Weather R.A.T.S.

WE LIVE IN AIR:
THE WATER CYCLE

Grade Level: 4	**Lesson # 8 in unit**
Time Required for Lesson: 4 1-hour lessons	**Time Required for Unit: 15 wks.**

Unit Summary: This unit examines weather patterns in four different parts of the Weather RATS network: Puerto Rico, Oklahoma, Arizona, and Massachusetts. Students will learn how to measure and track daily weather readings and discover the global connections between weather events in the four places. They will investigate global weather connections via the Jet Stream and other factors. As part of this unit, students will also study global contrasts in the water cycle, as it exists in each area. They will uncover the issues and social problems surrounding severe weather events in each area. Students will investigate how weather impacts people living in these areas by communicating with peers via the discussion forum. They will notice that even though people's daily lives are impacted in different ways by local weather, there are fundamental connections between weather events in different geographic locations: that we all "live in air," and are joined together by the atmosphere that sustains us all.

Lesson Summary: This lesson teaches the basics of the water cycle. The lesson uses online resources from www.teachersdomain.org to show video clips, see how water changes phase and location, and investigate different manifestations of the water cycle within the Weather RATS network.

Lesson Standards:

MA Science/Technology/Engineering:

E10 Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.

E11 Give examples of how the cycling of water, both in and out of the atmosphere, has an effect on climate.

MA Math:

4.D.1. Collect and organize data using observations, measurements, surveys, or experiments, and identify appropriate ways to display the data. (See also 3.D.1 for same standard)

4.D.2. Match representations of a data set such as lists, tables, or graphs (including circle graphs) with the actual set of data. (See also 3.D.2 for similar standard)

4.D.3. Construct, draw conclusions, and make predictions from various representations of data sets, including tables, bar graphs, pictographs, line graphs, line plots, and tallies. (See also 3.D.3. for similar standard)

MA Instructional Technology:

Standard 1. Demonstrate proficiency in the use of computers and applications as well as an understanding of concepts underlying hardware, software, and connectivity.

PreK-4 Exploratory Concepts and Skills

1.1 Develop basic skills for using hardware and applications (e.g., open/close a file, navigate using scroll bars, arrow keys, special keys, and mouse.

1.2 Use correct terminology for basic components of a computer system (e.g., monitor, keyboard, disk, printer, mouse), and develop understanding of their basic functions.

1.6 Explore and understand the basic function and purpose of a spreadsheet.

1.7 Collaborate with classmates to use teacher-selected web sites.

1.8 Collaborate with classmates and teacher to send a class e-mail message (online discussion forum hosted by UMass will meet this standard).

Standard 3. Demonstrate ability to use technology for research, problem solving, and communication. Students locate, evaluate, collect, and process information from a variety of electronic sources. Students use telecommunications and other media to interact or collaborate with peers, experts, and other audiences.

PreK-4 Exploratory Concepts and Skills

3.2 Explore the use of application programs (e.g., word processing, database, spreadsheet) for organizing information into charts, tables, and diagrams.

3.3 Explore the use of content-specific tools to enhance understanding of curriculum content (e.g., environmental probes, sensors, robotics, simulation software, and measuring devices).

3.5 Collaborate with classmates and teacher to exchange e-mail with another ` classroom (online discussion forum hosted by UMass will meet this standard).

Lesson Learning Objectives:

K-12 General:

• Develop an appreciation for the global nature of the atmosphere.

Level-specific:

• Impact of weather on ecosystems: the water cycle. Where does the water go? Compare water cycle in Arizona vs. Puerto Rico (drought vs. flooding).

CASA Connection:

How water cycles through the ground and atmosphere, and how it behaves while doing so, are at the core of CASA's research. CASA is developing the DCAS radar system in order to better observe and predict the behavior of water, as it is moved by global and local winds. Flash floods and hurricanes are two examples of the water cycle behaving badly. Flash floods in Texas, particularly in the Texas Medical Center (floods have a history of submerging corridors in the largest medical center in the world), are a hazard to life and property. Flash floods are also a problem in Puerto Rico, where the one NEXRAD radar unit on the island is located high in the central mountains. Because of its elevation, the beam cannot see the low-lying coastal areas where flooding occurs. Therefore, when the water cycle behaves badly in Puerto Rico, we have minimal ability to predict it. CASA wants to develop an improved radar system so that the storm clouds carrying all this water (back to the water cycle) can be better understood and more accurately predicted. The water cycle has the potential to be highly destructive and dangerous. Improved radar detection of the movement and behavior of water is a high scientific and engineering priority.

Lesson Background and Concept for Teachers:

The water cycle is a fundamentally important concept for understanding weather and climate. It is also widely misunderstood. The typical scenario which we see in textbooks, and which we teach students, is highly idealized and inaccurate for most places on the planet. We see lovely diagrams of the ocean next to a tall, snow-capped mountain. For example, look at these pictures, all of which depict the "ideal" view: http://www.srh.weather.gov/srh/jetstream/atmos/hydro.htm (double-click on the picture to see it enlarged); http://www.windows.ucar.edu/tour/link=/earth/images/watercycle_image.html&edu=high, or this one: http://earthobservatory.nasa.gov/Library/Water/water_2.html . These are all nice diagrams, but they do not look like most places on earth. In fact, a meteorologist from the University of Washington developed this scenario that we see in science textbooks of tall, snow-capped mountains directly adjacent to an ocean in the 1930's. The version of the water cycle that applies only to the Pacific Northwest coast has come to represent the way the water cycle operates everywhere. What does this imply for the rest of the country? What about Arizona, which is a flat desert? Or Oklahoma? There are no snow-capped mountains next to oceans in these locations. It is important to view the water cycle in its broader context, and consider the many ways that water moves in and out of the ground, plants, and atmosphere. It does NOT always follow the circular path shown in these "ideal" diagrams. Students should not be led to believe it does.

The reason it is important to tie studies of the water cycle to investigations of weather in the RATS schools is for exactly this reason: to ensure that students realize that the water cycle functions everywhere, but that its elements can differ in different geographic locations. How the water cycle impacts local climate and human society is not always the same, yet it is always profound.

The core of this lesson is from www.teachersdomain.com, the educational web site hosted by WGBH, Boston. This web site is a rich source of lesson plans and multimedia resources not only on science topics, but on other topics, as well. It is free, but teachers must register to use it. Teachers can create personal folders where video clips and lesson plans are stored for easy access. This lesson uses the Teachersdomain lesson plan called "Cycling Water Through the Environment" in its entirety. The lesson uses 7 multimedia resources, for which computers must have Flash and QuickTime. *It is not possible to conduct the lesson without these plugins.* The multimedia resources can be stored in the teacher's personal folder on the web site, thus streamlining access during class time. The teacher shows the multimedia resources at specified points during the lesson. Having the teacher's computer hooked up to a TV or displayed on a screen with an Infocus projector is essential. The teacher should also print the lesson plan from the web site prior to use.

The lesson plan for "Cycling Water Through the Environment" will be followed in its entirety and will not be repeated here.

Key Vocabulary/Definitions:

- *Water cycle:* the continuous circulation of water in the Earth-atmosphere system.
- *Evaporation:* the change of state in a substance from a liquid to a gas. In meteorology, the substance we are concerned about the most is water. For evaporation to take place, energy is required. The energy can come from any source: the sun, the atmosphere, the earth, or objects on the earth such as humans.
- *Condensation:* the process whereby water vapor in the atmosphere is returned to its original liquid state. In the atmosphere, condensation may appear as clouds, fog, mist, dew or frost, depending upon the physical conditions of the atmosphere. Condensation is not a matter of one particular temperature but of a difference between two temperatures: the air temperature and the dew point temperature.
- *Surface runoff:* Runoff occurs when there is excessive precipitation and the ground is saturated (cannot absorb anymore water). This runoff flows into streams and rivers, and then eventually back into the sea. Evaporation of this runoff into the atmosphere begins the hydrologic cycle over again. Some of the water percolates into the soil and into the ground water only to be drawn into plants again for transpiration to take place.
- *Snowmelt runoff:* Melting water from snow pack on mountains or in upland areas that finds its way to streams and rivers, then back into the sea.
- *Transpiration:* the evaporation of water from plants through stomata. Stomata are small openings found on the underside of leaves that are connected to vascular plant tissues. In most plants, transpiration is a passive process largely controlled

by the humidity of the atmosphere and the moisture content of the soil. *Of the transpired water passing through a plant only 1% is used in the growth process of the plant. The remaining 99% is passed into the atmosphere.*

- *Precipitation:* the result when the tiny condensation particles grow too large, through collision and coalesce, for the rising air to support, and thus fall to the earth. The water that falls to earth can be solid (snow, sleet, hail) or liquid (rain).
- *Groundwater:* Water flowing underground in bedrock and soils. Water flowing in rock formations follows aquifers, or underground rivers. Lakes and ponds form at places where the ground level dips below the groundwater level.
- *Infiltration:* A portion of the precipitation that reaches the earth's surface seeps into the ground. The amount of water that seeps through, or infiltrates, the soil varies with the degree of slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated with water. Water that doesn't infiltrate the soil flows away as surface runoff.

Materials Needed:

- Internet access coupled with display (TV, Smart Board, etc.)
- Computer(s) *must* have Flash and Quick Time installed.
- Regular access to computers in classrooms and in computer lab.
- Student journals, with or without writing prompts
- Wet Jeans pretest
- Bowls of water and ice
- Pebbles
- Potting soil
- Bottom half of 2 liter soda bottles (smaller water bottles also work)
- Gallon-sized re-sealable plastic bags
- Seeds (grass, beans, radishes, etc.)
- Large mixing bowl (plastic recommended)
- Coffee mug or plastic drinking glass
- Rock or other small weighted object
- Salt
- Pitcher
- Spoon or stirring utensil
- Plastic wrap, tape
- Small drinking cups
- Water cycle booklet reproduced from Teachersdomain.org
- Heat lamps, if lesson is taught during winter months

Lesson Sequence:

Introduction/Motivation:

Begin the lesson by administering the Wet Jeans pretest. This writing prompt gives students 7 choices for where water might go once it evaporates. Most students believe that the water in the jeans turns to vapor and is transmitted instantly to clouds. They don't stop to think

about the rate of speed that the water molecules would have to travel to reach a cloud in an hour! What force would blow water molecules straight up to an altitude of 4-7 miles in less than 60 minutes? They don't realize that water vapor exists at all levels of the Earth's atmosphere, including at the ground level. The rate at which water vapor migrates to higher levels in the atmosphere is quite slow. This aspect of the water cycle is completely overlooked in traditional instruction! The pretest highlights this instructional and conceptual misconception. It is advisable to collect and save the unmarked pretests until the end of the unit, when they can be returned for summary discussion.

The rest of the lesson follows the sequence outlined in the Teachers' Domain lesson plan. Part 1, Water Basics, activates background knowledge by focusing on questions: Can water come in different forms? What are some examples of each form? Where do you find solid water on earth? Liquid water? Water vapor? Flash images and interactive presentations engage students with these essential questions. Students may write their responses to the questions in a journal, or share their thinking in some other manner determined by the teacher. Journals are not essential, but are a powerful tool for students to develop critical thinking skills and deepen their knowledge of science concepts as they continue to revisit and revise their responses. They provide a clear picture of how student understanding develops over time. However, in the interests of time and efficiency, teachers may choose some other manner for sharing student thinking.

Body of Lesson:

Part 2 of the lesson, The Water Cycle, and Part 3, Making Fresh Water from Salt Water, have students conduct hands-on investigations of different representations of the water cycle. Distribute the water cycle booklets to students before doing part 2. The booklet is reproduced from the web site, but gives students a permanent copy of the Flash content used in the lesson. Part 2 also has students build a mini-biome out of the bottom half of a 2 liter soda bottle, and place it inside a closed Ziploc bag. The seeds planted in the bottle bottom generate moisture, which collects at the top of the Ziploc and precipitates. *NOTE: this activity will not work during the winter months!* The seeds require strong sunlight and warm temperatures to sprout. In December, nothing will happen. If the lesson is being taught during the winter, skip this portion and focus on the salt water still.

In part 3, students learn how to distill fresh water from salt water and connect that process to the ocean as a source of the planet's fresh water via the water cycle. This one also will not work well in winter months when the angle of the sun is low. In this case, however, using heat lamps will accelerate evaporation.

Closure:

At the end of the lesson, student understanding of the water cycle will be assessed through a large, detailed drawing. The picture will include all the stages of the water cycle seen in the Teachers' Domain slide show, the definitions of those stages, and 3 labeled examples each for the 3 phases of water. Students can use an index card, which should be given to them in advance, to organize information for the drawing.

Assessments:

Pre-lesson:

Wet Jeans pre-test.

Whole-class discussion of background questions from Part 1, Water Basics:

1. Can water come in different forms?
2. What are some examples of each form?

Students can address these questions in a Think/Pair/Share format. Students will think and record ideas individually. They will then pair up with a neighbor and discuss their individual thoughts. Student pairs will share their agreed upon responses in the whole-class format. Those shared responses can be collected on an overhead or poster.

In Process:

There are 16 questions in the lesson that follow the two introductory questions. These can either be distributed to students ahead of time or displayed as they are encountered during the course of the lesson. Student responses to these questions can be recorded in a Science Journal, either one used for other purposes or one dedicated to this lesson. Students should be responsible for their own thinking, but should be free to discuss ideas with classmates. The journals can be collected at the end of the lesson.

Summary:

Students will draw a detailed, labeled diagram of the water cycle that includes all stages of the cycle (with labels and definitions), and illustrated examples of each of water's 3 phases included in the drawing.

Lesson Extension Activities:

Students could investigate other versions of the water cycle that do not entail snow-capped mountains directly adjacent to an ocean. In other words, they should investigate how the water cycle works in the other 99% of the world. Amongst the RAT schools, how does the water cycle work in Arizona, which is a desert? How about in Oklahoma? Puerto Rico, a tropical island in the ocean? Students can diagram how the different phases of the water cycle operate in these areas, none of which fit the "classic" model of the Northwest Coast. They could develop a series of museum exhibits about the water cycle as it works in each RAT location. The separate exhibits would document and illustrate how different the water cycle can be in different parts of the world, and the many different ways it impacts life and culture in each location.

References:

Teachers' Domain: http://www.teachersdomain.org/
(Note: this is a web site maintained for educators by WGBH, Boston. Its is free, but teachers must register to use it.)

Jetstream Online Weather School. The Hydrologic Cycle:
http://www.srh.weather.gov/srh/jetstream/atmos/hydro.htm

(Double click on the picture to see an excellent color diagram of the "traditional" water cycle.)

Kevin Kloesel, personal communication.

Keeley, Page, Francis Eberle, and Lynn Farrin. *Uncovering Student Ideas in Science: 25 Formative Assessment Probes.* Arlington: NSTA Press, 2005.

Additional Resources and Information:
NASA Earth Observatory: The Water Cycle
http://earthobservatory.nasa.gov/Library/Water/water_2.html

UCAR (University Corporation for Atmospheric Research):
http://www.windows.ucar.edu/tour/link=/earth/images/watercycle_image.html&edu=high

Digital Library for Earth System Education, lists over 178 links to educational web sites relating to the water cycle and aimed at students in grades 3-5:
http://www.dlese.org:80/library/query.do?q=water+cycle&s=0&gr=04

Among those resources that are listed by DLESE, are the following, which represent a small fraction of the rich resources available in this catalog:

US Geological Survey, the Water Cycle: http://ga.water.usgs.gov/edu/watercycle.html

Columbia Education Center, Academy Curriculum Exchange. The Water Cycle. Lesson plan aimed at primary and early elementary students.
http://ofcn.org/cyber.serv/academy/ace/sci/cecsci/cecsci190.html

Missouri Botanical Garden, Water Cycle.
http://www.mbgnet.net/fresh/index.htm

Environmental Protection Agency, Thirstin's Water Cycle. Good example for younger students, with voice-over commentary. Headphones suggested.
http://www.epa.gov/safewater/kids/flash/flash_watercycle.html

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Cycling Water Through the Environment

Teacher's Domain, WGBH, Boston

http://www.teachersdomain.org/

The following questions are connected with the lesson on the water cycle that you are studying. The first two questions will be done as a Think/Pair/Share activity at the start of the lesson. You responses to the other questions will be your own. You may talk with other students about your ideas, but you are responsible for your own thinking and your own writing. You should go back to your earlier responses and add more to them if more thoughts occur to you. Be sure to include drawing and labeled diagrams as part of your answers! Good thinking is verbal *and* visual.

Think/Pair/Share Questions

1. Can water come in different forms?
2. What are some examples of each form?

Individual Response Questions

3. Did we see all the different phases of water in the slideshow?
4. Can you think of any more examples to add to our list?

5. Where do you find solid water on Earth?
6. Where do you find liquid water on Earth?
7. Where do you find water vapor on Earth?

8. Where does precipitation come from?
9. Why do you think there are different forms of precipitation?
10. What happens to rain/hail/show when it reaches Earth's surface?

11. How will the water move from the soil to the plant?
12. How will the water get into the air?
13. How will the water move from the air back to the soil?
14. How does the biome in a baggie represent Earth?

15. What has happened to the seeds?
16. Why don't you need to water the plants?

17. How does the water cycle affect your everyday life? Explain 4 ways.
18. Does water ever disappear and leave Earth and its atmosphere? Why or why not?

Cycling Water Through the Environment
Summary Assessment

Show your deep understanding of the different stages of the water cycle by drawing a detailed, labeled diagram of the water cycle on a large, blank piece of paper. You must include the following in your diagram:

1. ALL stages of the water cycle, with labels on each stage and a short definition of what that stage is about. That information is in your water cycle packet.

2. Labeled examples in the picture of ALL 3 phases of water. Give 3 labeled examples for each phase, for a total of 9 examples. That information is in your journal.

3. Directional arrows showing how water moves from one stage to another. You may use different sets of arrows. In other words, water may follow more than one path.

You will be given a large index card on which you should write important notes, definitions, sketches and ideas. You can use this index card while you are making your drawing. Go through your notes and packets to organize your information. Then put the most important information on the index card.

Your drawings will be scored using the following rubric:

Score	Description of Typical Picture
4 Advanced	Picture shows **complex, in-depth understanding** of the water cycle. **All required information** is present in the picture. Picture is **neatly** drawn and labeled in **great detail**.
3 Proficient	Picture shows **reasonable** understanding of the water cycle. **Most required information** is present in the picture. Picture is drawn and labeled in **reasonable detail**.
2 Needs Improvement	Picture shows a **basic** understanding of the water cycle. **Some of the required information** is present in the picture, but **much is missing**. Picture is **not neatly drawn or labeled**. **Details are missing**.
1 Warning	Picture shows a **minimal** understanding of the water cycle. **Very little of the required information** is present in the picture. Picture is **hard to understand**. **Most details are missing**.
0 Failing	Picture is **blank**, or contains only **irrelevant information.**

This rubric does not assess artistic talent! You need to produce a neat, carefully labeled diagram, not a work of art. You might do a practice diagram at home to prepare for the assessment.