# 5-ESS2 Earth's Systems

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Students who demonstrate understanding can:

**5-ESS2-a. Use models to describe interactions between the geosphere, hydrosphere, atmosphere, and biosphere and identify the limitations of the models.** [Clarification Statement: The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [Assessment Boundary: Students should only be assessed on the interactions of two systems at a time.]

**5-ESS2-b. Use evidence from observations to explain the role of the ocean in supporting ecosystems and their organisms, shaping landforms, and influencing climate.** [Clarification Statement: Evidence for supporting ecosystems could include distribution of fish. Evidence for shaping landforms could include pictures of coastal erosion. Evidence for influencing climate could include temperature patterns in coastal vs. continental regions.] [Assessment Boundary: Students should only be assessed on the role of the ocean in supporting ecosystems in general, not on specific ecosystems.]

**5-ESS2-c. Develop and revise models to describe how wind and clouds interact with landforms to determine patterns of weather.** [Clarification Statement: An example could be when clouds go over mountains, they release their water as precipitation.] [Assessment Boundary: Assessment should not include weather maps.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

### Science and Engineering Practices

**Developing and Using Models**

Modeling in 3–5 builds on K–2 models and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop and revise models collaboratively to measure and explain frequent and regular events. (5-ESS2-c)
- Use simple models to describe or support explanations for phenomena and test cause and effect relationships or interactions concerning the functioning of a natural or designed system (5-ESS2-a)
- Identify limitations of models. (5-ESS2-a)

**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions.

- Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem. (5-ESS2-b)

### Disciplinary Core Ideas

**ESS2.A: Earth Materials and Systems**

- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. (5-ESS2-a)
- The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. (5-ESS2-b)
- Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-c)
- Human activities affect Earth's systems and their interactions at its surface. *(secondary to 5-ESS3-a)*

**ESS2.C: The Roles of Water in Earth's Surface Processes**

- Water is found almost everywhere on Earth: as vapor; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface. (5-ESS2-a),(5-ESS2-c)
- Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-a)

### Crosscutting Concepts

**Patterns**

- Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena and designed products. (5-ESS2-c)

**Systems and System Models**

- A system can be described in terms of its components and their interactions. (5-ESS2-a),(5-ESS2-b)

*Connections to other DCIs in this grade-level: will be added in future version.*

*Articulation of DCIs across grade-levels: will be added in future version.*

*Common Core State Standards Connections:*

*ELA/Literacy –*

**RI.5.3** Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. *(5-ESS2-b)*

**RI.5.10** By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 4–5 text complexity band independently and proficiently. *(5-ESS2-b),(5-ESS2-c)*

**W.5.7** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. *(5-ESS2-b)*

**SL.5.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly. *(5-ESS2-b),(5-ESS2-c)*

**SL.5.5** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. *(5-ESS2-b)*

*Mathematics –*

**MP.3** Construct viable arguments and critique the reasoning of others. (5-ESS2-b),(5-ESS2-c)

**5.G.2** Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. (5-ESS2-b)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice, Disciplinary Core Idea, or Crosscutting Concept.

# Plants and the Water Cycle
# Lesson Plan

## Overview

Plants interact with their environment in many ways that we cannot see. Children often enjoy learning about these "hidden secrets" of plant life. In this lesson, children will learn about role of plants in recycling water by collecting water vapor that is emitted, or *transpired,* by green plant leaves. Students will learn that this process helps to cool plant leaves, just as perspiration helps to cool their own bodies. In addition, students learn that the water vapor transpired by leaves contributes to the formation of clouds and eventually returns to the surface in the form of rain.

| | |
|---|---|
| Suggested Lesson Sequence | Please see the Greenlinks Module description. |
| Lesson Level | Extended |
| Science Connections | · Students learn that while people **perspire** water through their skin to keep cool, plants **transpire water vapor** through their leaves to keep cool.<br>· Students learn that **water vapor** from plants helps to form **clouds** in the sky, and that clouds are made of water **droplets** that can then fall to the ground as rain.<br>· Students learn that rain water is taken up by plant roots, which feed the water through the plant stem and back to leaves once again to continue the **water cycle**. |
| Math Connections | · Students will **measure** accumulations of water in **milliliters.** |
| Human Connections | · Students learn about the important role of plants in delivering **moisture** to the air and sustaining the environment for humans and other living organisms.<br>· Students consider the implications of human plant **removal** on the water cycle. |
| Lesson Assessment | · Assessment and Standards Table (Word)<br>· Assessment Activity Description (below)<br>· Authentic Assessment (below) |

**Materials**

Keeping Cool interactive slide show (Powerpoint)
Arrange the Water Cycle assessment slide show (Powerpoint)
Transpiration Activity Sheet (Word)
A pair of glasses or small mirror, preferably kept in a cool place prior to use
Access to a broadleaf tree or shrub growing outside; or a broadleaf potted plant growing inside. *Note: this activity works best on a sunny day.*
Gallon-sized plastic bags that can be sealed shut
Clothespins
Digital camera (optional)
Eye dropper and graduated cylinder with milliliter scale marked on the side (optional)

*About the slideshows:* these slideshows are not meant for students to read through on their own. They are intended to be viewed together, to outline and illustrate a discussion of the lesson's themes, led by the teacher. You might have a different student read the text on each slide.

**Vocabulary**

- **Exhale:** to breathe out. When exhaling, animals emit water vapor and other gases to the atmosphere from their mouth.
- **Gas:** a form of matter that fills the shape of a container and expands (gets larger) when heated. Many gases are invisible. The air we breathe in and out is made of different mixtures of gases.
- **Perspiration:** the process of sweating. When people perspire, they sweat through tiny pores in their skin. People keep cool by perspiring water through their skin.
- **Stomate:** a tiny, mouthlike pore in a leaf. Gases (including water vapor) pass through a leaf's many stomates.
- **Transpiration**: the process through which plants give off (emit) water vapor, largely through tiny (microscopic) pores in leaves called stomates. Plants keep cool by transpiring water through their leaves.
- **Vapor**: the gas form of a substance. Water vapor is water in the form of a gas.
- **Water cycle**: the process of water moving through various parts of the Earth. An example of a water cycle is when water is taken up from soil by plant roots, moves through the plant to its leaves, enters the outside air by transpiring through the leaves, and then forms clouds which rain out to return the water to the soil surface.

**Procedure**

## I. Assessing Prior Knowledge

To introduce the concept of plant transpiration, ask students what they think happens when they exhale (breathe out) when they are outside on a very cold day. For students who have lived in or experienced cold climates, they should recall the interesting phenomenon of "seeing your breath." A person's exhaled breath is what releases water vapor and other gases from their lungs. Plants emit water vapor through their leaves mainly by a process called *transpiration*. Although "seeing your breath" is not an identical process to plant transpiration, it provides students with a conceptual model to help them understand what occurs when plants release (transpire) water vapor. The human body and plant leaves are both moist on the inside, and when gases from inside animals or plants are released to the outside, these gases carry water vapor with them.

## II. Contextual preparation

Have students brainstorm to come up with ideas for how to test what might be in their breath that they would see on a cold day, by using a pair of glasses or a small mirror. Show students how the glass or small mirror becomes "clouded" when it is breathed upon, and reveal to the students that these "clouds" on the glass are actually made up of very small water droplets. (Hint: keeping the glasses or mirror cool prior to this demonstration will allow the water droplets to persist longer.) In cold air, this water vapor within our warm breath quickly turns to very small water droplets in mid-air, and becomes visible as a "cloud" of breath. This discussion should set the stage for students to later recognize that plants complete a similar process; when the sun heats water inside plant stems and leaves, it is released into the atmosphere as a vapor through small pores in the leaves. Furthermore, students may begin to realize that as water is warmed (either in our bodies or in plant leaves exposed to the sun), it tends to turn partly to an invisible gas (vapor) form, and that when this vapor is cooled (either by the cold air, or a cool mirror), it turns back into a visible liquid droplet form.

Using a computer, show children the Keeping Cool Slide Show. In these slides, many of the concepts mentioned above will be reinforced through the use of photos and cartoons. The slide show reveals various aspects of the water cycle, including plant transpiration. Through transpiration, water vapor passes through tiny pores in the leaves of plants to enter the atmosphere. This water vapor then rises in the atmosphere, cools and forms droplets which accumulate into clouds, then rains out to moisten soils and be taken up by plant roots once again.

## III. Student Activities

1. To learn about the process of transpiration, children will collect water that transpires through the tiny pores of leaves called stomates. On the playground, choose a deciduous tree or shrub with broad leaves in direct sunlight. This activity will work best outside on a warm, clear day. Depending on the climate, weather, and location in which you live, you will

experience varying degrees of success. In the case that broadleaf plants are not available outside, place a potted plant in a sunlit window inside. Repeated trials may be necessary.

2. Children should carefully slide a large, transparent plastic bag over a branch or stem of a plant containing at least 3 or 4 large healthy leaves that are dry on their surfaces. Secure the bag around the stem with a clothespin. For interesting comparison purposes, students may wish to use several different species of plants (or use different numbers of leaves) for this activity.

3. Children can observe and record findings over the course of a day on the Transpiration Activity Sheet. If the leaves are green and healthy on a warm, sunny day, children should see water droplets accumulate on the interior of the plastic bag. *(Note: little or no water will collect in the bag when leaves are brown and/or absent or on needleleaf plants during cold weather.)*

4. Children may take a digital photo of the amount of water that has accumulated in the plastic bag.

5. Children may also measure the amount of water in the droplets by collecting the water in an eyedropper and measuring in a graduated cylinder with a milliliter scale marked on the side.

6. Students also may wish to crush a healthy green leaf in their hand. Many broadleaf plants will produce a moist "slime" when crushed. This moistness comes from water held within the tissues of the leaf. Water turns from this liquid form into a gas (vapor) form during the transpiration process.

7. Teachers should discuss with children the important role that plants play in the water cycle through transpiration. Plants are a vital part of all ecosystems. Without plants to recycle water back to the atmosphere, rainwater would collect in rivers, flow to the ocean, and leave behind very dry landscapes. If a landscape is dry, then there is little water to evaporate off the land or transpire through leaves to produce more clouds and, subsequently, more rain. This results in another type of cycle - a drought cycle. Many people across the globe are concerned about the role of plants in the water cycle. For example, as tropical rainforests are cut down, how will this change the water cycle in tropical areas? The plants in rainforests across the globe recycle millions of gallons of water a day. Will once-lush forests turn into deserts? Scientists all around the tropics are conducting studies to investigate this issue and many related questions. The United Nations has convened a special group of scientists to examine the possibility of increased desert formation (also known as *desertification*) around the world, and how we may take measures against desertification.

## IV. Assessment

By collecting and observing water that transpires through the leaves of plants, children will learn about the role of plants in the water cycle. Some of the questions (from the student activity sheet) that may be used to assess children's understanding of the water cycle are listed below. In addition, you may show students the Arrange the Water Cycle assessment slideshow to assess their knowledge about how plants play an integral role in water cycling. In this slide show, students should be able to identify that the water is in:

*A. Plants (water in leaves) and air (water vapor in atmosphere).*
*B. Soil and roots.*
*C. Clouds and air (water droplets in the form of rain).*
*D. Clouds.*

The photo arrangement showing the sequence of movement for the water should be in the following order:

*...A, D, C, B, A, D, C, B, A, D...*

**Questions for Class Discussion**

1. Where does the water in the plastic bags come from?

   *Water is absorbed in the roots of the plants, travels through the trunk, stems, and branches and then transpires though tiny pores in the leaves.*

2. If the bag had not been placed over the plant, where would the water that you observed have gone?

   *The water vapor would enter the atmosphere (air) and possibly form clouds high above the ground when it cools.*

3. Is there a connection between the water that transpires from plant leaves and the water that falls to Earth from clouds (rain and snow)?

   *The water transpired by plants produces more clouds, and subsequently, more rain.*

4. How do your results compare with your classmates (who may have collected water in other types of plants)? Be sure to think about the size of the leaves.

   *Results will vary, although children should find that large sunlit broad leaves will transpire more than smaller leaves, brown leaves, needle leaves, and shaded leaves.*

5. Why do you think trees are important part of keeping rainforests rainy?

*Refer to the explanation in section III.6 above.*

## Extensions for Authentic Assessment

1. How much water?

Students may be challenged to think about how much water an individual tree may have transpired throughout the course of a day. This problem holds promise for being very challenging mathematically. Students need to collect water in their bags, measure the water with an eye dropper and graduated cylinder, determine how much water is likely to be transpired from a single leaf, and then estimate the total number of leaves on the tree to calculate the total amount of water transpired. You may need to provide some scaffolding to help students complete this task. As they work on this task, students should be reminded that this kind of estimation is exactly what scientists do on a larger and slightly more technical scale.

2. Vocabulary Story

Have students write a story about the water cycle as if they were a small molecule, or fundamental particle, of water. In writing the story, have students study and use the words provided in the vocabulary list above.

**Unit**
Earth History

**Title**
1. Crayon Rock Cycle

**Summary**
What's the big deal about rocks? They don't move, aren't flashy, and seem pretty useless to the untrained eye. However, geologists are rock detectives, discovering clues to the ancient past. If you know how to read them, rocks can tell an observant scientist about what a place looked like millions and even billions of years ago. This activity introduces the 3 main types of rocks and the processes that form them. Wax crayons are eroded into sediment, compacted into sedimentary rock, partially melted and pressed into metamorphic rock, and finally melted and cooled into igneous rock. This understanding is the basis of the rock cycle. In the Going Further section, there is a recipe for making your own sandstone, siltstone and conglomerate using sediments and a sodium silicate solution.

**Objectives**
Can describe the 3 major types of rock (sedimentary, metamorphic, and igneous) and discuss the relationships between them
Can diagram the rock cycle
Given one of the three major types of rock, can describe the geologic processes that formed it

**Vocabulary**
Sedimentary rock
Erosion
Sediment
Cement
Lithifaction
Metamorphic rock
Igneous rock
Magma
Rock cycle

**Time**
45-50 minutes

**Grouping**
individual

**Materials**
Each student needs:

- Copy of the Rock Cycle Template
- 1 wax crayon (Crayola brand crayons works well)
- 1 plastic knife
- 6 inch square of aluminum foil
- Styrofoam or other cup to hold hot water
- Source of hot water (I use a hot pot style electric water heater)

For the whole class:
- Samples of sedimentary, metamorphic, and igneous rock, sorted into boxes of the same rock type
- 3-6 large containers or water pitchers for water that has cooled down in the students' cups

**Setting**
classroom

**Teacher Background**
The rock cycle is perhaps the most basic, fundamental principle of geology. All rocks are related to each other and may be transformed from one kind to another. In its simplest form, the rock cycle describes the relationships between the 3 major types of rock:
1. Igneous Rocks - Formed from the cooling of molten rock (magma).
2. Sedimentary Rocks - Formed from layers of sediment as the pressure of overlying layers compacts the sediment into rock. Sometimes, a cementing agent, dissolved minerals such as silica or carbonates, helps bind the sediment particles together.
3. Metamorphic Rocks - Formed from other rocks that are exposed to intense heat and pressure and thus change their physical and/or chemical form.

Molten rock or magma solidifies either rapidly at the Earth's surface or slowly under the Earth's surface into igneous rock (this is the whole crayon we start with). As these rocks are exposed to erosion and weathering, they are broken down into sediment (a pile of crayon shavings). The grains of sediment may be transported long distances by water, wind or gravity, and eventually deposited in layers. As more and more sediment layers build up on top of each other, the sediments are compacted and sometimes cemented together into sedimentary rock (squishing the crayon shavings together) in a process called lithifaction. With heat and pressure (partial melting in hot water), the rock will undergo a physical and/or chemical change into metamorphic rock. If the rock is melted completely and cooled, you once again have igneous rock.

The rock cycle is attributed to James Hutton (1726-1797), the "father of geology" who meticulously explored and documented the landscape of the British Isles. Hutton proposed the principle of uniformitarianism, the idea that the processes that shape the world today also operated in the past. His idea brought about the revolutionary notion that given how long it takes for geologic processes to occur today, the Earth must be very very old for all the existing landforms to have been created, not merely the 6000 years allowed by tracing Biblical genealogy. One of his most famous quotes states that with respect to the Earth there is "no vestige of a beginning, and no prospect of an end."

With greater scientific sophistication and the plate tectonics revolution, many geologists now believe that the basic rock cycle described in this lesson is too simple. The basic rock cycle is cyclical, with no apparent direction or trend. Instead, if plate tectonics is taken into account, there may indeed be a trend towards greater and greater diversity of rock types over time. For more information, see the Tectonic Rock Cycle at http://csmres.jmu.edu/geollab/fichter/Wilson/PTRC.html

**Student Prerequisites**

It helps the discussion of sedimentary rocks if students are familiar with soil separation and identifying different sediments (gravel, sand, silt, clay) by size. See Soil Analysis Lesson and/or the Sediment Study Project.

**Getting Ready**

1. Rip sheets of aluminum foil into 6 inch squares
2. Set out remaining materials – crayons, knives, cups, and hot water source
3. Copy Rock Cycle Template handout
4. Sort the rock samples into the 3 main categories of rocks if they aren't already sorted

**Lesson Plan**

1. Pass around samples of sedimentary rock. Ask students to observe the rocks and describe some of the similarities between them. As students offer their ideas, write them on the board in one column. You should end up with a list like: First rock type: can see grains, grains can be of different sizes, has layers or streaks, grains come off if you rub it.
2. Collect the sedimentary rocks then pass around samples of metamorphic rocks. Ask students to observe the rocks and describe how these rocks are different from the sedimentary rocks. Again, write their ideas in a column on the board. You should end up with a list like: Second rock type: no grains, has crystals, many colors, very hard, swirly patterns.
3. Collect the metamorphic rocks then pass around samples of igneous rocks. Ask students to observe the rocks and describe how these rocks are different than the other two types of rocks. Again, write their ideas in a column on the board. You should end up with a list like: Third rock type: no grains, some have crystals, some have lots of holes, uniform texture and pattern throughout the rock, no layers or swirls.
4. Tell the students that they have been observing and categorizing the 3 major types of rocks: sedimentary, metamorphic, and igneous rocks. Explain that

today, they will be using crayons to model the processes that create each of these 3 types of rock.

5. Pass out the handout, crayons, foil, and knife.
6. Tell students that they have been given a sample of a crayon rock. Looking at the 3 descriptions on the board, which one is this sample most similar to. It doesn't have grains, layers or streaks. Thus it is an igneous crayon rock! On their handout, in the box at the top of the circle, have students write "igneous rock".
7. The first step is to create sediment. Have students unwrap their crayons then create a pile of crayon shavings on their piece of aluminum foil by scraping it with the knife. They may trade crayons among themselves to acquire a mixture of colors. Give them around 5 minutes to build up a decent sized pile.
8. On the diagram, the arrow from "igneous rock" can be labeled "erosion". The next box can be labeled "sediment".
9. Now fold over the foil to wrap up the sediment pile. Press down on the pile as hard as you can. Gently unwrap it. The sedimentary crayon rock will be fragile but should hold together in a packed layer.
10. Discuss the similarities between the sedimentary crayon rock and the real sedimentary rocks the students observed earlier.
11. On the diagram, the arrow from "sediment" can be labeled "lithifaction – compacting and cementing sediments together". The next box can be labeled "sedimentary rock". Discuss this process as it occurs in the real world with layers being squeezed under other layers.
12. Now get a helper to pass out the cups and go around yourself to fill each cup with hot water. Have another helper place containers for cooled water near each table or cluster of desks.
13. Each student should create a little boat for their sedimentary crayon rock and float his or her boat on the hot water. Watch as the heat from the water melts the crayon. Remove the foil when the wax is soft to the touch and the colors have swirled together but not so much that the colors are indistinguishable. Let the metamorphic crayon rock cool.
14. Discuss the similarities between the metamorphic crayon rock and the real metamorphic rocks the students observed earlier.
15. On the diagram, the arrow from "sedimentary rock" can be labeled "metamorphism – heat and pressure transforms the rock". The next box can be labeled "metamorphic rock". Discuss this process as it occurs in the real world with rocks being subjected to intense heat and pressure beneath the surface of the Earth.
16. At this point, the temperature of the water the cups may have cooled. Ask students to dump their water into the containers. Go around and refill each cup with hot water.
17. Each student should put their metamorphic crayon rock back in the foil boat and float it on the hot water. This time, allow the wax to melt until a smooth pool of liquid wax forms and the colors blend together uniformly. Carefully remove the foil and let the igneous crayon rock cool.

18. Discuss the similarities between the igneous crayon rock and the real igneous rocks the students observed earlier.
19. On the diagram, the final arrow from "metamorphic rock" can be labeled "melting into magma then cooling". Discuss this process as it occurs in the real world with rocks being melted deep within the Earth then extruded again as volcanoes or bubbles of magma that do not reach the surface.
20. Ask the students if they think this igneous rock could be turned into sedimentary rock? How? Could it be turned directly into metamorphic rock? How? Could a metamorphic rock be turned directly into sedimentary rock? How?
21. Add additional arrows across the middle of the rock cycle to illustrate that any type of rock can turn into any other type of rock. For example, metamorphic rock can be eroded into sediment then compacted and cemented into sedimentary rock.
22. If there is time, students can experiment with turning their igneous crayon rock into a new sedimentary, metamorphic, or igneous crayon rock.
23. Clean up! Students can keep their crayon rocks.

## Assessment

1. 9th grade teacher Marcie Krech, has a list of great extension activities related to the rock cycle (http://mjksciteachingideas.com/)
   They include a vocabulary cut & paste, a lab, a whole class puzzle, a game and a comic strip activity. In fact, Marcie has put her whole Earth Science curriculum online for others to learn from. Thank you!
2. Give students rocks to classify as sedimentary, igneous, or metamorphic.

## Going Further

1. Make sedimentary rocks! Any sediment (powdered clay, silt, playground sand, or a sand and gravel mixture) can be turned into a sedimentary rock with the addition of a dilute sodium silicate solution. See the Sources section for where to purchase sodium silicate. The recipe:
   - 15 ml dilute sodium silicate, dilute full strength sodium silicate with water in a 1 to 1 ratio (a 20 ml syringe is a great measuring tool and dispenser for this viscous solution)
   - 6 tablespoons of sediment (playground sand works great although kids like to mix and match sediments for their own special rock type)

   Mix the sediment and sodium silicate in a clear plastic 9 oz cup with a disposable stirrer like a popsicle stick. Be careful not to get sodium silicate on your hands or in your eyes. Smooth out the surface of the mixture with the stirrer. Set aside for 2 days. Once the mixture is completely dry, it can be popped out of the cup and examined up close. If you plan on doing the Layers Upon Layers lesson, consider adding layers of a different sedimentary rock on top of the first before removing the rock from the cups. You are, in effect, creating a permanent version of the depositional cups formed in the Layers Upon Layers lesson.

2. Try the History of Rock lesson where students research a rock and discover the story of its formation.
3. The National Parks Service has a great collection of teacher lesson plans related to rocks and the rock cycle called Geodetectives (http://www.nps.gov/brca/forteachers/randmmain.htm) There are individual activities for each of the 3 main rock types, a candy rock cycle activity, and a brilliant idea for comparing rocks to identify which rocks are best used for what purposes – building a house, tools, jewelry, etc.

## Sources

The best write up for the crayon rock cycle activity is available from Eric Muller of the Exploratorium's Teacher Institute. Go to The Crayon Rock Cycle at http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf
Eric has developed many other fantastic activities, particularly for Earth Science.

For additional information about the rock cycle, go to:

- Rocksandminerals.com (http://www.rocksandminerals.com/rockcycle.htm)
- The Department of Geology at James Madison University (http://csmres.jmu.edu/geollab/fichter/Wilson/PTRC.html)
- Wikipedia (http://en.wikipedia.org/wiki/Rock_cycle)

Sodium silicate solution (also called water glass) can be purchased from most science supply companies such as Flinn Scientific (http://www.flinnsci.com) and Science Kit & Boreal Labs (http://sciencekit.com/). 500 ml costs $5-6. Sometimes it can be found at marine supply stores in quart-sized containers for sealing the outside of boats.

## Standards

Grade 6

Plate Tectonics and Earth's Structure

Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:

a *Students know* evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and midocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.

Shaping Earth's Surface

Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:

a *Students know* water running downhill is the dominant process in shaping the landscape, including California's landscape.

b *Students know* rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.

# Rock Cycle