine Debris

Trash and marine debris in our lakes, rivers, and oceans has a direct impact on our lives. Broken glass, medical waste, and other harmful, discarded items can injure people or make them sick. Trash can contain bacteria or chemicals that pollute the water. And when someone litters, it means someone else has to clean it up. For local governments, that can mean spending millions of dollars every year just to clean up litter and trash.

Ugly, dirty waters filled with marine debris can hurt a local community. When a lake, river, or ocean is polluted or filled with trash, no one wants to go there. The community loses the opportunity to give its residents a great place to have fun, and also loses the opportunity to help businesses and create jobs. On the other hand, attractive waterfronts are places residents and tourists like to visit. New businesses can open to rent boats or bikes, or sell things like hot dogs and ice cream, which, in turn, creates jobs.

Wildlife is also harmed by marine debris. Small animals can be cut by jagged cans or trapped in containers. Sea birds, sea turtles, fish, and other marine animals often become entangled in marine debris, causing injury or death. Additionally, marine animals often eat marine debris that they mistake for food. Eating the marine debris can lead to starvation or malnutrition when the marine debris collects in the animal’s stomach, causing the animal to feel full.

What Can be Done to Prevent Marine Debris?

Marine debris is a problem created by people. It is also a problem people can solve. Here are some things you can do to help:

1. Get bugged by litter. Set an example for those around you by always putting trash in a proper receptacle.
2. Put a lid on trash. Place trash in covered garbage bins to keep debris from blowing or washing away.
3. Reduce, reuse, and recycle. Trash is becoming a bigger problem in our waterways and oceans in part because there is simply more of it. Reducing the amount of trash that goes into garbage cans, garbage trucks, and landfills helps reduce the amount of waste that is accidentally blown or washed into the environment.

4. Volunteer for a cleanup. Organize a cleanup of a waterway in your hometown. Or sign up for the Ocean Conservancy’s annual International Coastal Cleanup (ICC). The ICC is held every September in both inland and coastal areas. To sign up for a cleanup, visit www.coastalcleanup.org.

**Materials**

**Part 1**
Download and use the lesson Plastics in the Water Column from the Monterey Bay Aquarium at www.montereybayaquarium.org/PDF_files/teaching_activities/Plastics_in_theWater_Column6-8.pdf

**Part 2**
- 20 index cards

**Part 3**
For each participant:
- Waterproof gloves
For each team:
- Large garbage bags
- Trash Cleanup Tally Sheet
- Pencil
- Clipboards (optional)

**Preparation**

**Part 2**
You will create two sets of index cards, one for **Decomposition Time** and one for **Trash Item** using the information provided in the answer chart below.

<table>
<thead>
<tr>
<th>Decomposition Time</th>
<th>Trash Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 4 weeks</td>
<td>Paper towel</td>
</tr>
<tr>
<td>6 weeks</td>
<td>Newspaper</td>
</tr>
<tr>
<td>2 months</td>
<td>Cardboard box</td>
</tr>
<tr>
<td>1 to 5 years</td>
<td>Cigarette filter</td>
</tr>
<tr>
<td>1 to 20 years</td>
<td>Plastic grocery bag</td>
</tr>
<tr>
<td>50 years</td>
<td>Plastic foam cup</td>
</tr>
<tr>
<td>80 to 200 years</td>
<td>Aluminum can</td>
</tr>
<tr>
<td>450 years</td>
<td>Plastic beverage bottle</td>
</tr>
<tr>
<td>450 years</td>
<td>Disposable diaper</td>
</tr>
<tr>
<td>&gt;600 years</td>
<td>Glass bottle</td>
</tr>
</tbody>
</table>
Part 3
Identify a safe and easily accessible local stream, river, lake, or beach that is in need of a waterway cleanup. Avoid areas with steep banks and fast-moving water. Contact the private landowner or public management authority for the area to receive permission for learners to conduct a waterway cleanup project. Create a map or set of directions for adults to use to transport youth to the site.

Enlist the support of enough adults to supervise all the teams of youth on the day of the cleanup. No group of youth should work unsupervised. Everyone should wear safety gloves. Learners should not handle sharp objects or items they do not recognize. If collection of large-size trash, such as tires and appliances, is anticipated, one team of adults should take on this segment of the project.

Make arrangements to properly dispose of all the bags of trash and other items collected at your event.

PROCEDURE
Part 2
Lead a discussion of marine debris using the information provided in the Background section. Learners can use the websites listed at the end of this lesson to access additional information and images of marine debris.

Gather the learners around a table and place the Decomposition Time cards on the table where everyone can see them. Pass two or more Trash Item cards to each pair of learners. Ask the learners to discuss their items and place each on the table under the decomposition time they believe applies to that item. After all the items are placed, ask if anyone disagrees with any placements. Work through the items, correcting any matches that are not as listed on the chart above.

Part 3
Before the cleanup event, discuss with learners the site that has been selected. Ask them to predict the amount of trash they will find in each category on the Trash Cleanup Tally Sheet. Communicate the date and time of the event, and arrange transportation and permission slips if needed. Discuss appropriate clothing and footwear.

On Cleanup Day
Divide your group into teams. There should be at least one adult with each youth team. Each team member must wear safety gloves. One team member should record the team members’ names and the items collected on the Trash Cleanup Tally Sheet as the team moves along. At the end of the event, each team should total the amount of trash collected on the tally sheet.
Follow-up

After the cleanup, ask learners to add up the numbers from all the Trash Cleanup Tally Sheets, calculating the totals for each category as well as for the entire cleanup. Discuss the totals with the group. Ask learners if they found more or less trash than they expected. Did they notice any trends? These trends could include:

- Did certain types of items make up a big part of the debris? Where might these items have come from (storm drains, littering, industrial facilities)?
- What were some of the most unusual types of debris found? Where might these items have come from?
- Which types of debris could pose problems to area wildlife? How?
- Will waterway cleanups solve the marine debris problem? Why or why not?
- What are some steps we can take to prevent marine debris in the first place?
- Ask learners to also discuss how lifestyles in the community may have contributed to the collected debris. Questions they could address include:
  - Is the waterway near an area with a large population?
  - Does the area near the waterway have recycling programs?
  - Do these items seem to be things that residents use every day?

Extension

The organization Oikonos has an excellent free online curriculum on the effects of plastics on Hawaiian albatross called “Winged Ambassadors” at http://oikonos.org/education/. Albatross are large birds that often mate for life. The albatross chick remains on or near the nest for 5 to 6 months, depending entirely on its parents to provide food from the ocean. The parents have been tracked flying thousands of miles in a matter of days to forage in productive ocean waters for food items like squid, fish eggs, and small fish near the sea surface. The parents produce energy-rich oil from their food, which they deliver in their stomach and regurgitate into the mouth of their chick back at the nest.

Prior to leaving the nest, albatross chicks regurgitate a mass of indigestible material called a bolus. Boluses give us clues as to the types of food and trash eaten by albatross parents at sea. Unfortunately, nearly all boluses from Hawaiian albatrosses also include human-made trash, such as fishing line and plastics. These floating items concentrate alongside albatross food items, and are scooped up and unintentionally fed to the chicks.

Where is Oregon's Trash Going?

Learners will study the albatross that inhabit the North Pacific. Their movements and foraging behavior are greatly influenced by the patterns of wind and water in this ocean basin. For example, large circular systems of ocean currents, called gyres, are the result of the wind's push on the surface of the ocean. The wind transports the water (and anything else floating on it or drifting in it) around the ocean, following a circular path. The California Current moves south from Washington along the Oregon Coast. This is the eastern side of the north Pacific gyre. In the “Winged Ambassadors” curriculum, the Bolas
Analysis Lesson has a map of these currents that shows how plastic trash from Oregon can end up being eaten by birds in Hawaii.

Reference
Adapted from Marine Debris: The Urban-Coastal Connection, Environmental Protection Agency, retrieved at http://water.epa.gov/type/ocmb/marinedebris/index.cfm

Additional Online Marine Debris Resources
http://marinedebris.noaa.gov/
http://more.soest.hawaii.edu/education/teachers/science_kits/marine_debris_kit.htm
http://water.epa.gov/type/ocmb/marinedebris/index.cfm
http://www.marinedebrissolutions.com/ Marine debris solutions
Majestic Plastic Bag Mockumentary—good to start a conversation; not 100% accurate on the Pacific Garbage Patch—www.youtube.com/watch?v=GLgh9h2ePYw
http://education.nationalgeographic.com/education/encyclopedia/marine-debris/?ar_ a=1 National Geographic
www.oceanconservancy.org/our-work/international-coastal-cleanup/
At this link you can download a report on the amount of Marine Debris collected, listed by states and countries, in the most recent annual International Coastal Cleanup
## Trash Cleanup Tally Sheet

<table>
<thead>
<tr>
<th>Items Found of Land-Based Activity Origin</th>
<th>Number Tally</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances</td>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>Bags: Paper</td>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>Bags: Plastic</td>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>Balloons: Latex</td>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>Balloons: Mylar</td>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>Beverage Bottles: Glass</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>Beverage Cans</td>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>Bleach/Cleaner Bottles</td>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>Building Materials</td>
<td>10.</td>
<td></td>
</tr>
<tr>
<td>Caps, Lids</td>
<td>11.</td>
<td></td>
</tr>
<tr>
<td>Cars/ Car Parts</td>
<td>12.</td>
<td></td>
</tr>
<tr>
<td>Cigarettes/ Cigarette Filters</td>
<td>13.</td>
<td></td>
</tr>
<tr>
<td>Cigarette Lighters</td>
<td>14.</td>
<td></td>
</tr>
<tr>
<td>Cigar Tips</td>
<td>15.</td>
<td></td>
</tr>
<tr>
<td>Clothing, Shoes</td>
<td>16.</td>
<td></td>
</tr>
<tr>
<td>Cups, Plates, Forks, Knives, Spoons</td>
<td>17.</td>
<td></td>
</tr>
<tr>
<td>Food Wrappers/Containers</td>
<td>18.</td>
<td></td>
</tr>
<tr>
<td>Pull Tabs</td>
<td>19.</td>
<td></td>
</tr>
<tr>
<td>6-Pack Holder Plastic Rings</td>
<td>20.</td>
<td></td>
</tr>
<tr>
<td>Oil/Lube Bottles</td>
<td>21.</td>
<td></td>
</tr>
<tr>
<td>Straws, Stirrers</td>
<td>22.</td>
<td></td>
</tr>
<tr>
<td>Tires</td>
<td>23.</td>
<td></td>
</tr>
<tr>
<td>Tobacco Packaging/Wrappers</td>
<td>24.</td>
<td></td>
</tr>
<tr>
<td>Toys</td>
<td>25.</td>
<td></td>
</tr>
<tr>
<td>Other/Miscellaneous: Fill in below</td>
<td>26.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items Found of Water-Based Activity Origin</th>
<th>Number Tally</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bait Containers/Packaging</td>
<td>28.</td>
<td></td>
</tr>
<tr>
<td>Buoys/Floats</td>
<td>29.</td>
<td></td>
</tr>
<tr>
<td>Fishing Line</td>
<td>30.</td>
<td></td>
</tr>
<tr>
<td>Fishing Lures</td>
<td>31.</td>
<td></td>
</tr>
<tr>
<td>Rope</td>
<td>32.</td>
<td></td>
</tr>
<tr>
<td>Other/Miscellaneous: Fill in Below</td>
<td>33.</td>
<td></td>
</tr>
</tbody>
</table>

**Items found of land-based Activity origin**

Add Row Total 1. through 27.

**Items found of water-based activity origin**

Add Row Total 28. through 34.

Total of all trash items =
14. Amazing Marine Mammal Trivia Game

**Concept**
Marine mammals are some of the most amazing animals on Earth

**Materials**
- A scratch pad and pen for each team
- A large sheet of paper and a marker with which to keep score

**Procedure**
People are fascinated by trivia and everyone learns best when they are having fun, so this activity combines some amazing animal facts with light-hearted competition. Everyone who participates and has a good time is a winner.

Divide the learners into two teams of three or more. Have each team select the name of a marine mammal as their team name.

Read series of multiple-choice questions aloud. After each question, the teams confer amongst themselves and write down their selected answer. Call on each team to reveal its answer. The teams with correct answers get one point per answer and remain seated. The teams with incorrect answers must stand during the next question and are awarded a letter from a selected animal (like the basketball game “horse”). If a standing team gives a correct response for the next question, they may be seated, but they keep their letter. The game is over if (1) the leader runs out of questions, (2) one team spells the name of the selected animal (p.e.n.g.u.i.n.), or (3) the group runs out of time.

After the game ask learners to pick one animal they want to learn more about for a research project.

**Questions**
(Correct answers are in **bold type**.)

1. What type of whale was Moby Dick?
   A. Sperm whale
   B. Humpback whale
   C. Gray whale

2. Why are humpback whales called Humpback?
   A. Because their back is odd shaped
   B. **Because they hump their backs when they dive**
   C. They were named for George Humphrey
3. What products were made from the whales when they were killed in the 1880s?
   A. Oil for lamps
   B. Ladies’ corsets
   C. Meat to eat
   D. All are correct

4. Can whales breathe through their mouths?
   A. Yes
   B. No

5. Which whale would you not likely see on the Oregon Coast?
   A. Blue whales
   B. Sperm whales
   C. Gray whales
   D. Beluga whales

6. Which whale is known for its singing?
   A. Blue whales
   B. Killer whales
   C. Humpback whales
   D. Fin whales

7. Which whale traps small fish in a “bubble net”?
   A. Orca whales
   B. Humpback whales
   C. Minke whales

8. Which is the most numerous of the great whales today?
   A. Blue whales
   B. Right whales
   C. Sperm whales
   D. Fin whales

9. Which mammal has the longest migration?
   A. Lemmings
   B. Gray whale
   C. Caribou

10. What is the migration route of the gray whale?
    A. From Alaska to Mexico
    B. From California to Guam
    C. From Hawaii to Alaska
11. Blue whales give birth to one calf
   A. Every year  
   B. Every other year  
   C. Every 3–4 years

12. Finding one’s prey and locating surroundings using sound waves instead of sight is called?
   A. Singing  
   B. Echolocation  
   C. Sounding

13. What is the best means of protecting whales today?
   A. Killing predators  
   B. Protecting habitat  
   C. Stopping whaling

14. Predators of gray whales are
   A. Hammerhead sharks  
   B. Dolphins  
   C. Killer whales

15. Which whale has the longest baleen?
   A. Bowhead whale  
   B. Gray whale  
   C. Blue whale

16. The sperm whale only has teeth in its lower jaw.
   A. True  
   B. False

17. Sperm whales use their teeth to feed on
   A. Plankton  
   B. Giant squid  
   C. Sharks

18. When a whale jumps out of the water, it is called
   A. Breaching  
   B. Lobtailing  
   C. Navigating

19. Besides oil and baleen, Eskimos made use of almost every part of the whale. Which of the following is a use for whale parts?
   A. Windows  
   B. Toys  
   C. Drums  
   D. All of the above
20. In the early to mid-19th century, whalers went on long voyages to kill sperm whales and collect their oil. How long would the whalers be at sea on each voyage?
   A. 3 months
   B. 1 year
   C. 3–5 years

21. Ambergris is a product from whales that was used as a base for perfumes. What is ambergris?
   A. Hardened whale oil
   B. Waxy substance formed in whale intestines
   C. Whale poop

22. The largest member of the dolphin family is the
   A. Killer whale
   B. Bottle nose dolphin
   C. Common dolphin

23. Killer whales hit seals and sea lions with their tail in order to stun them.
   A. True
   B. False

24. A group of whales is called a
   A. Herd
   B. Pride
   C. Pod
   D. School

25. Which cetacean has a tusk-like tooth up to 9 feet long that makes it look like a unicorn?
   A. Unicorn whale
   B. Narwhal
   C. Beaked whale

26. Inuit Eskimos remove the skin from Narwhals in strips. The skin is eaten raw or boiled. Besides the calorie-rich fat, what nutritional value does the “muktuk” have?
   A. Vitamin C
   B. Niacin
   C. Iron

27. What keeps whales warm in the cold northern waters?
   A. Blubber
   B. Fur
   C. Thick skin
28. What is used to divide the whales into different groups?
   A. Teeth and baleen
   B. Number of blow holes
   C. Both

29. Whales have resting periods that are similar to sleep.
   A. True
   B. False

30. How can we tell the age of Baleen whales?
   A. Counting rings on the wax plugs from their ears
   B. Counting the rings on their teeth
   C. Counting the rings on their scales

31. The whales with the longest life spans are the
   A. Sperm and Fin whales
   B. Killer whales
   C. Gray whales

32. A baby seal is called a
   A. Calf
   B. Darling
   C. Kit
   D. Pup

33. What does the walrus use its tusks for?
   A. Digging clams
   B. Pulling itself up on ice shelves
   C. Fighting

34. Which animals are the pinnipeds?
   A. Beaked whales
   B. Largest whales
   C. Seals and Sea lions

35. Which is the largest pinniped?
   A. Steller’s sea lion
   B. California sea lion
   C. Elephant seal

36. What is the smallest marine mammal?
   A. Sea otter
   B. Harp seal
   C. Polar bear
37. Killer whales are identified by researchers in the field by the shape of their fins and by their markings.
   A. True
   B. False

38. Sea otter fur conserves heat by the following:
   A. Waxy covering on their fur
   B. Hollow fur fibers
   C. Trapping air and with dense underfur

39. Which pinnipeds would you expect to see along the Oregon Coast?
   A. Ringed seal, Elephant seal, and Harp seal
   B. California sea lion, Steller’s sea lion, and harbor seal
   C. River seal, Gray seal, and Monk seal

40. The polar bear’s main source of food is
   A. Fish
   B. Seals
   C. Penguins

41. Spinner dolphins can leap up to 20 feet in the air.
   A. True
   B. False

42. Sea otters do not have a layer of blubber to keep warm. They need to eat 25 percent of their body weight each day to survive. How many pounds of food does a 65-pound otter need daily?
   A. 10 pounds
   B. 16 pounds
   C. 20 pounds

43. Sea otters can be found
   A. On the Oregon Coast
   B. On the California and Alaskan coasts
   C. Only around the Hawaiian Islands

44. Sea otters use stones as anvils on which to break open the shells of their prey.
   A. True
   B. False

45. One predator of the sea otter is
   A. Humans
   B. Octopus
   C. Mackerel
   D. Sharks
46. Sea otters wrap themselves in kelp to keep from drifting while they sleep.
   A. True
   B. False

47. The closest relative to dolphins are
   A. Fish
   B. Deer
   C. Polar bears

48. An adult Blue whale weighs as much as
   A. 10 elephants
   B. 18 elephants
   C. 30 elephants

49. Where would you find Narwhals?
   A. In the high Arctic region only
   B. From Guam to the Marianas Islands
   C. In the southern hemisphere only

50. The only great whale that is not listed as endangered is the
   A. Blue whale
   B. Humpback whale
   C. Gray whale

51. Are there any freshwater whales?
   A. Yes
   B. No

52. Are there any whales that have become extinct since the 1800s?
   A. Yes
   B. No

53. What is the deepest that a whale can dive?
   A. Sperm whales can dive deeper than 1 mile
   B. Blues can dive down to 5 miles
   C. Humpbacks can dive down to 3 miles

54. Why do whales make seasonal migrations?
   A. They move to warmer waters during the winter and bear their calves
   B. They run out of habitat in their summer feeding grounds
   C. They enjoy visiting tropical islands during the winter

55. What is a female whale called?
   A. Sow
   B. Cow
   C. Doe
56. What is the likely cause of strandings?
   A. The whale is ill from parasites or disease
   B. The lead animal becomes ill and disoriented and other members of the pod follow him/her
   C. Whales practice mass suicides
   D. A and B

57. Whales have been protected for several decades and
   A. Their numbers are recovering rapidly
   B. Some scientists think there may never be a full recovery of stocks to historic numbers
   C. Most stocks have fully recovered

58. You can tell a dolphin from a porpoise by
   A. The shape of its tail
   B. The number of blow holes
   C. The shape of their teeth

59. The bottle-nosed dolphin is found in
   A. Shallow coastal waters
   B. Open ocean around islands
   C. Rivers and lakes as well as the ocean

60. Are there species of dolphins that are found in rivers?
   A. Yes
   B. No

61. Most scientists believe that whales evolved from an ancient, now-extinct terrestrial mammal.
   A. True
   B. False

62. Seals, sea lions, and walruses are called “pinnipeds.” What does this term mean?
   A. Four-footed
   B. Pin-footed
   C. Feather-footed

63. The largest member of the dolphin family is the
   A. Bottle-nosed dolphin
   B. Killer whale
   C. White-sided dolphin

64. Baby whales gain weight quickly because
   A. They immediately begin feeding on Krill
   B. Their mother’s milk is very rich in fat
   C. They eat continuously from the moment they are born
65. Mammals have hair, give birth to their calves, and feed their young milk. Do whales have these characteristics?
   A. Yes
   B. No

66. Most mammals have five senses—touch, hearing, sight, smell, and taste. Which of these senses have whales lost?
   A. Hearing and touch
   B. Sight and taste
   C. Smell and taste

67. Can whales have external parasites such as lice?
   A. Yes
   B. No

68. Which marine mammals are being trained to retrieve scientific equipment from the ocean floor?
   A. Sea lions
   B. Sperm whales
   C. Killer whales

69. The greatest threat to whales today is
   A. Rapid human population growth, which is changing the world’s oceans
   B. Marine debris
   C. Radioactive wastes dumped into the ocean
Appendix
Inquiry in Action ©

1. Determine what learners know or have observed. Identify knowledge gaps or misunderstandings.

2. What do learners want to know? What questions do learners have?

3. Team asks a question that they can explore through scientific investigation.

4. Team designs a simple scientific investigation.

5. Team selects appropriate equipment to collect data, designs a data sheet (if needed).

6. Team collects data and completes data sheet.

7. Team describes their investigation and their reactions.

8. Team thinks critically and logically to make the relationship between evidence and explanations and presents their analysis of the findings.

9. Through group discussion, apply findings to everyday experiences or real-world examples.

10. Are all teams/learners satisfied with the proposed analysis of findings?

11a. Yes: Move on to the next inquiry.

11b. No.
4-H Science Checklist

A “Science Ready” 4-H experience is a program that is framed in science concepts, based on science standards, and intentionally targets the development of science abilities and the outcome articulated by the 4-H Science Logic Model. Additionally, it integrates the essential elements and engages participants in experiential and inquiry-based learning. In addition to the following criteria, it's also recommended that science programs offer a sustained learning experience that offers youth the opportunity to be engaged in programs with relevant frequency and duration. Use the following checklist to assess the program you deliver.

*To meet the needs of children, youth, and the nation with high-quality science, engineering, and technology programs.*

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you providing science, engineering, and technology programs based on National Science Education Standards?</td>
<td>✓</td>
</tr>
<tr>
<td>Science education standards are criteria to judge quality: the quality of what young people know and are able to do; the quality of the science programs that provide the opportunity for children and youth to learn science; the quality of science teaching; the quality of the system that supports science leaders and programs; and the quality of assessment practices and policies. <a href="http://www.nap.edu/readingroom/books/nses/">http://www.nap.edu/readingroom/books/nses/</a></td>
<td></td>
</tr>
<tr>
<td>Are you providing children and youth opportunities to improve their science abilities?</td>
<td>✓</td>
</tr>
<tr>
<td>Predict, Hypothesize, Evaluate, State a Problem, Research Problem, Test, Problem Solve Design Solutions, Measure, Collect Data, Draw/Design, Build/Construct, Use Tools, Observe, Communicate, Organize, Infer, Question, Plan Investigation, Summarize/Relate, Invent/Implement Solutions, Interpret/Analyze/Reason, Categorize/Order/Classify, Model/Graph/Use Numbers, Troubleshoot, Redesign, Optimize, Collaborate, Compare</td>
<td></td>
</tr>
<tr>
<td>Are you providing opportunities for youth to experience and improve in the Essential Elements of Positive Youth Development?</td>
<td>✓</td>
</tr>
<tr>
<td>Do youth get a chance at mastery—addressing and overcoming life challenges in your programs? Do youth cultivate independence and have an opportunity to see oneself as an active participant in the future? Do youth develop a sense of belonging within a positive group? Do youth learn to share a spirit of generosity toward others?</td>
<td></td>
</tr>
<tr>
<td>Are learning experiences led by trained, caring adult staff and volunteers acting as mentors, coaches, facilitators and co-learners who operate from a perspective that youth are partners and resources in their own development?</td>
<td>✓</td>
</tr>
<tr>
<td>Are activities led with an experiential approach to learning?</td>
<td>✓</td>
</tr>
<tr>
<td>Are activities using inquiry to foster the natural creativity and curiosity of youth?</td>
<td>✓</td>
</tr>
<tr>
<td>Does your program target one or more of the outcomes on the 4-H Science Logic Model and have you considered the frequency and duration necessary for youth to accomplish those outcomes?</td>
<td>✓</td>
</tr>
</tbody>
</table>
## 4-H Science Competency Self Assessment

Please fill in the circle that tells you how much you are capable of using the knowledge and skills in each of these areas when you work with youth in 4-H Science programs.

<table>
<thead>
<tr>
<th></th>
<th>0 Never</th>
<th>1 Sometimes</th>
<th>2 Usually</th>
<th>3 Most of the Time</th>
<th>4 Always</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CARING ADULT</strong></td>
<td></td>
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<tr>
<td>I use language of respect</td>
<td>0</td>
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</tr>
<tr>
<td>I listen to youth in a nonjudgmental way</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I demonstrate shared leadership through youth-adult partnerships</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I encourage youth to think about what they are learning</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I make verbal contact with all youth</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I encourage learners when they experience setbacks</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I offer praise and encouragement when youth take initiative and leadership</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I identify, build on, and celebrate the potential of all youth</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I respect youth of different talents, abilities, sexual orientations, and faiths</td>
<td>0</td>
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<tr>
<td><strong>INCLUSIVE ENVIRONMENT (BELONGING)</strong></td>
<td></td>
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<tr>
<td>I help youth feel welcome and part of a group</td>
<td>0</td>
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<tr>
<td>I establish a climate of fairness and openness</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I respond positively to the ranges of youths' feelings</td>
<td>0</td>
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<tr>
<td>I cultivate a sense of togetherness among youth</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I value and act upon the ideas of others</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I serve as a role model for inclusion and tolerance</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I initiate, sustain, and nurture group interactions and relationships</td>
<td>0</td>
<td>0</td>
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<tr>
<td><strong>SAFE ENVIRONMENT</strong></td>
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<tr>
<td>I conduct myself in a calm manner</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I reduce or eliminate physical and environmental hazards</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I re-emphasize ground rules related to conduct</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I intervene when safety demands it</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td><strong>SEE ONESELF IN THE FUTURE</strong></td>
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<tr>
<td>I project an optimistic, positive manner</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I reinforce the idea that all youth can succeed</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I offer positive encouragement and support even in the face of setbacks</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I talk about the future and youth's role in it</td>
<td>0</td>
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</tbody>
</table>
### 4-H Exploring Water Habitats: Wetlands, Streams, Oceans

**VALUES AND PRACTICES SERVICE TO OTHERS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Never</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Most of the Time</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I encourage youth to contribute to the communities in which they live</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I voice support for giving back to the community through service</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I believe in science's role in improving communities</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I provide opportunities for youth to link their experiences to citizenship</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I identify opportunities for youth to become civically engaged</td>
<td>0</td>
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</table>

**OPPORTUNITIES FOR SELF-DETERMINATION**

<table>
<thead>
<tr>
<th>Description</th>
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<th>Sometimes</th>
<th>Usually</th>
<th>Most of the Time</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I provide experiences that encourage youth to share evidence</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I identify opportunities for youth to compare claims with each other</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I articulate strategies for data collection and analysis</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I work with youth to identify sources of information</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>I actively consult, involve, and encourage youth to contribute to others</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I provide opportunities for youth to determine program expectations and direction</td>
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**ENGAGEMENT IN LEARNING**

<table>
<thead>
<tr>
<th>Description</th>
<th>Never</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Most of the Time</th>
<th>Always</th>
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</thead>
<tbody>
<tr>
<td>I guide youth in learning for themselves</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I create opportunities for problem solving via discussion, debate, and negotiation</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I work with youth to establish appropriate goals for their age</td>
<td>0</td>
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</tr>
<tr>
<td>I provide opportunities for youth to link their experiences to the real world</td>
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<td>0</td>
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<tr>
<td>I use a variety of questioning and motivational approaches</td>
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<td>0</td>
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<tr>
<td>I use multiple learning approaches to meet learners' needs</td>
<td>0</td>
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**OPPORTUNITIES FOR MASTERY**

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<th>Description</th>
<th>Never</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Most of the Time</th>
<th>Always</th>
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</thead>
<tbody>
<tr>
<td>I suggest challenges that can be explored by direct investigation</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I encourage youth to make predictions</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I assist youth in developing hypotheses related to their investigations</td>
<td>0</td>
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<tr>
<td>I allow youth to conduct formal and open-ended tests and experiments</td>
<td>0</td>
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<tr>
<td>I have youth discuss their finding with each other and evaluate evidence critically</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>I encourage youth to share their knowledge by teaching others and leading new activities</td>
<td>0</td>
<td>0</td>
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<tr>
<td>I help youth see setbacks as opportunities for new explorations</td>
<td>0</td>
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<tr>
<td>I support youth to set new goals, and try new ideas and approaches</td>
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<tr>
<td>I provide opportunity for youth to use appropriate technology</td>
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</tbody>
</table>
Copy pages for lessons
1. Ocean

FACT: Water vapor. When water is a gas, it's called vapor.

FACT: Water is in its most pure form as water vapor.

FACT: Pure water has no smell, taste, or color.

FACT: Water vapor is 0.001% of the world's water supply.

FACT: Water is evaporated into the air by the sun.

2. (c) Water vapor Evaporating from the Ocean

2. (b) Water vapor Evaporating from the Ocean

FACT: The water in the air above Earth is called atmospheric water. It is 0.001% of the world's water supply.

FACT: 97.54% of the world's water is salt water.

1. Ocean

FACT: 2.54% of the world's water is freshwater.
FACT: Water is a chemical combination of two atoms of hydrogen (H) and one atom of oxygen (O). This chemical combination is written as the formula H\(_2\)O.

Ocean

2. (d) Water Vapor Evaporating from the

FACT: The water vapor evaporating from the ocean cools as it gets higher in the air. When the vapor cools, it condenses into a group of tiny water droplets that we see as clouds.

FACT: Rain falls when tiny water droplets join together with other water droplets in a cloud. They fall out as rain.

FACT: Rain falls when tiny water droplets join together with other water droplets in a cloud. They fall out as rain.

FACT: When the water droplets join they form bigger rain drops that are too heavy to stay in the air. When the water droplets join they form bigger rain drops that are too heavy to stay in the air.
4-H Exploring Water Habitats: Wetlands, Streams, Oceans

4. (b) Rain

FACT: There are approximately 2 quarts of water in the air above every square foot of land on an average day.

5. Runoff

FACT: As rain water runs off a parking lot it carries oil spilled by leaky cars. Where is the oil going?

6. Stream

FACT: Only about 0.0001% of the world's water supply is found in streams or rivers.

7. Sun

FACT: The energy needed to move water "up" in the water cycle is provided by the sun. The sun's energy is needed to power evaporation and transpiration. Gravity causes rain to fall and water to flow downhill. Together the sun and gravity are the natural forces that power the water cycle.
FACT: During the process of transpiration, water vapor is evaporated from the surface of leaves in a process called photosynthesis, a plant is making food and releasing both oxygen and water vapor.

8. (a) Infiltration of Soil

Water that does not soak into the soil. Water that does not put water on the soil too fast, it does not saturate the soil slowly. When rain or garden sprinklers water the soil, this is infiltration. Water infiltrates a soil, this is infiltration. When water soaks into and through the soil.

FACT: The water in soil accounts for about 0.005% of the world's water.

8. (b) Infiltration of Soil

Water in soil.

FACT: Both pollutants that are bad for plants and minerals plants need to grow enter the plants through the water they absorb with their plant roots. When they absorb both oxygen and water vapor.

FACT: The plant's stems and leaves stay in the plant's stems and leaves.
11. Snowflake
FACT: Water must be at or below 32 degrees Fahrenheit (F) to be in a solid form. The freezing point of water is the temperature at which liquid water changes to the solid form called ice. A snowflake is a crystalline structure of water. Snowflakes form when falling in the Cascade Mountains, may become part of the snowpack, which may melt each spring or it may become part of the Cascade Mountains or fall into the North Santiam River. The city of Salem takes a large percentage of its public water supply from the snowpack in 650 square miles of forest located within the North Santiam Watershed.

13. Slushy, Melting Snow
(a) FACT: The North Santiam River flows west toward Salem from the Cascade Mountains.
(b) FACT: Polar ice caps and mountain glaciers contain 1.81% of the world’s water. This water is stored for long periods of time and is released only by melting.

12. Snow Pack
FACT: When water freezes it expands, but make a block of ice. Individual snowflakes freeze together to form a block of ice. A glacier is formed when the snowpack becomes part of a glacier. A glacier is a large ice sheet that moves slowly. The North Santiam River flows west toward Salem from the Cascade Mountains. The city of Salem takes a large percentage of its public water supply from the snowpack in 650 square miles of forest located within the North Santiam Watershed.

14. Snowflake, Melting Snow
FACT: Water must be at or below 32 degrees Fahrenheit (F) to be in a solid form. The freezing point of water is the temperature at which liquid water changes to the solid form called ice. A snowflake is a crystalline structure of water. Snowflakes form when falling in the Cascade Mountains, may become part of the snowpack, which may melt each spring or it may become part of the Cascade Mountains or fall into the North Santiam River. The city of Salem takes a large percentage of its public water supply from the snowpack in 650 square miles of forest located within the North Santiam Watershed.
14. Percolation Through Soil

FACT: As water moves through the soil, pollution 250,000 gallons of water. If you dig a hole straight toward the water table, it picks up contaminants from the soil. Spilling everyday things like a single quart of motor oil onto soil is enough to pollute 250,000 gallons of water. This water would be the water table. Where the water table is exposed by the earth, you would eventually reach ground water. If you dig a hole straight into the earth, you would eventually reach ground water. This water is the upper surface of inland freshwater wetlands. Inland freshwater wetlands occur along the shores of lakes, ponds, rivers, streams, and creeks. There are few trees, but a great variety of plants and animals.

15. Water Table

FACT: The water table is the upper surface each day. An average person drinks 1,500 pounds of water every year. This is equal to nearly eight 8-ounce glasses.

16. Spring Flow

FACT: A spring might be found. A slope of a hill, a spring might be found. Where the water table is exposed, by the slope of a hill, a spring might be found. These are few trees, but a great variety of plants and animals.

17. Wetland

FACT: Inland freshwater wetlands occur along the shores of lakes, ponds, rivers, streams, and creeks. There are few trees, but a great variety of plants and animals. As water moves through the soil, it picks up contaminants from the soil. Spilling a single quart of motor oil onto soil is enough to pollute 250,000 gallons of water.
<table>
<thead>
<tr>
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<th>18. Estuary</th>
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<tbody>
<tr>
<td></td>
<td>FACT: The type of wetland richest in the ocean. Water of rivers meets the salt water of the oceans. This is the place where the fresh plants and wildlife is the coastal salt marsh.</td>
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<tr>
<td></td>
<td>FACT: Freshwater lakes and inland seas make up 0.017% of the world’s water. People who use wells to provide water to their homes are using groundwater. Groundwater makes up 0.62% of the world’s water supply.</td>
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<td>20. Lake</td>
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<td>FACT: Water stored in pockets in the earth is called groundwater. Groundwater makes up 0.62% of the world’s water supply. People who use wells to provide water to their homes are using groundwater.</td>
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<td>21. Rosa Raindrop</td>
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<td>FACT: The type of wetland richest in plants and wildlife is the coastal salt marsh. This is the place where the fresh plants and wildlife is the coastal salt marsh.</td>
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<td>4-H Exploring Water Habitats: Wetlands, Streams, Oceans</td>
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</tbody>
</table>
**Phytoplankton**

We are small single-celled plants. We cannot run away when zooplankton, salmon, aquatic insects, and snails come to eat us.

---

**Algae**

We are small multicelled plants. We must grow and multiply very fast because so many animals eat us. Some of these animals are aquatic insects, crayfish, tadpoles, and mallard ducks.
**Duckweed**

We are small multicelled plants. We grow very fast in quiet pools along the stream edge. Here, we may provide shade and cover for tadpoles or juvenile salmon. We provide food for aquatic insects, mallard ducks, and raccoons.

**Sedges**

We are a plant that grows in wet areas along the edge of the stream. Beetles eat our roots. Ruffed grouse and mallard ducks eat our seeds.
Oak

We are big trees. We may grow in forests and open prairie areas. Mallard ducks, ruffed grouse, raccoons and humans use our acorns. Land insects, such as grasshoppers and beetles, may be found on our leaves. The osprey may rest on our branches while eating a salmon. The leftover salmon parts fall to the ground and become fertilizer for us.

Alder

We are trees and shrubs that grow near streams. When we drop branches, they may fall into the stream, adding to the woody debris. We shade the stream in summer. When we drop our leaves into the stream, algae may grow on them or they may be eaten by aquatic insects and crayfish. Ruffed grouse feed on our catkins. Raccoons use us for shelter.
Zooplankton

We are tiny animals that are eaten by many aquatic insect larvae, juvenile salmon, and other small swimmers. We need nutrients from phytoplankton, rotting leaves, and animals.

Stonefly Larvae

We live on or under rocks or stones in the stream. That is where our name comes from. Some of us eat plants. Other types eat small insects and zooplankton. Fish like to eat us. We are also eaten by raccoons and mallard ducks.
Caddis Fly Larvae

We build little homes around our soft bodies from tiny pieces of gravel or pieces of leaves and twigs. We eat plants and leaves that drop into the stream. We try to hide from mallard ducks, crayfish, and raccoons who would like to eat us.

Mayfly Larvae

We eat zooplankton and plants. Many animals eat us, including larger aquatic insects, such as stonefly and beetle larvae. Salmon and mallard ducks also eat us.
Snail

When we spot a water strider, beetle, salmon, or raccoon we just pull our foot into our shells. Then we hope we don’t get eaten. Our eyes and mouth are on our foot. Pretty odd? Nope! The phytoplankton and algae we eat grow where we crawl.

Beetle

I hide under leaves or swim fast to keep from being eaten by frogs or salmon. I just want to eat my mayfly larvae and greens.
Grasshoppers

Sometimes we come to the stream in search of water, but mostly we get water from the tree and grass leaves we eat. Ruffed grouse, raccoons, and frogs will eat us if we don’t hop fast enough!

Tadpoles

We are vegetarians, eating only plants such as phytoplankton and algae. When we grow up, we will be carnivorous like our parents (who are frogs) and will eat other animals. Very few of our hundreds of brothers and sisters will survive to have their own eggs because so many animals like to eat us. We must watch out for raccoons, otter, great blue herons, and belted kingfishers.
Juvenile salmon

Once we come out of our gravel nest, we are very hungry. We need to eat a lot of food to grow. As we get bigger, we eat bigger food. We eat both plants and animals, including phytoplankton and everything from zooplankton to beetles. There are many of us because we are eaten by mallard ducks, raccoons, osprey, belted kingfishers, great blue herons, and otters.

Crayfish

We are the stream sanitation department. We clean up anything dead, often using the body of a dead animal as a temporary home. We also eat algae, caddisfly larvae, and worms. Raccoons, otters, and some people consider us a delicacy.
Mallard Duck

We live near the stream and on the water. We eat sedge, acorns, and duckweed. We also eat aquatic insects, fish eggs, tadpoles, small frogs, and fish. We will even scavenge on dead salmon. We have many ducklings each spring because so many are eaten by great blue herons and otters.

Frog

We are mainly carnivorous animals. As you see in cartoons, we love to eat insects. We also enjoy snails and small crayfish. When feeding along the edge of the stream, we have to watch out for mallard ducks, otters, raccoons, and great blue herons.
Ruffed Grouse

We are forest-loving birds. We like to eat grasshoppers, beetles, berries, sedge seeds, acorns, alder leaves and catkins, wild grape, and woody plants. Very few animals eat us once we are adults. Our chicks may be eaten by raccoons.

Osprey

We are called fish hawks because our main diet is fish. We may also eat snakes, frogs, and ducklings. We need large trees to roost in and to build safe nests for our young.
Raccoon

I just love water! Clean, clear water where I can catch my food and wash it too! I am not afraid of any other stream animals. I like to eat duckweed, acorns, grasshoppers, caddisfly larvae, stonefly larvae, snails, frogs, fish, crayfish, and small creatures found in the water and mud along the shore.

Otter

I would rather play than eat. I play every chance I get – even with my food! I like to eat crayfish, fish, beetles, and frogs.
Great Blue Heron

I can see frogs hiding in the cattails, and I sneak up on them with my big, wide feet. If the frog gets away, I’ll poke in the mud with my long bill to find crayfish or snap at a young salmon. I also enjoy snakes and grasshoppers.

Belted Kingfisher

Our loud cry can sound like a crazy laugh as we swoop over the stream. We eat any small swimmers we can catch: crayfish, frogs, small snakes, beetles, and even young birds. We nest in a burrow that is 3- to 7-feet deep in soft soil on banks or cliffs.
Habitat Component: Woody Debris
Large branches, logs, and logjams provide shade and create deep pools of cool water.

Habitat Component: Riffles, Runs, Gravel
Boulders and cobbles create riffles where aquatic insects live. Each type of salmon likes different types and sizes of gravel in a streambed.
Habitat Component: Sun

Consistent water temperatures and high oxygen levels are important to the stream habitat. Plants growing on the stream banks shade the water. This helps to keep it cool. Woody debris and boulders help mix oxygen into the water.
Habitat Component: Salmon carcass
4-H Exploring Water Habitats: Wetlands, Streams, Oceans

Stonefly Nymph

My distinguishing characteristics
■ 2 tails; 2 sets of wing pads

How I get oxygen
■ Through body surface
■ Some small gills; push-up

How I get food
■ Filter; 3rd pair of legs

Why I’m special
■ Only tolerant of high oxygen levels
■ Special channels in jaws to suck body fluids of prey

Predacious Diving Beetle

My distinguishing characteristics
■ Most species build cases of nets; soft body

How I get oxygen
■ Through body surface

How I get food
■ Filter feeder, predator, or scavenger

Why I’m special
■ I have a streamlined body for crawling on rocks; only tolerate high to medium oxygen levels

SENSITIVE TO POLLUTION

Caddisfly Larva

My distinguishing characteristics
■ Up to 6 centimeters long; robust jaws

How I get oxygen
■ Through gills along abdomen

How I get food
■ Voracious predator

Why I’m special
■ I only tolerate high to medium oxygen levels
■ Special channels for oxygen uptake
■ Suck body fluids of prey

SENSITIVE TO POLLUTION

Mayfly Nymph

My distinguishing characteristics
■ 2 tails; sometimes 2; set of wing pads

How I get oxygen
■ Through body surface

How I get food
■ Filter, predator, or scavenger

Why I’m special
■ I build cases of heavy materials (rocks) to avoid being swept away by fast-flowing streams; in ponds, I build cases of heavy materials (rocks) to avoid

SENSITIVE TO POLLUTION

Stonyfly Nymph

My distinguishing characteristics
■ Up to 6 centimeters long; robust jaws

How I get oxygen
■ Through body surface

How I get food
■ Voracious predator

Why I’m special
■ I only tolerate high oxygen levels
■ Special channels for oxygen uptake
■ Suck body fluids of prey

SENSITIVE TO POLLUTION

(Somewhat tolerant of pollution)

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■ Through body surface

How I get food
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■ Special channels for oxygen uptake
■ Suck body fluids of prey

SENSITIVE TO POLLUTION

(Somewhat tolerant of pollution)
**Invertebrates.**

**Why I'm special.**

- I can survive low oxygen levels fatal to most.

**How I get food.**

- Scavenger -- eats decaying matter and sewage.
- Through body surface, but can tolerate water with no oxygen.
- I have a segmented body! I build a vertical tube from which one end protrudes.
- My distinguishing characteristics:
  - Cylindrical body, tail-like breathing tube.
  - My tolerant to pollution.

**How I get oxygen.**

- From atmosphere through breathing tube.
- I can breathe, even in oxygen-poor environments.
- Some of us have substances in blood to hold.
- Why I'm special.

**How I get food.**

- Scavenger or omnivore.
- Predator, herbivore of omnivore.
- Predacious; instantly devours or chemore.
- Through body surface.
- My distinguishing characteristics:
  - My small cylindrical body; sometimes blood red.

**Why I'm special.**

- Males can carry females on their backs during mating; female then sheds half of exoskeleton, which becomes a case into which fertilized eggs are placed for development.
- Why I'm special.

**How I get food.**

- Predacious; instantly devours or chemore.
- Through body surface.
- My distinguishing characteristics:
  - My small cylindrical body; sometimes blood red.

**How I get oxygen.**

- Through gills under body.
- My tolerant to pollution.

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**How I get oxygen.**

- Through gills under body.
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- I can breathe, even in oxygen-poor environments.
- Why I'm special.

**How I get food.**

- Scavenger; I eat decaying matter and sewage.
- Predacious; instantly devours or chemore.
- Through body surface.
- My distinguishing characteristics:
  - My segmented body! I build a vertical tube from which one end protrudes.

**How I get oxygen.**

- Through gills under body.
- My distinguishing characteristics:
  - My segmented body! I build a vertical tube from which one end protrudes.
**Crane Fly Larva**

- **My distinguishing characteristics**: Cylindrical body; I often have lobes on my hind end.

- **How I get oxygen**: From atmosphere through spiracles (openings) at hind end.

- **How I get food**: Active predator, herbivore, or omnivore

- **Why I’m special**: I eat woody, decaying matter, so I have gut bacteria to digest cellulose.

---

**Aquatic Sowbug**

- **My distinguishing characteristics**: Flattened body, top to bottom; 7 pairs of legs.

- **How I get oxygen**: Through body surface on legs.

- **How I get food**: I’m a scavenger when I’m eating decaying matter; otherwise, I’m an omnivore.

- **Why I’m special**: Males clasp female under them during mating; female sheds half of exoskeleton, which becomes a case into which fertilized eggs are placed for development.

---

**Mosquito Larva**

- **My distinguishing characteristics**: Small body; I float on the surface.

- **How I get oxygen**: From atmosphere through a feeding tube.

- **How I get food**: I am a scavenger; I feed on microorganisms.

- **Why I’m special**: I swim or dive when disturbed.

---

**Crayfish**

- **My distinguishing characteristics**: I have 5 pairs of legs; first pair often robust; I look like a small lobster.

- **How I get oxygen**: Through gills under body and through a feeding tube.

- **How I get food**: Scavenger or omnivore.

- **Why I’m special**: I crawl backward when disturbed; males display some courtship behavior to reduce female aggressiveness.

---

**SOMEWHAT TOLERANT OF POLLUTION**

1. **Why I’m special**: Males clasp female under them during mating; female sheds half of exoskeleton, which becomes a case into which fertilized eggs are placed for development.

2. **How I get food**: I’m a scavenger when I’m eating decaying matter; otherwise, I’m an omnivore.

---

**SOMEWHAT TOLERANT TO POLLUTION**

1. **My distinguishing characteristics**: Cylindrical body; I often have lobes on my hind end.

2. **How I get oxygen**: From atmosphere through spiracles (openings) and through gills under body.

3. **How I get food**: Active predator, herbivore, or omnivore

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**Hellgrammite**

- **My distinguishing characteristics**
  - Up to 9 centimeters long

- **How I get oxygen**
  - Through gills alongside of abdomen; some fishflies have breathing tubes.

- **How I get food**
  - Active predator

- **Why I'm special**
  - I can swallow prey without chewing.

**Water Boatman (adult)**

- **My distinguishing characteristics**
  - I have long swimming hairs on my legs.

- **How I get oxygen**
  - From atmosphere, by carrying air bubble from water's surface on body.

- **How I get food**
  - Omnivore, scavenger, or predator

- **Why I'm special**
  - The swimming hairs on my legs act like oars.

**Water Strider (adult)**

- **My distinguishing characteristics**
  - I have a light-colored underside; I swim on my back.

- **How I get oxygen**
  - From atmosphere, by carrying air bubble from water's surface on body.

- **How I get food**
  - Active predator

- **Why I'm special**
  - I can stay on the surface because my feet have a small surface area and are water repellent.

**Backswimmer (adult)**

- **My distinguishing characteristics**
  - I can swim on my back and I have a sleek body.

- **How I get oxygen**
  - From atmosphere, by carrying air bubble on body.

- **How I get food**
  - Omnivore, scavenger, or predator

- **Why I'm special**
  - The swimming hairs on my legs act like oars.
4-H Exploring Water Habitats: Wetlands, Streams, Oceans

**Whirligig Beetle (adult)**

*My distinguishing characteristics*
- I am black, and I congregate in schools.

*How I get oxygen*
- Through gills at the end of my abdomen

*How I get food*
- Active predator

*Why I'm special*
- I have two pairs of eyes to see above and below the water's surface; I have a type of 'radar' to locate objects in the water; I secrete a white, odorous substance to deter predators.

**Dragonfly Nymph**

*My distinguishing characteristics*
- Stout body, grasping jaws

*How I get oxygen*
- Dissolved oxygen, through gills in internal body chamber

*How I get food*
- Active predator

*Why I'm special*
- I cling to vegetation or hide in clumps of dead leaves or sediment.

**Black Fly Larva**

*My distinguishing characteristics*
- I can move to avoid objects, using silk; I can only stay on rocks attached to rocks.

*How I get oxygen*
- Through body surface

*How I get food*
- Filter feeder

*Why I'm special*
- I have a large body, but I also have small hooks that attach to rocks; I have two pairs of eyes to see above and below the water's surface; I have a type of 'radar'

**Damselfly Nymph**

*My distinguishing characteristics*
- I have a small body but also have small hooks at the end of my abdomen to attach to rocks.

*How I get oxygen*
- Through gills at the end of my abdomen

*How I get food*
- Filter or scavenger

*Why I'm special*
- I cling to vegetation or hide in clumps of dead leaves or sediment.

**Somewhat Tolerant of Pollution**

**Black Fly Larva**

**Whirligig Beetle (adult)**

**Somewhat Tolerant of Pollution**

**Damselfly Nymph**

**Dragonfly Nymph**

**SOMEWHAT TOLERANT OF POLLUTION**

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Literature cited