Focused Learning Lessons
Science
Grades 9-12
ESS-H-A1

Overview:
This lesson enables learners to construct a working model that traces the flow of energy through the processes of the water cycle.

Approximate Duration: This lesson takes 40-45 minutes of class time.

Benchmark:
ESS-H-A1 investigating the methods of energy transfer and identifying the sun as the major source of energy for most of the Earth's systems
ES GLE: 2. Trace the flow of energy through the processes in the water cycle.
Benchmark:
SI-H-A2 designing and conducting scientific investigations
SI GLE: 2. Describe how investigations can be observation, description, literature survey, classification, or experimentation.

Objectives:
1. The learner will identify the method of energy (heat) transfer operating in each of the processes in the water cycle.
2. The learner will describe the role of the Sun in the processes of the water cycle.

Teacher Preparation:
This activity can be used with individual students or small groups of students. If necessary, the model can be set up at a demonstration station, and groups of learners can rotate to the station to make their observations.

All safety precautions for the use of electricity in close proximity to a container of water need to be taken and reviewed with learners before beginning the activity.

Attachment 4 contains background information on the three methods of heat transfer that affect the water cycle. The three methods of heat transfer and the water cycle make an excellent introduction to a study of meteorology. Weather on Earth would not exist in the troposphere as it does if heat were not being transported from the surface of the Earth upward into the atmosphere.

Materials/Equipment/Resources:
For each group of learners or demonstration setup prepare the following materials.
- 1 square, disposable, aluminum cake pan with clear plastic lid
- 150 ml water
- book 2 cm thick
- plastic zipper bag
- ice cubes

- clear tape
- clamp light with shade (see attachment 2 for details)
- 75 or 100 watt light bulb (check clamp light for maximum recommended bulb wattage
- stopwatch or watch with second hand

Each learner should have a copy of Student Handout 1

Lesson Procedures:

Set or Opener:
One means of engaging learners in a study of the water cycle is to take them outside to observe clouds. Pictures of clouds can be used, but, if possible, learners should have an opportunity to observe and sketch real clouds and put their sketches on the wall to share. The sketches lead quite naturally to the question of how clouds form, the part they play in the water cycle, and the source of energy needed for all of the processes in the water cycle, including cloud formation.

Once the processes of the water cycle are listed, including changes that occur in water during each process, learners are ready to construct a working model of the water cycle so that they can observe ongoing processes and phase changes.

Body of the Lesson:

1. Distribute Student Handout 1, Attachment 1, to each learner. Review safety precautions and steps in the construction of the model.
2. Divide learners into groups of three or four, depending upon class size and available materials. A suggested division of labor can be found in Attachment 3. Once job assignments are determined, the next step is to distribute materials to each group.
3. Allow time for learners to read the instructions for constructing the model.
4. Each group should follow steps one through four in the construction of its model.
5. Each group should read, discuss, and answer questions one and two on their handout (making predictions) before continuing.
6. The construction should be completed (step five), initial observations recorded, and the light turned on (step 6).
7. The learners will make observations of changes that occur in the model and record their observations every two minutes for 10 minutes.
8. The light should be turned off after 10 minutes. CAUTION should be emphasized, as the light and fixture will be very hot!
9. The learners will discuss and answer questions three through eight on their handout.
10. Each group will turn in their handouts to the instructor, step seven.

Closure:
The lesson should conclude with a brief discussion in which guiding questions are used to lead students to the understanding that all of the energy that drives the water cycle can be traced back to the Sun.

Attachments:

Attachment 1: Teacher Background
Attachment 2: Student Handout 1 (with lab report and data chart and questions)
Attachment 3: Key to Handout 1
Attachment 4: Background on Heat Transfer

Sample Assessment Items:

1. Which process in the water cycle requires the release of heat energy?
   A. precipitation
   B. condensation
   C. evaporation
   D. runoff
2. An early morning rain shower produces puddles on the sidewalk outside your school. When you come outside for lunch the puddles are almost gone.
3. Explain what natural process could have caused the puddles to disappear and what part the Sun played in the process. (2 points)

Sample Assessment Item Key:

1. *B, condensation is the correct answer because condensation in the water cycle occurs when the air is cooled and water vapor coalesces to form liquid water droplets. This process releases heat.*
2. *Rubric for Evaluation:*
   2 point: The answer should include the process of evaporation and that it is the Sun that provides the heat energy to increase movement of water molecules until they vibrate fast enough to break the bonds of the liquid water and escape as water vapor molecules into the atmosphere
   1 point: The answer should include one of the two parts required for 2 points
   0 points: The answer contains neither of the two parts listed above or no answer at all

Reference Links:

http://ga.water.usgs.gov/edu/watercyclegraphichi.html
This site contains a nice water cycle diagram suitable for secondary classroom use, good general information on the water cycle, and water in general.

http://mbgnet.mobot.org/fresh/cycle/
This site contains a good explanation of the processes in the water cycle, the scientific concepts, and cloud formation.

http://faldo.atmos.uiuc.edu/w_unit/LESSONS/water.cycle.html
This site contains a follow-up activity, plus additional information on the water cycle.

http://www.genesismission.org/educate/scimodule/heat/develop_1SA.pdf
This site contains a series of experiments related to the three methods of heat transfer.

Attachment 1: Teacher Background

Group Work and Suggested Lab Jobs

During the activity phase of this lesson it will be useful if each member of the activity group has a specified task to perform. A suggested division of labor is listed below for both three-member groups with a modification for a fourth member.

Three-member group:

Job 1-Materials Manager
This member is accountable for picking up and returning materials and supplies, and making sure that everyone has the materials they need to perform their task. This group member is also responsible for the appropriate use and handling of materials and equipment in the care of the group.*

Job 2-Principal Investigator
This member of the group has the primary duty of constructing and using the model. It is the role of the principal investigator to oversee that directions are followed and safe and correct use of the model occurs at all times.

Job 3-Recorder/Reporter
This group member will speak for the group in post activity discussions and will record and maintain the "official data" report for the group (although each member is responsible for completing an individual lab report). Having only the Recorder/Reporter ask questions for the group during the activity will also keep the activity manageable for the instructor.

*If a four-member group is desirable, the fourth person can be the "Quality Control Expert," who makes sure data is being collected accurately, time is being used wisely, and learners are consistently on task. If there is no fourth person, the activity manager and perform these tasks.

It is strongly recommended that the lab jobs be rotated on a regular basis.

Attachment 2: Student Handout 1
Tracing The Flow of Energy Through The Water Cycle

Building a water cycle model:

Materials:

1 square, disposable, aluminum cake pan with clear plastic lid
150ml room-temperature water
book 2cm thick
plastic zipper bag
ice cubes
clear tape
clamp light with shade (see attachment 2 for details)
75 or 100 watt light bulb (check clamp light for maximum recommended bulb wattage)

Instructions:

1. Measure and pour 150ml room-temperature water into a square, disposable, aluminum cake pan.

2. Place the clear plastic lid on the cake pan and snap it shut. Wipe up any water drops that have spilled before going on to the next step.

3. Lift one end of the closed cake pan and place a book 2cm thick under one end so the pan is tilted and the water collects at the lower end.

4. Set up the clamp light so that it shines down directly on the lower end of the pan. Set up the light fixture so the bulb is 10cm from the plastic lid and shining down onto the water in the aluminum pan. CAUTION: Do not allow the bulb to get closer to the plastic lid than the recommended 10cm. Make certain the work area is dry after the model is closed.

5. Place several ice cubes in the zipper bag and close the seal. Using the clear tape secure the bag of ice to the upper end of the clear plastic cake pan lid. The ice bag should be centered on the top of the cake pan lid at the higher end. Observe the model. Record your observations in the data section.

6. Turn on the light. Observe what changes occur in the model every two minutes for ten minutes. Record your observations in the data section.

7. Answer the analysis questions that follow the data section.

Student Handout 1: Data

Time in Minutes	Observations
0	
2	
4	
6	
8	
10	

Student Handout 1: Data Analysis Questions

1. What did the light source represent in the model?

2. After you turn on the light what changes do you think will occur in the following parts of the model?
    - The water inside the lower end of the model
    - The air inside the upper end of the model
    - The underside of the lid at the upper end of the model

3. As the 10 minute observation period passed, what water cycle processes did you observe, and what evidence do you have that they were taking place?

4. How was energy being transferred from the light bulb to the water inside the model?

5. What evidence was present in the model to support the idea that water travels in a complete cycle that includes the earth's surface, the atmosphere, and the ocean?

6. Use the back of this page or another sheet to make a sketch of the water cycle that you observed operating in the model you built. Label the processes in your sketch, and draw arrows to show the direction in which the water is moving.

7. What was the purpose of the ice in the zipper bag?

8. Which process in the water cycle was missing from the model? Describe a possible modification to the model that would add this process.

Attachment 3: Key

Suggested answers to data analysis questions are below.

1. *The light source represented the Sun.*

2. *Some possible answers might include:*
   - *The water temperature will increase*
   - *The water will evaporate*
   - *The ice will melt*
   - *A cloud, or fog, will form inside the model*

3. *Learners should observe condensation form on the underside of the lid at the upper end of the model, and in ten minutes drops of precipitation may fall to the aluminum surface and run back down into the water at the lower end.*

4. *The energy was being transferred by means of radiation.*

5. *The water from the "ocean" end evaporated, condensed under the ice bag, and precipitated back to the surface where it traveled back the "ocean."*

6. *The sketch the learner makes should include:*
   - *Evaporation (arrows pointing up from the ocean)*
   - *Condensation*
   - *Precipitation (rain falling from the clouds)*
   - *Run Off (arrows on the surface pointing back toward the ocean*

7. *The bag containing the ice cooled the air at the upper end of the model and enabled the water vapor to condense on the underside of the lid of the model and, over time, form drops of precipitation. (If the upper part of the Earth's troposphere were not colder than the Earth's surface, there would not be the temperature differential that is necessary for weather to occur.)*

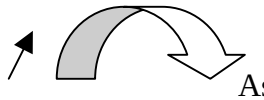
8. *Infiltration is the process that was missing. One modification would be to place a layer of sand near the top end of the model with a clearly defined space between the sand area and the water at the lower end. Then, when the precipitation fell to the sand surface and soaked in, it would travel underground back to the model sea. Learners may think of other ways to redesign the model to include infiltration.*

Attachment 4
Background on Heat Transfer

The Earth receives nearly all of its energy from the sun, and most energy transfer on or near the Earth's surface can be traced back to the sun. Energy is transferred by three methods:

1. Conduction-by direct contact between substances (like the warm soil touching the air, or a saucepan sitting on a hot stove burner).

2. Convection is the transfer of energy through rising currents of heated (usually) fluid substances.

Heated air or fluid rises.  As it cools, it sinks back down.

***Note**: The bottom of the Earth's atmosphere is heated first by direct contact with the Sun-heated Earth's surface, and then upward through rising currents of heated air. About half of the **In**coming **So**lar Radi**ation** (called "insolation") received from the Sun goes into heating the Earth's surface itself. The remaining 50% is either reflected back into space or absorbed by (mostly) the upper atmospheric layers. The presence of convection in the troposphere (rising warm air currents and sinking cooler air currents), causes the top of the troposphere to be colder than the bottom, which is the reason weather occurs near the earth's surface. Without convection, there is no mechanism to drive what we know as weather, and the troposphere is the only layer of the Earth's atmosphere with both sufficient air and the convection to drive its movement.*

3. Radiation is the flow of energy through empty space in the form of electromagnetic waves. Radiation is the only transfer method that moves energy from the Sun through the vacuum of space to the Earth. It is also the fastest method, with waves moving at the speed of light.