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Earth Space Systems Science

Unit 1: Introduction to Systems

Earth Space Systems Science
Unit I: Introduction to Systems

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Earth/Space Systems Science

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Earth Space Systems Science
Unit I: Introduction to Systems

Description

Some important themes pervade science, mathematics, and technology and appear over and over again. They are ideas that help us to develop understanding. One such important idea is that of a "system"- the ability to think about a whole in terms of its parts, and how these parts relate to each other and the whole. In science, we also need to think about inputs and outputs and the interactions among the system components.

In this unit, students will have opportunities to begin to apply systems thinking to some simple earth systems. Students will discuss what properties of a system are the same as the properties of its parts, and what properties arise from the interactions of its parts. Students will begin to develop an understanding of feedback as it applies to an earth system and how to represent some simple components of a system graphically.

A key question for this unit is:

1. What is meant by a systems approach to Earth/Space science?

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Key Concepts

- A system has some properties that are different from those of its parts, but appear because of the interaction of those parts.

- In defining a system it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its input and output are expected to be.

- The feedback from one part of a system to another part of a system can be used to understand a system.

- Even in simple systems, it may not always be possible to accurately predict the result of changing some part of a system. (AAAS, p.266)

- Weather and climate involve the transfer of energy in and out of the atmosphere. Solar radiation heats the landmasses, oceans, and air. (AAAS, p. 70)

- Transformation of energy usually produces some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with. (AAAS, p. 86)

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Earth/Space Systems
Science Instruction

1. **What do students need to know or be able to do to understand events across spheres (subsystems of the Earth-space systems)?**

5. Student Project for each sphere: analyze another event following modeling by the teacher of the exemplar event

Energy Balance/Conservation of Energy

Mass Balance/Conservation of Mass

Events

- What are some "events" that occur?
- events drive the system
- events happen when the system gets out of balance
- events help the system get back into balance

How do the systems and subsystems of each sphere behave and interact?

- atmosphere
- biosphere
- hydrosphere/cryosphere
- geosphere
- space sphere

What do we need to know to understand
stems?

parts/components (i.e. reservoir of matter or energy)

state of the system or set of attributes that characterize a system (i.e. sea surface temperature)

links between/among components (reflectivity of a surface [albedo] and surface temperature)

feedback loops

system in equilibrium (and stable and unstable conditions)

how a system responds to disturbances (i.e. effects of volcanic eruption on climate)

3. What are the tools that help us understand the spheres?

- remote sensing
- modeling
- observational networks
- system diagram or flow chart or concept map
- graphs and graph-making
- computer as an analysis tool

4. Track an event throughout the course to model interactions for students.
How does the event impact each sphere?
How do each of the other spheres impact the event?

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CONTENT OUTLINE

Introduction to Earth/Space Systems Science

I. Introduction to Systems

II. Introduction to Earth as a System

III. The Mini Water Cycle

IV. Equilibrium and Conservation of Mass in the Global Water Cycle

V. Equilibrium and Conservation of Energy in the Global Water Cycle

HSA Rubric for Brief Constructed Response Items
Science Rubric, August 2000

	Level of Understanding	Synthesis of Information	Use of Supporting Details	Use of Accurate, Scientific Terminology	Application of Information
4	The student has a **FULL and COMPLETE UNDERSTANDING** of the question or problem.	The response reflects a complete synthesis of information.	Pertinent and complete supporting details demonstrate an integration of ideas.	The response is enhanced through the use of accurate terminology to explain scientific principles.	An effective application of the concept to a practical problem or real-world situation reveals an insight into scientific principles.
3	The student has a **GOOD UNDERSTANDING** of the question or problem.	The response reflects some synthesis of information.	The supporting details are generally complete.	Mostly accurate terminology is used to explain scientific principles.	The concept has been applied to a practical problem or real-world situation.
2	The student has a **BASIC UNDERSTANDING** of the question or problem.	The response provides little or no synthesis of information.	The supporting details may be incomplete or have minor errors.	Limited accurate terminology is used to explain scientific principles.	The application of the concept to a practical problem or real-world situation is inadequate.
1	The student has **SOME UNDERSTANDING** of the question or problem.	The response addresses the question.	The supporting details are only minimally effective.	Little or no accurate terminology is used to explain scientific principles.	The application, if attempted, is irrelevant.
0	The student has **NO UNDERSTANDING** of the question of problem. The response is completely incorrect or irrelevant.				
	On the High School Assessment, the bullet that defines application criteria will only be used when application is requested in the item show.				

HSA Rubric for Brief Constructed Response Items
Science Rubric, August 2000

LEVEL 4

There is evidence in this response that the student, using analysis, has a full and complete understanding of the question or problem.

- The student has synthesized information to provide a correct answer.
- The supporting evidence consists of an integration of ideas.
- The student has effectively applied the information to a practical problem in a related area of science, mathematics, or technology.
- The response is enhanced through the use of accurate terminology to explain scientific principles.

LEVEL 3

There is evidence in this response that the student, using analysis, has a good understanding of the question or problem.

- The student has synthesized information to provide a correct answer.
- The supporting evidence is complete.
- The student has applied the information to a practical problem within the particular concept area of science.
- The response uses mostly accurate terminology to explain scientific principles.

LEVEL 2

There is evidence in this response that the student has a basic understanding of the question or problem.

- The student provides a correct answer.
- The supporting evidence is only moderately effective.
- The student has applied the information to a practical problem within the scope of the question.
- The response uses limited accurate terminology to explain scientific principles.

LEVEL 1

There is evidence in this response that the student has some understanding of the question or problem.

- The student provides a partially correct answer.
- The supporting evidence is only minimally effective.
- The student has attempted to apply the information.
- The response makes little or no use of accurate terminology to explain scientific principles.

LEVEL 0

There is evidence that the student has no understanding of the question or problem.

- The response is completely incorrect or irrelevant, or there is no response

Scoring Criteria for Graphs

The student will organize data appropriately using a graph.

Level 4
Data are accurately plotted (90-100%) and the graph includes nine of the ten elements.

Level 3
Data are accurately plotted and the graph includes seven of the ten elements,
OR
data are mostly accurate (80-89%) and the graph includes nine of the ten elements.

Level 2
Data are accurately plotted and the graph includes five of the ten elements,
OR
data are generally accurate (70-79%) and the graph includes seven of the ten elements.

Level 1
Data are accurately plotted and the graph includes three of the ten elements
OR
Data are somewhat accurate (60-69%) and the graph includes five of the ten elements.

Level 0
Data are inaccurately plotted (<60%) or the graph includes fewer than five elements.

ELEMENTS OF THE GRAPH

- Appropriate title
- X-axis labeled correctly with appropriate quantities/variables
- X-axis labeled correctly with appropriate units
- Appropriate intervals indicated on the X-axis
- Given the length of axes on the grid, the scale is appropriate for the range of data
- Y-axis labeled correctly with appropriate quantities/variables
- Y-axis labeled correctly with appropriate units
- Appropriate intervals indicated on the Y-axis
- Given the length of axes on the grid, the scale is appropriate for the range of data
- Origin correctly identified

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Lesson Planning Organizer

LESSON	TITLE	STUDENT OUTCOME	TIME fifty-Minute Blocks
1	Introduction to Systems	The student will be able to represent a simple system by using standard flow chart symbols.	3
2	Introduction to Earth as a System	The student will be able to model a familiar earth system by using standard system symbols.	2-3
3	The Mini Water Cycle	The student will be able to evaluate the global water cycle by comparing it to a working model.	1
4	Equilibrium and Conservation of Mass in the Global Water Cycle	The student will be able to explain "equilibrium of a system" and "conservation of mass" by analyzing the results of a laboratory demonstration.	1
5	Earth Energy Balance--Equilibrium and Conservation of Energy	The students will be able to construct and interpret a thermal system by analyzing experimental data.	2-3
6	Introduction to Spheres	The student will be able to determine the interrelationships among Earth's spheres by investigating the tools of Earth Science.	1
Approximate Number of Time Blocks			11

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Lesson 1: INTRODUCTION TO SYSTEMS

Estimated Time: Three fifty-minute blocks

Indicators(s): Core Learning Goal 1

1.2.1 The student will identify meaningful answerable scientific questions.

1.2.3 The student will formulate a working hypothesis

1.5.2 The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

Indicators(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits (at least) – Ocean-atmosphere-land interactions (current changes, continental movement, El Niño, La Niña)

Student Outcome(s):

The student will be able to represent a simple system by using standard flow chart symbols.

Brief Description:

In this introductory lesson, the teacher will begin to guide student thinking about systems and introduce standard symbols used to make a system flow chart. The teacher begins by using a familiar object or concept to the student and helping the student to analyze this familiar object or concept. An example using a bicycle is listed below.

Background knowledge / teacher notes:

Teacher note: NASA Ambassador Joyce Tugel (jtugel@mhs.sad35.k12.me.us) designed a WebQuest Activity that introduces the concept of Earth as a system. Her introductory activity, IS A BIKE A SYSTEM? Available:
http://education.gsfc.nasa.gov/ESSSProject/NewLessons/systems/Tugel/systemsexplore1.htm

for an exploratory lesson on the bicycle as a system. Ms. Tugel gives this example for exploration using a bicycle:

Begin the lesson by bringing a bicycle in to class; if you're feeling particularly brave, ride it in at the beginning of the period! This concrete example is familiar to all students, and allows them to explore and extend their ideas about systems. Have students share their answers and reasoning with their group. Then share the reasoning of the team with the entire class. See if the class can decide whether their working definition of systems needs modification. Use their written responses and oral discussion as a means of formative assessment.

QUESTIONS TO ASK ABOUT SYSTEMS: Bring in a variety of objects (examples: musical instruments, toys, electronic devices such as a boom box or camera, sports equipment, representations of cars, trains). Distribute a different object to each group, and ask them to answer the same set of questions about the objects. Ask each team to share their objects with the class and explain why they believe this does or does not represent a system. Use their written responses and oral discussion as a means of formative assessment. Again, check to see if the class working definition of systems needs modification, clarification, or refinement.

This lesson was based on "Seeing the Cell as a System" from Project 2061. AAAS. 1997. Resources for Science Literacy: Professional Development. New York. Oxford University Press. Internet address: http://project2061.aaas.org/tools/rsl/index.html

Credit: NASA Ambassador Joyce Tugel (jtugel@mhs.sad35.k12.me.us

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Lesson Description:

ENGAGE	Present students with a piece of equipment that is part of a system they might be familiar with (such as a computer mouse). As a class, brainstorm a list of systems. *Some responses might be stereo system, solar system, computer system, ecosystem, and circulatory system*. Give each group a different object such as musical instruments, toy cars or trains, electronic devices such as a boom box or camera, sports equipment, Each group will answer the same set of questions about the objects. Ask each team to share their objects with the class and explain why they believe this does or does not represent a system Questions About Systems Directions: Working in cooperative groups, discuss the following questions about your object. Remember that there is no single correct response. Make sure you will be able to explain your reasoning when you share your thoughts with the class! 1. When this system is working, what does it do? 2. For this system to work, must it receive any input? 3. What, if any, output does this system produce? 4. Identify at least four parts of this system. Describe what each part does, and tell how each part contributes to the system as a whole. 5. Can any one part of the system do what the whole system does? Explain your answer. 6. Identify two parts of this system that must interact if the system is to work. Describe how these parts interact. 7. What is the boundary of this system? Where does it begin and end? 8. Are there any subsystems within the whole system? If so, describe one subsystem.

	9. Describe how this system would change if one of the parts wears out. 10. Does your object fit our working definition of a system? Do we need to modify our working definition to make a bicycle fit our definition? If so, how? Each group shares its answers with the class.
EXPLORE	Students choose one of the systems and list the parts of the system. As a group, create a draw a graphic representation or diagram of your system on newsprint. On your diagram be sure to describe the following: · The "name" for the system · A list of the parts of the system · Draw arrows between parts of the system affect each other. <u>Adaptive Strategy:</u> Before asking the students to draw a graphic representation of their system, develop a sample with the class to provide a model for their work
EXPLAIN	Ask students to write one or two sentences explaining the reasons for the arrows they have drawn. Each group shares the diagram and the explanation with the class. Encourage students to add to the interactions of each groups' presentations.
EXTEND	Working in your lab groups, set up a system to demonstrate flow of heat. Materials: heat lamp, containers, soil, water, thermometers or CBLs with temperature probe Give students the Standards for System Diagrams worksheet. Using the symbols model how to develop a systems diagram. Have each group identify the components of their system, make a simple diagram of the system and explain how the parts affect each other. <u>Adaptive Strategy:</u> Provide a frame for the system and provide students a list

	of terms to be placed in the system diagram. As students are designing their system, use the following questions to guide their work. · How does your system demonstrate flow of heat? · How can you measure the change in heat energy that occurs in your system? · Describe conditions that will affect the change in heat that is absorbed by the soil.
EVALUATE	***Journal Write:*** Using your systems diagram, explain how components of the system affect each other. Adaptive Strategy: Provide a frame paragraph and word list for students to complete instead of independently writing an explanation. Give students a sentence starter or topic sentence for their journal writing. Have each student group pair with another group and evaluate each other's journal entries.

Materials:

- Musical instruments
- Toy cars or trains
- Electronic devices such as a boom box or camera
- Sports equipment
- Heat lamp
- Containers
- Soil
- Water
- Thermometers
- CBLs with temperature probe
- Questions About Systems

- Standards for System Diagrams

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QUESTIONS ABOUT SYSTEMS

Directions: Working in groups, discuss the following questions about your object. Remember that there is no single correct response. Make sure you will be able to explain your reasoning when you share your thoughts with the class!

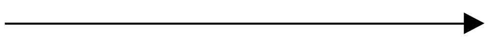
1. When this system is working, what does it do?
2. For this system to work, must it receive any input?
3. What, if any, output does this system produce?
4. Identify at least four parts of this system. Describe what each part does, and tell how each part contributes to the system as a whole.
5. Can any one part of the system do what the whole system does? Explain your answer.
6. Identify two parts of this system that must interact if the system is to work. Describe how these parts interact.
7. What is the boundary of this system? Where does it begin and end?
8. Are there any subsystems within the whole system? If so, describe one subsystem.
9. Describe how this system would change if one of the parts wears out.
10. Does your object fit our working definition of a system? Do we need to modify our working definition to make a bicycle fit our definition? If so, how?

Standards for System Diagrams

Directions: Use these symbols to represent the components of a flowchart or system diagram.

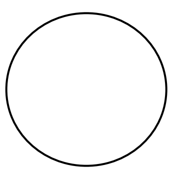
1. A box to symbolize a source of a matter or energy or a sink into which matter or energy flows.

2. An arrow to symbolize the connection and direction between a source and a sink.



This is called a "flow".

3. A circle symbolizes a condition or factor that will affect the system.



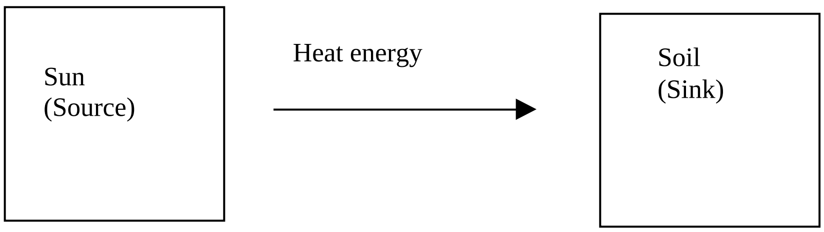
4. To represent soil being warmed by the Sun, combine symbols.

5. What factors might affect how much heat energy is absorbed by the soil?

ANSWER KEY

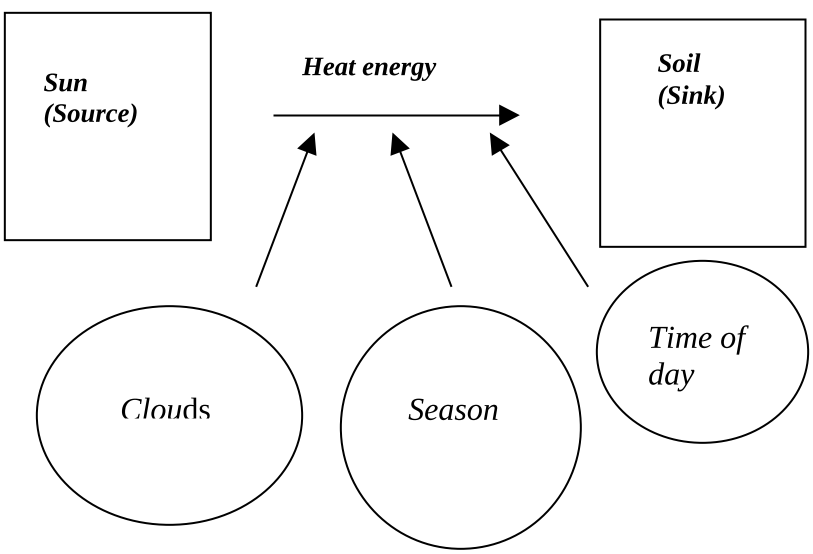
4. To represent soil being warmed by the Sun, combine symbols.

Possible solution:



5. What factors might affect how much heat energy is absorbed by the soil?

Possible Solution:



Resources:

Questions to Ask about Systems.

Available:

http://education.gsfc.nasa.gov/ESSSProject/NewLessons/systems/Tugel/systemsexplore2.htm

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Lesson 2: INTRODUCTION TO THE EARTH SYSTEM

Estimated Time: Two to three fifty minute blocks

Indicators(s): Core Learning Goal 1

1.2.1 The student will identify meaningful answerable scientific questions.

1.2.3 The student will formulate a working hypothesis

1.5.2 The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

1.5.6 The student will read a technical selection and interpret it appropriately.

Indicators(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits (at least) – Ocean-atmosphere-land interactions (current changes, continental movement, El Niño, La Niña)

Student Outcome(s):

The student will be able to model a familiar earth system by using standard system symbols.

Brief Description:

In this lesson, the teacher will begin to guide students' thinking about Earth as a group of systems. Students apply their knowledge of a system diagram to model an earth system.

Background knowledge / teacher notes:

Lesson Description:

ENGAGE	Ask students to apply systems thinking to Earth by answering *Questions to Ask about Systems* with Earth in mind. Adaptive Strategy: Help students recognize first what is flowing, its sources, then the direction of the flow, and finally what it's affecting.

	Questions About Systems
	Directions: Working in groups, discuss the following questions about Earth. Remember that there is no single correct response. Make sure you will be able to explain your reasoning when you share your thoughts with the class! 1. When this system is working, what does it do? 2. For this system to work, must it receive any input? 3. What, if any, output does this system produce? 4. Identify at least four parts of this system. Describe what each part does, and tell how each part contributes to the system as a whole. 5. Can any one part of the system do what the whole system does? Explain your answer. 6. Identify two parts of this system that must interact if the system is to work. Describe how these parts interact. 7. What is the boundary of this system? Where does it begin and end? 8. Are there any subsystems within the whole system? If so, describe one subsystem. 9. Describe how this system would change if one of the parts wears out. Does your object fit our working definition of a system? Do we need to modify our working definition to make a bicycle fit our definition? If so, how? Each group shares its answers with the class. Technical Connection: Brainstorm smaller earth systems (subsystems). Show the first 2 sections of the video, Our Home: Earth From Space NASA. *Our Home: Earth From Space: Introduction to Systems.* Available: http://education.gsfc.nasa.gov/video/part01.mov

	NASA. *Our Home: Earth From Space: Satellites Looking at Earth from Space.* Available: http://education.gsfc.nasa.gov/video/part02.mov
EXPLORE	Model how to create a system diagram for an Earth subsystem by using one of the subsystems identified by the students. ***Journal Write****:* Using standard system symbols, create a diagram of your system. Describe the following: 1. A "name" for the system 2. A list of some sources and sinks. 3. The flow (arrows) between the sources and sinks and the direction of the flow 4. The conditions that affect the system
EXPLAIN	***Journal Write:*** Write a short paragraph summarizing the system. Adaptive Strategy: Provide a topic sentence or sentence starter for the paragraph. Use a web or other graphic organizer to organize the paragraph before writing. Provide a frame paragraph with word list for the paragraph. One or two groups share their diagrams and explanations with the class. Encourage students to contribute other ideas clarifying or adding to each groups' presentations.
EXTEND	Working in groups, read the technical passage, "The Global Water Cycle" which describes an earth system. Adaptive Strategies: The passage is written at approximately 8-9 grade reading level. Before reading, do a mini- lesson on the prefix re- and suffixes –ly, -tion, and –ed.

	Introduce vocabulary in the context of a sentence from the article. Vocabulary: evaporates, precipitation, atmosphere –Use a Directed Reading Activity to teach the technical reading. See Resource pages. Use a highlighter to highlight vocabulary source, flow, and sink. To help students visualize the water cycle, show them a picture of the cycle. USGS. *Picture of the water cycle.* Available: http://ga.water.usgs.gov/edu/watercyclegraphic.html ***Journal Write:*** Using standard system symbols, students work with their group members to create a systems diagram of the global water cycle as described in the reading passage. 1. Create a name for the system 2. Label the sources and sinks 3. Label the flow (arrows) between the sources and sinks and the direction of the flow 4. Label the approximate percentages of the flows ***Journal Write:*** Write a short paragraph summarizing the system. Adaptive Strategy: Provide a topic sentence or sentence starter for the paragraph. Use a web or other graphic organizer to organize the paragraph before writing. Provide a frame paragraph with word list for the paragraph. Have one or two groups share their diagrams and the explanations with the class. Encourage students to contribute other ideas clarifying or adding to each groups' presentations. Career Connection: What careers are related to the study of Earth/Space Systems Science?

	This is a growing field with many applications to a variety of careers. Some fields to keep in mind and that may be investigated by students are both direct connections and applied issues. (Mathematics is a fundamental skill in all) · Forestry · Conservation and conservation biology · Migration of populations · Water management · Public policy application · Stock market and futures prediction/financial markets/Gross National Product/costs and benefits associated with Earth/Space systems events · Hazards mitigation- severe storms, flood security, drought, fire risk · Agriculture - crop forecasting, fish catch (ex. tuna industry) · Health issues- famine/outbreaks of asthma/modeling of malaria, cholera and other diseases · Technological/instrumentation applications based on satellite and other types of remote sensing · Weather forecasting and weather-related events · Statistical analysis of data
EVALUATE	As a class, create a scoring tool to evaluate the completeness of the system diagram. Students can use Activity Specific Scoring Tool as a guide. Some suggested criteria: · Appropriate use of system symbols · Identification of system components · Appropriate use of flows to connect the components Groups exchange systems diagram and evaluate using the Activity Specific Scoring Tool.

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Materials:

- Questions About Systems
- Technical passage: The Global Water Cycle
- Sample Activity Specific Scoring Tool
- Picture of the water cycle

QUESTIONS ABOUT SYSTEMS

Directions: Working in groups, discuss the following questions about Earth. Remember that there is no single correct response. Make sure you will be able to explain your reasoning when you share your thoughts with the class!

1. When this system is working, what does it do?
2. For this system to work, must it receive any input?
3. What, if any, output does this system produce?
4. Identify at least four parts of this system. Describe what each part does, and tell how each part contributes to the system as a whole.
5. Can any one part of the system do what the whole system does? Explain your answer.
6. Identify two parts of this system that must interact if the system is to work. Describe how these parts interact.
7. What is the boundary of this system? Where does it begin and end?
8. Are there any subsystems within the whole system? If so, describe one subsystem.
9. Describe how this system would change if one of the parts wears out. Does your object fit our working definition of a system? Do we need to modify our working definition to make a bicycle fit our definition? If so, how?

The Global Water Cycle

One way a system can behave is to cycle. A cycle is a sequence of events that continuously reoccurs. Matter is transferred from one part of the cycle to another and returned. In a perfect cycle, no matter or energy would be lost. In nature, some matter and energy are lost from the system, but this is usually very small. There are many cycles in the universe. The sun, each of the planets, and the moon all have chemical cycles. There are also cycles of chemical substances in living things. Some biological materials cycle between living and nonliving things.

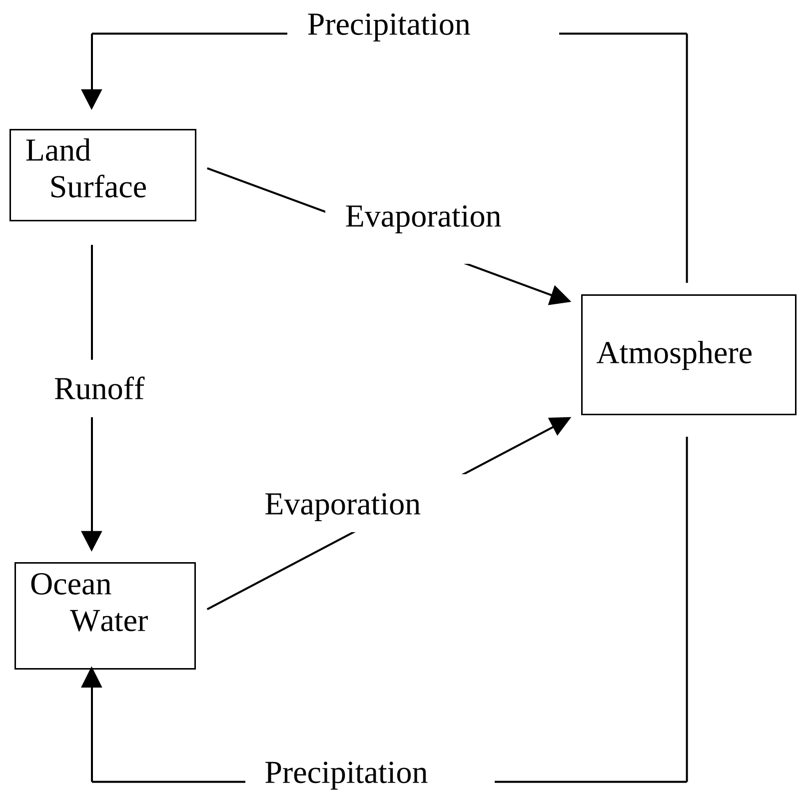
The physical and life processes of Earth involve cycles on many scales of time and space. There are smaller cycles within larger global cycles. Some cycles require only a few minutes; others may take millions of years.

One example of a cycle on a global scale is the water cycle. This cycle may be thought of as a system. In the water cycle system, we can follow the transport of water from one part of the Earth to another. Water evaporates into the atmosphere from the Earth's surface. Most of this water (about 86%) comes from the oceans. Additional water (about 14%) evaporates from the land.

Water returns to the Earth's surface from the atmosphere as precipitation. The amounts of precipitation falling back on the land and oceans are slightly different-22% back to the land and 78% to the oceans. About 8% of the precipitated water is returned to the oceans by runoff from rivers.

Cycles and systems usually remain in balance over short and long periods of time and space. The water cycle and life cycles of plants and animals are examples of cycles that stay in balance. Sometimes, however, major changes occur during the cycling of materials. Big changes in the Earth's climate, such as the ice ages, are examples of major changes in an Earth system. Natural changes in both time and space and disruptions to cycles and systems are part of the way in which the Earth's cycles and systems function.

System Model



- Water evaporates into the atmosphere from Earth:
  86% of the evaporated water comes from the oceans.
  14% of the evaporated water comes from the land.

- Water returns to Earth's surface by precipitation:
  78% falls back into the oceans.
  22% falls back on the land.
  8% of the precipitation falling on the land returns to the oceans as runoff from rivers.

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Sample **Activity Specific Scoring Tool**

System Diagram

2: A complete and full explanation is given which includes all of the following scoring cues:

- System symbols are used correctly.
- All system components are correctly identified.
- Components are connected correctly using flows

1: A partial explanation is given, but the response lacks one or two of the scoring elements above and/or is inaccurate.

- Most system symbols are used correctly.
- Most system components are correctly identified.
- Most components are connected correctly using flows

0: All other responses

Resources:

NASA. *Our Home: Earth From Space: Introduction to Systems.*

Available: http://education.gsfc.nasa.gov/video/part01.mov

NASA. *Our Home: Earth From Space: Satellites Looking at Earth from Space.*

Available: http://education.gsfc.nasa.gov/video/part02.mov

USGS. *Picture of the water cycle.*
Available: http://ga.water.usgs.gov/edu/watercyclegraphic.html

Lesson 3: THE MINI WATER CYCLE

Estimated Time: One fifty-minute block

Indicators(s): Core Learning Goal 1

1.4.8 The student will use models and computer simulations to extend his/her understanding of scientific concepts.

1.5.2 The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

Indicators(s): Core Learning Goal 2

2.3.1 The student will describe how energy and matter transfer affect Earth systems. Assessment limits (at least) -Atmospheric circulation (heat transfer systems – conduction/convection/radiation, phase change, latent heat, pressure gradients, general global circulation, Coriolis effect)

Student Outcome(s):

The student will be able to evaluate the global water cycle by comparing it to a working model.

Brief Description:

Students will use a beaker, watch glass, and water to construct and investigate a physical model of the water cycle system.

Background knowledge / teacher notes:

This lesson builds on the understanding of the components and interactions of the water cycle system established in the previous lessons. In this lesson students will practice identifying the attributes of a familiar physical system (a model of the water cycle) and then analyze this system by creating a systems diagram.

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Unit I: Introduction to Systems

Lesson Description:

ENGAGE	Show students the following materials: beaker, watch glass, and water. Brainstorm how to model the global water cycle using these materials. What's missing? *An energy source, hot plate, heat lamp*
EXPLORE	Working in lab groups set up a working mini-water cycle. <u>Adaptive Strategy:</u> Provide a model of a mini-water system for students to use as a guide as they set up their system.
EXPLAIN	As your group, observe the water cycle, discuss the following questions: 1. Carefully observe the watch glass and note any observations. 2. What changes are observed as the water is heated? 3. What causes these changes to occur?
EXTEND	***Journal Write****:* Create a system diagram of the min-water cycle.
EVALUATE	***Journal Write****:* Write a paragraph, comparing the model of the mini-water cycle to the global water cycle. List similarities and differences. Use evidence from your laboratory to support your answer. <u>Adaptive Strategy:</u> Students complete a Venn Diagram instead of writing a paragraph.

Materials:

- 250 mL beaker
- Watch glass sufficient to completely cover beaker
- Hot plate
- Safety goggles and aprons
- Hot hands or beaker tongs

Resources:

University of Illinois (2000) *Online Meteorology Guide Hydrologic Cycle.*

Available: http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/home.rxml

NASA's Jet Propulsion Laboratory. *The Hydrologic Cycle.*

Available: http://www-airs.jpl.nasa.gov/html/edu/clouds/Water_cycle.html

Lesson 4: EQUILIBRIUM AND CONSERVATION OF MASS IN THE GLOBAL WATER CYCLE

Estimated Time: One fifty-minute block

Indicators(s): Core Learning Goal 1

1.5.1 The student will demonstrate the ability to summarize data (measurements/observations).

Indicators(s): Core Learning Goal 2

2.3.1 The student will describe how energy and matter transfer affect Earth systems. Assessment limits (at least) -Atmospheric circulation (heat transfer systems – conduction/convection/radiation, phase change, latent heat, pressure gradients, general global circulation, Coriolis effect)

Student Outcome(s):

The student will be able to explain "equilibrium of a system" and "conservation of mass" by analyzing the results of a laboratory demonstration.

Brief Description:

Students observe a teacher demonstration of the beaker/watch glass mini-water cycle. The teacher will make measurements of the mass of water and condensate (on the watch glass cover) at several times during the boiling process, and students record this data in their journal. At the completion of the lab demonstration the students analyze the data by making a graph of mass vs. time, and have a discussion within their groups. The results of this discussion are shared with the class.

Background knowledge / teacher notes:

A perfectly "closed" system is one in which there is no net loss with respect to given quantitative variables such as mass and energy. Quantities can be transferred to different parts of the system but the net change is always zero. The beaker watch glass system is an example of an experimental or "closed" system with respect to mass.

Lesson Description:

ENGAGE	Demonstrate the beaker/watch glass mini-water cycle. Using the Experimental Design sheet · Draw a sketch of the demonstration system · Write a hypothesis about the mass of the water in the entire system over time · Design a data table to record mass and time measurements. <u>G/T Connection:</u> Illustrate the hypothesis through a graph. <u>Adaptive Strategy:</u> Provide sentence starters on the lab organizer sheet for students who need them for the problem, hypothesis, and conclusion.
EXPLORE	Measure the mass of the entire system at various times during the process of boiling. ***Journal Write:*** Record data in your data table.
EXPLAIN	Students make a graph of mass vs. time. Working in small groups, students explain the shape of the graphed line. *Line will be an almost horizontal line, actually a slightly decreasing slope indicating a small net loss of mass of the system.*
EXTEND	Discussion: What does the graph indicate? Provide guidance to help students understand the conservation issues and the apparent loss of mass in the system *The apparent loss of mass is due to unrecovered vapor escaping into*

	the atmosphere. ***Journal Write:*** Based on the results of the demonstration and your graph, write a conclusion for the experiment. Use data from the experiment to support your answer.
EVALUATE	***Journal Write:*** Explain "equilibrium of a system" and "conservation of mass." Use evidence from the beaker/watch glass system demonstration to help explain your answer.

Materials:

- 100 – 250 mL beaker
- Watch glass
- Beaker tongs
- Safety goggles
- Water
- Hot plate
- Stop watch
- Balance suitable for measuring mass to the nearest 0.1 grams.
- Graph paper

Experimental Design

TITLE OF THE EXPERIMENT: ___________________________________

DIAGRAM OF EXPERIMENT SET UP

LIST YOUR MATERIALS: ____

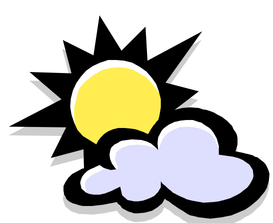
____

STATE YOUR QUESTION OR PROBLEM: ___________________________

____

HYPOTHESIS: I think if____

then ____



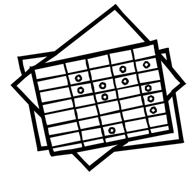
DATA

Think about how you are going to collect your data. Design a table to record your data.

GRAPH

What type of graph best suits your data?

Results



1. Do you see a trend in the data?
2. What do your results mean?

____

____

____

____

____

____

CONCLUSION:

1. What did you learn from this experiment?
2. Does your data support your hypothesis?
3. What evidence do you have to support your conclusion?

____

____

____

____

____

____

Resources:

Lesson 5: EARTH ENERGY BALANCE-- EQUILIBRIUM AND CONSERVATION OF ENERGY

Estimated Time: Two to three fifty-minute blocks

Indicators(s): Core Learning Goal 1

1.4.1 The student will organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title).

1.5.1 The student will demonstrate the ability to summarize data (measurements/observations).

1.5.6 The student will read a technical selection and interpret it appropriately.

Indicators(s): Core Learning Goal 2

2.3.1. The student will describe how energy and matter transfer affect Earth systems. Assessment limits (at least) -Atmospheric circulation (heat transfer systems – conduction/convection/radiation, phase change, latent heat, pressure gradients, general global circulation, Coriolis effect)

Student Outcome(s):

The students will be able to construct and interpret a thermal system by analyzing experimental data.

Brief Description:

The main objectives in this lesson are for the students to begin making distinctions about thermal transfer, observe a system achieving equilibrium, and reinforce their understanding and ability to construct and interpret a basic system model.

The students use an experimental set up (heat lamp and beaker-of-water) to measure the transfer of thermal energy from a heat lamp to a beaker-of-water. This is somewhat analogous to the radiant solar energy incident on the Earth's surface (see note below on the limitation of this experimental setup as a model for solar energy absorption).

By graphing the temperature change of the water in the beaker the students will find that the system achieves thermal equilibrium at some temperature. The students then construct a system model of the heat lamp/beaker-of-water with respect to thermal transfer, and compare this system and the Global Water Cycle.

Guide the students' understanding of how thermal equilibrium is established and how thermal energy is conserved in this system. Lead a discussion on the importance of a simplified system model, as well as its limitations.

Background knowledge / teacher notes:

The suggested lab setup is a heat lamp shining directly on a 250 mL beaker with about 50 mL of water at room temperature (about 20 degrees C). A standard 250-watt heat lamp bulb at a distance of 20 cm from the water surface will warm the water. The system will achieve equilibrium in less than 45 minutes. The water in the beaker will absorb the energy from the lamp more quickly if it is placed on a piece of black construction paper.

A perfectly closed system has no net loss with respect to given quantitative variables such as mass and energy. Quantities can be transferred to different parts of the system but the net change is always zero. The heat lamp/beaker-of-water system is an example of an experimental or closed system with respect to thermal energy. Experimentally it is very difficult to insulate a system against losses of thermal energy to the environment outside the system being analyzed. The important relationship that drives this system is that the energy source for the system produces a constant rate of heating, but as the water gets hotter it emits more energy leaving less energy available for raising the temperature of the water. Eventually the water reaches equilibrium when the energy it absorbs is balanced by the energy it emits.

A further experimental problem is measuring and keeping track of the thermal energy of a system. While it is easy to measure the temperature of the water in the beaker, it is not easy to measure the thermal energy associated with other parts of the system (such as the lamp). Thus the students must indirectly understand equilibrium. Students are guided by seeing that the temperature of the water in the beaker stops increasing even though the energy from the heat lamp remains constant. Likewise, conservation can not be measured directly, but must be inferred.

The heat lamp/beaker-of-water model is a necessarily over-simplified version of thermal transfer for the Earth energy system, notably omitting the role of the atmosphere surrounding Earth.

It should also be noted that it would be incorrect to understand that Earth is warmed from infrared (long wave heat energy) radiation transferred directly to Earth from the Sun. Rather, the primary energy transfer is radiant short wave light energy. In the student lab, primarily conduction and convection, and not radiation warm the water in the beaker.

The teacher will need to guide the students in distinguishing thermal transfer by radiation, conduction, and convection as applicable to their experimental work.

The students will also need guidance in understanding how a feedback loop works to change quantities within a system.
Accommodations: Vocabulary will need to be introduced or reviewed before the lesson. Vocabulary terms may include: thermal energy, equilibrium, independent variable, dependent variable, conduction, convection, and radiation.

Lesson Description:

ENGAGE	Discussion: How can we measure the transfer of thermal energy between a heat lamp and a beaker of water? What are the independent and dependent variables?

	Working in pairs, sketch a graph predicting the change in temperature of the water in the beaker.
EXPLORE	Work in groups of two or three. Students measure the change in temperature of the water in a beaker with a heat lamp shining on it from a fixed distance. Adaptive Strategy: Help students develop a data table. Teacher Note: Make sure the water in the beaker has time to reach a thermal equilibrium with its environment. Sample data and graph are available in resources.
EXPLAIN	***Journal Write:*** Construct a graph of temperature vs. time for the water. Discuss with your lab group, an interpretation for the shape of the curve. Two or three groups share their graph and interpretations with the class. ***Journal Write:*** 1. Summarize the experiment. Write a conclusion based on the post-lab class discussion. 2. Based on your experimental work, construct a simplified system diagram that models thermal energy transfer.
EXTEND	Read the technical article *Cat on the Mat.* Teacher Note: The Cat on the Mat has a lot of data in the columns that may overwhelm some students. They may need a word of caution. Do not eliminate. According to Fry's Readability, the reading grade level of this passage is approximately 10 – 11th grade. ***Journal Write:*** 1. Using the information in the Cat on the Mat article, construct a

	graph of temperature vs. time for the specified time period. 2. Discuss the article and the graph in your small group. Write interpretation of the graph in your journal. 3. Based on the table of solar energy and temperature values, summarize the concepts of thermal equilibrium and conservation of energy. 4. Describe how the story provides information that extends the concept of thermal transfer and equilibrium beyond the water cycle. Working in groups, make a simple system diagram of the *Cat on the Mat*. Share system diagram with other groups in the class. Adaptive Strategy: Provide a frame paragraph with a word box for the journal entry summarizing the concepts of thermal equilibrium and conservation of energy.
EVALUATE	Give each student the Science Rubric. Students use the rubric to assess the summary of the process of thermal equilibrium as presented before the class, and/or the system model of the Cat on the Mat.

Materials:

- Heat Lamp
- 250 mL beaker
- 50 mL water
- Standard lab thermometer or TI-83/CBL with temperature probe
- Stopwatch
- Graph paper
- Small piece of black construction paper
- Science Rubric
- Cat on the Mat reading

Earth Space Systems Science
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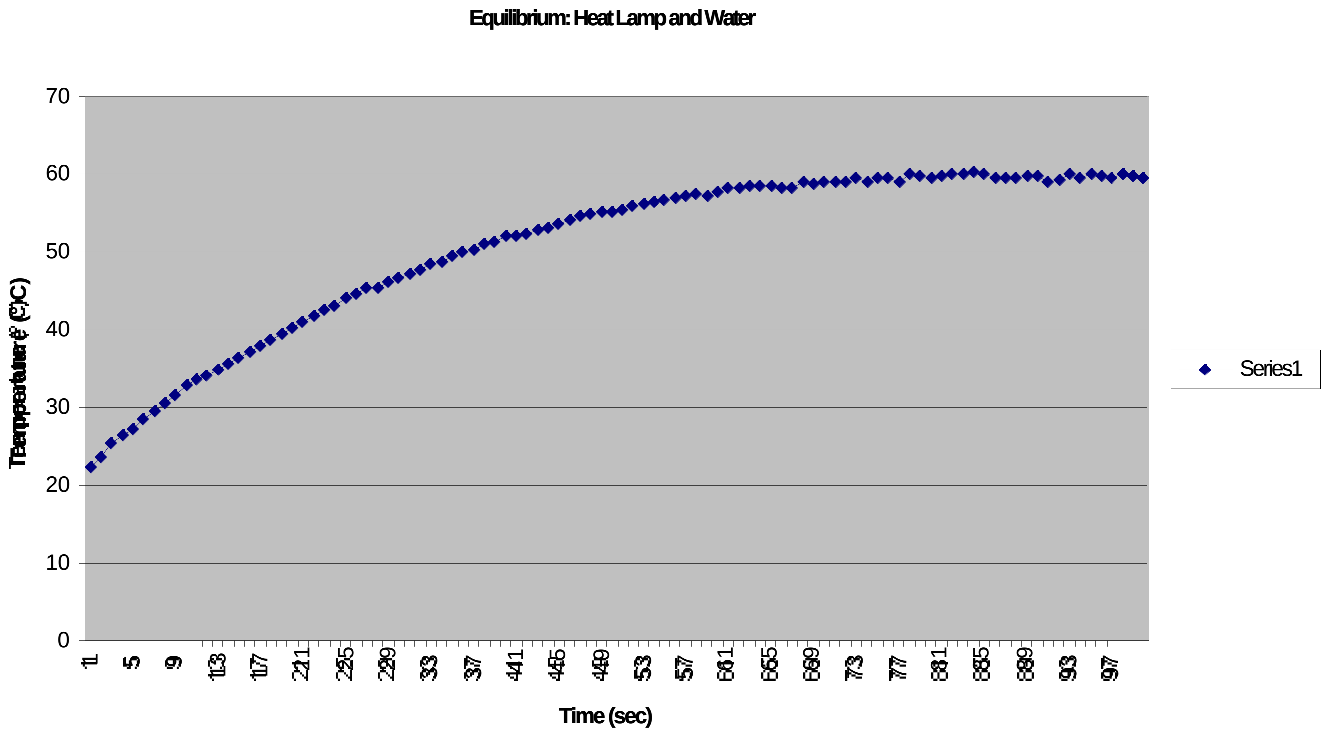
- System diagram for Cat on the Mat
- Alternative systems diagram for Cat on the Mat
- Heat lamp data and graph

Heat Lamp Data

Time	Temp
Time (sec)	(° C)
0	22.4
30	23.7
60	25.3
90	26.4
120	27.3
150	28.5
180	29.6
210	30.5
240	31.6
270	32.8
300	33.5
330	34.1
360	35.1
390	35.6
420	36.5
450	37.1
480	38.1
510	38.8
540	39.6
570	40.2
600	40.9
630	41.8
660	42.5
690	43.2
720	44.1
750	44.7
780	45.4
810	45.5
840	46.1
870	46.7
900	47.3
930	47.7
960	48.4
990	48.6
1020	49.5
1050	49.9

1080	50.3
1110	50.9
1140	51.4
1170	52.1
1200	52.1
1230	52.3
1260	52.9
1290	53.1
1320	53.6
1350	54.2
1380	54.5
1411	54.8
1441	55.2
1471	55.1
1501	55.5
1531	55.8
1561	56.1
1591	56.5
1621	56.6
1651	56.9
1681	57.3
1711	57.4
1741	57.3
1771	57.7
1801	58.1
1831	58.1
1861	58.4
1891	58.5
1921	58.5
1951	58.1
1981	58.2
2011	58.9
2041	58.7
2071	58.9
2101	58.9
2131	59.1
2161	59.4
2191	59.5
2221	59.4
2251	59.5

2281	59.4
2311	59.9
2341	59.7
2371	59.5
2401	59.7
2431	59.8
2461	59.9
2491	60.2
2521	60.1
2551	59.4
2581	59.4
2611	59.5
2641	59.7
2671	59.7
2701	59.7
2731	59.2
2761	59.9
2791	59.5
2821	59.9
2851	59.7
2881	59.4
2911	59.5
2941	59.7
2971	59.4


Equilibrium: Heat Lamp and Water
70
60
50
40
30
20
10
0
Temperature (°C)
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
61
65
69
73
77
81
85
89
93
97
Time (sec)
Series1

HSA Rubric for Constructed Response Items

Science Rubric, August 2000

	Level of Understanding	***Synthesis of Information***	***Use of Supporting Details***	***Use of Accurate Scientific Terminology***	
4	The student has a **FULL and COMPLETE UNDERSTANDING** of the question or problem.	The response reflects a complete synthesis of information.	Pertinent and complete supporting details demonstrate an integration of ideas.	The response is enhanced through the use of accurate terminology to explain scientific principles.	An effective application of the concept to a practical problem or real-world situation reveals an insight into scientific principles.
3	The student has a **GOOD UNDERSTANDING** of the question or problem.	The response reflects some synthesis of information.	The supporting details are generally complete.	Mostly accurate terminology is used to explain scientific principles.	The concept has been applied to a practical problem or real-world situation.
2	The student has a **BASIC UNDERSTANDING** of the question or problem.	The response provides little or no synthesis of information.	The supporting details may be incomplete or have minor errors.	Limited accurate terminology is used to explain scientific principles.	The application of the concept to a practical problem or real-world situation is inadequate.
1	The student has **SOME UNDERSTANDING** of the question or problem.	The response addresses the question.	The supporting details are only minimally effective.	Little or no accurate terminology is used to explain scientific principles.	The application, if attempted, is irrelevant.
0	The student has **NO UNDERSTANDING** of the question of problem. The response is completely incorrect or irrelevant.				
	On the High School Assessment, the bullet that defines application criteria will only be used when application is requested in the item show.				

Cat on the Mat

Every morning around 9 AM sunlight streams in the window onto a rug. Because of the location of the rug, a black cat stretches out on the rug to sun himself. Due to the absorbed solar energy, the temperature of the cat's fur (actually it's the temperature of the air trapped in the fur) increases from 65 degrees F at 9 AM to about 78.8 degrees F at 10 AM. The sun continues to shine in the window on the sleeping cat until 2 PM.

Think about how the temperature of the cat's fur changes throughout the day starting at 9 AM.

Journal Write:

1. Draw a graph predicting how the temperature of the cat's fur will change from 9 AM to 2 PM.
2. Write a brief interpretation of the line on your graph.

We say that the temperature of the cat's fur reaches equilibrium with its surrounding environment because the temperature stops increasing. This happens because the cat, in addition to absorbing solar energy, radiates heat energy to its surroundings. The amount emitted depends on the temperature of the fur.

At 9:10 the cat's fur is still relatively cool, so it emits relatively little energy. Let's say that at that time, the cat is constantly absorbing 100 heat-units of solar energy every second and emitting 43 heat-units (so that there is a "net" absorption of 57 heat-units [100 – 43 = 57]). The 57 heat-units would raise the surface temperature of the cat's fur a few degrees.

After about an hour the cat would continue to absorb 100 heat-units of energy, but, because of its higher temperature, emit about 82 heat-units in the same time period. Now there will only be 18 heat-units of net absorbed solar energy (100 – 82 = 18), and that will cause a comparatively smaller increase in the temperature of the cat's fur.

By examining the table below you can see that this pattern will continue until the energy emitted by the cat's fur equals the amount absorbed, leaving no net energy to heat the fur and increase its temperature. The temperature of the cat's fur is now in thermal equilibrium.

Data Table: Cat on the Mat

Time (hh:mm)	Solar Energy Absorbed (heat-units)	Heat Energy Emitted (heat-units)	Net Energy (heat-units)	Temperature Increase (degrees F)	Temperature of cat's fur (degrees F)
9:00					65.0
9:10	100	43.3	46.7	3.2	68.2
9:20	100	51.0	49.0	2.9	71.1
9:30	100	58.4	41.6	2.4	73.5
9:40	100	65.3	34.7	2.1	75.6
9:50	100	71.5	28.5	1.7	77.3

10:00	100	76.9	23.1	1.5	78.8
10:10	100	81.5	18.5	1.1	79.9
10:20	100	85.4	14.6	0.9	80.8
10:30	100	88.5	11.5	0.8	81.6
10:40	100	91.0	9.0	0.5	82.1
10:50	100	93.0	7.0	0.5	82.6
11:00	100	94.6	5.4	0.3	82.9
11:10	100	95.8	4.2	0.3	83.2
11:20	100	96.8	3.2	0.2	83.4
11:30	100	97.5	2.5	0.2	83.6
11:40	100	98.1	1.9	0.1	83.7
11:50	100	98.6	1.4	0.1	83.8
12:00	100	98.9	1.1	0.1	83.9
12:10	100	99.2	0.8	0.0	83.9
12:20	100	99.4	0.6	0.1	84.0
12:30	100	99.5	0.5	0.0	84.0
12:40	100	99.6	0.4	0.0	84.0
12:50	100	99.7	0.3	0.0	84.0
1:00	100	99.8	0.2	0.0	84.0
1:10	100	99.9	0.1	0.1	84.1
1:20	100	99.9	0.1	0.0	84.1
1:30	100	99.9	0.1	0.0	84.1
1:40	100	99.9	0.1	0.0	84.1
1:50	100	99.9	0.1	0.0	84.1

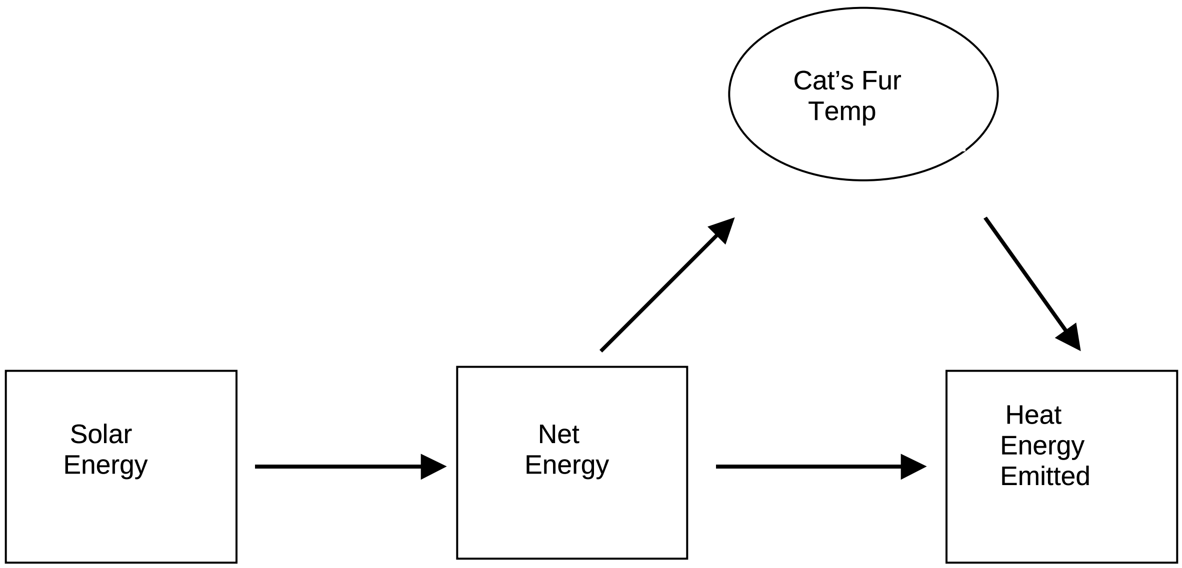
2:00	100	100	0.0	0.0	84.1

Journal Write:

1. Using the data in the table, construct a graph of the cat's fur temperature throughout the day.
2. Compare this graph to the one you predicted at the beginning of the activity.
3. Do you think you understand how this heating system (Solar energy and Cat) works?
4. What questions do you still have regarding the system?

In a similar way, if the sun started shining on Earth eons ago, as the temperature of the Earth increased, the amount of energy emitted would also increase. The amount of solar energy that reaches Earth and is absorbed by Earth has stayed relatively constant over time at about 100 units. Today Earth has reached its equilibrium temperature. Earth is continuously gaining 100 units of solar energy and emitting an equal amount. Actually, about half of what is emitted is net radiation; the rest is lost through sensible heat (conduction and convection), and through energy transferred when water evaporates from the surface, condenses in the atmosphere, and precipitates (as was demonstrated in the mini-water cycle).

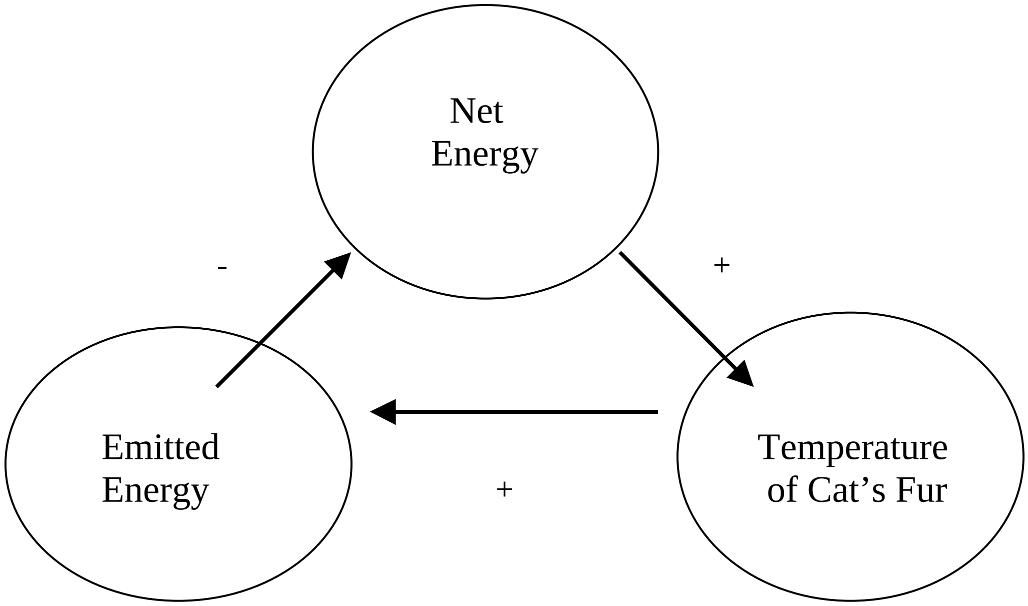
SYSTEM DIAGRAM FOR THE CAT ON THE MAT



The system diagramed above shows Net Energy as a component of the system that results from the difference (mathematical) between the amount of energy absorbed by an object (Solar Energy) and the amount of energy the object emits (Energy Emitted). It is this Net Energy that is available for increasing the temperature of an object (in this case, the temperature of the cat's fur).

The feedback loop (Net Energy Fur Temp Emitted Energy) occurs because as the cat's fur increases in temperature (the result of the Net Energy absorbed) the fur also emits more heat energy, which causes the amount of Net Energy to decrease. It is this negative feedback loop that drives the system into equilibrium.

ALTERNATIVE SYSTEM DIAGRAM FOR THE CAT ON THE MAT



The Causal Loop Diagram:
This alternative system diagram enables one to readily predict system trends. We begin by making a closed loop of system components, connecting the various system components in a sequential order by arrows that represent a causal relationship. Next we place a positive or negative sign next to the connecting arrows. A positive sign means that the components have a direct relationship – an increase or decrease in one component is associated with a corresponding increase or decrease in the other component. A negative sign means the opposite: that an increase in one component is associated with a corresponding decrease i the other component and vice versa.

For the system diagram above, there is a + sign between the **Net Energy** and **Cat Temperature** because an **increase** in **Net Energy** causes the **Temperature** to **increase**. Since an **increase** in **Temperature** causes the **Emitted Energy** to **increase** we put a + sign between them. And a - sign shows that **increasing** the **Emitted Energy** produces **less Net Energy** available to cause an increase in the **Temperature** of the cat's fur. Since there is an odd number of negative signs (one), this system will tend toward equilibrium.

Analyzing the trend is easy: simply count whether there is an odd or even number of negative connections. If there is an odd number of negative connections (like the heat lamp/beaker-or-water system or the Cat on the Mat) the system is called a "balancing loop" and the causal connections will force the system toward equilibrium. Any other system will produce an ever increasing or decreasing change for the measured system effect.

A causal loop diagram is a very effective tool for analyzing a system, enabling the easy generation of reasonable hypotheses abou making alterations to the system with respect to a particular component (called "applying leverage" to the system).

Resources:

Lesson 6: INTRODUCTION TO SPHERES

Estimated Time: One fifty-minute block

Indicator(s): Core Learning Goal 1

1.4.2 The student will analyze data create and/or interpret graphics (scale drawings, photographs, digital images, etc.).

1.4.8 The student will use models and computer simulations to extend his/her understanding of scientific concepts.

1.5.8 The student will describe similarities and differences when explaining concepts and/or principles.

1.5.9 The student will communicate conclusions derived through a synthesis of ideas.

Indicator(s): Core Learning Goal 2

2.1.1 The student will describe the purpose and advantage of current tools, delivery systems and techniques used to study the universe. Assessment Limits (at least) – Tools (optical and radio telescopes, spectrometers)

2.1.2 The student will describe the purpose and advantage of current tools, delivery systems and techniques used to study the atmosphere, land and water on Earth. Assessment Limits (at least) – Tools (spectrometers, seismograph).

Student Outcome(s):

The student will be able to determine the interrelationships among Earth's spheres by investigating the tools of Earth Science.

WHAT DOE S THE RESEARCH SAY?

During the high school years, students continue studying the earth system introduced in grades 5-8. At grades 9-12, students focus on matter, energy, crustal dynamics, cycles, geochemical processes, and the expanded time scales necessary to understand events in the earth system. Driven by sunlight and earth's internal heat, a variety of cycles connect and continually circulate energy and material through the components of the earth system. Together, these cycles establish the structure of the earth system and regulate earth's climate. In grades 9-12, students review the water cycle as a carrier of material, and deepen their understanding of this key cycle to see that it is also an important agent for energy transfer. National Research Council, *National Science Education Standards* (1996).

Brief Description:

In this lesson, students are introduced to the five spheres: biosphere, geosphere, atmosphere, hydrosphere, and space. They investigate the tools scientists use to gather data about these five spheres.

Background knowledge / teacher notes:

Students learn how Earth's five spheres are interdependent. Each sphere comes into direct contact with at least one other sphere; a change in one sphere impacts other spheres. During this lesson, students get acquainted with each of the five spheres; they do not investigate any single sphere in great detail. This is a preview of coming units. The overview featured in this lesson is an ideal opportunity to introduce the tools of Earth Science. Much of what we know and understand about our planet is the result of remote sensing. In many cases, satellites orbiting Earth are used to collect data for earthbound scientists. The websites in this lesson offer many examples of how satellites supply us with vast amounts of information. Other examples of remote sensing, such as seismographs and weather balloons, are included.

Lesson Description:

ENGAGE	Place the "Personal Spheres" diagram on the overhead. Discussion: 1. What do these five topics have in common? *All are part of a "well-rounded" life.* 2. Why are they illustrated as separate spheres? *Represent facets of a life that can be independent of each other, although they can influence one another.* 3. How can a change in one part of your life affect the other parts?

	Now, show a picture of Earth as viewed from space. A good example can be found by visiting Lunar and Planetary Institute. *Shuttle Views of the Earth: Clouds From Space.* Available: http://www.lpi.usra.edu/images/sclo/sclo_S02.gif Or a similar image may be used. Discussion: 1. What can you see on the planet's surface? *Land, water* 2. What can you see surrounding the planet? *Atmosphere, or thin layer of air, space* 3. To the best of our knowledge, what makes Earth unique among all other planets in our solar system? *Life*
EXPLORE	Place the following terms on the overhead, chalkboard, or chart paper: · Space · Atmosphere · Geosphere · Hydrosphere · Biosphere Working in groups, students brainstorm descriptions for these terms. Adaptive Strategy: Help students identify prefixes such as "geo" and "hydro." Draw upon their prior knowledge to help them define these words. The activity can also be done as a jigsaw. Students create a graphic organizer illustrating these five spheres of Earth. Materials: blank paper, colored markers, pencils, or crayons, tape, magazines, scissors.
EXPLAIN	Students take a "gallery walk" and compare the graphic organizer posters. Discussion: What are the characteristics of the atmosphere? Hydrosphere? Geosphere? Biosphere? Space?

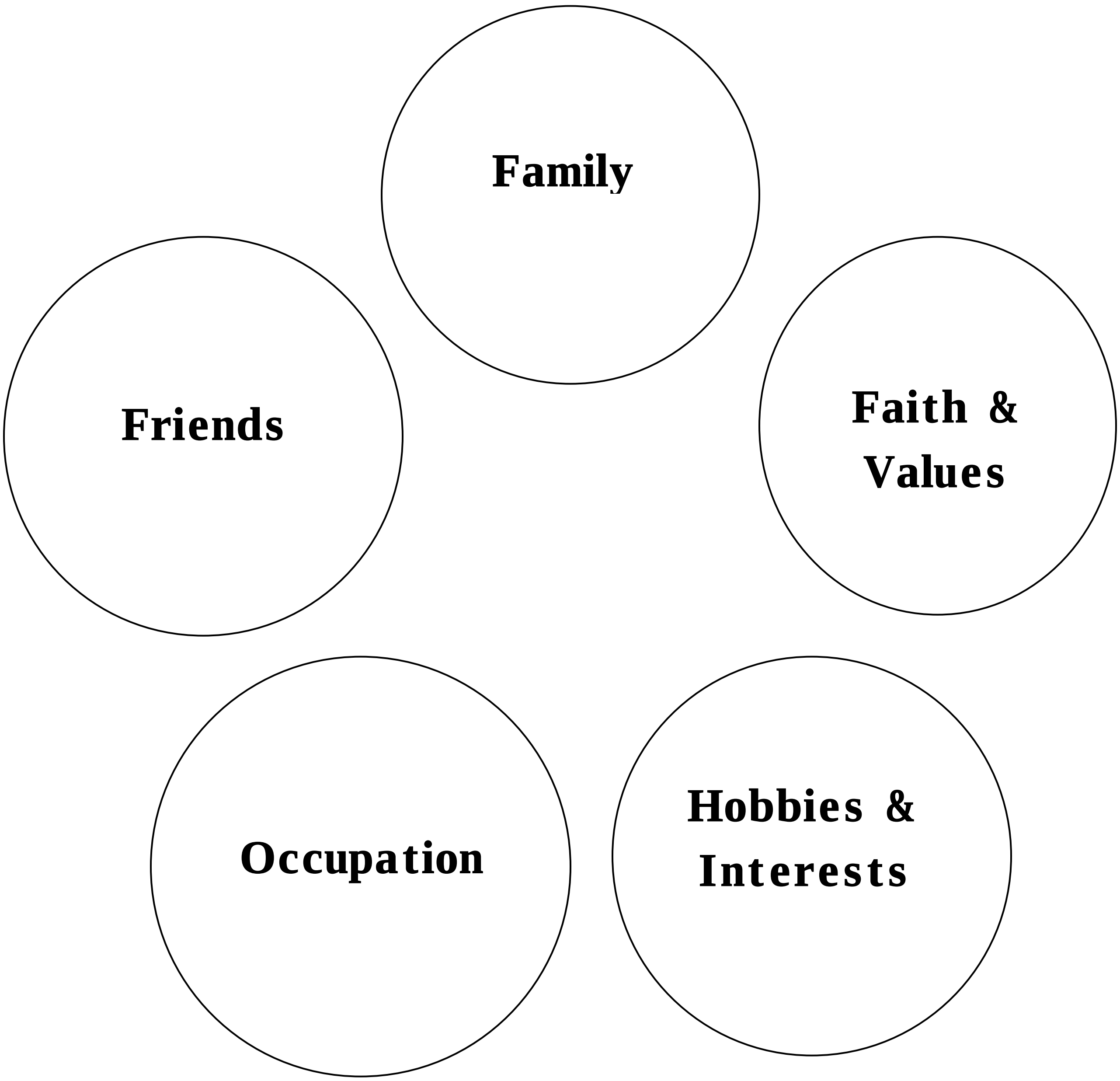
	Encourage students to share their ideas.
EXTEND	Think-Pair-Share: You have identified Earth's five spheres. It is the job of Earth scientists to study these spheres, gathering as much data as possible. What tools do scientists use to study each of the five spheres? Adaptive Strategy: Help students review conditions found in each of the spheres, and discuss the conditions that prevent humans directly visiting and researching this area. Technical Connection: Working small groups, read to be informed about tools. Record the information in a graphic organizer. (See resources) Teacher Note: You can assign specific satellites to research or have them gather information on a few of the satellites discussed in the following websites. Adaptive Strategy: Complete the graphic organizer as a class. NASA. *Earth Sciences Sentinels.* Available: http://www.gsfc.nasa.gov/gsfc/earth/sentinel/earthsen.htm NASA. SpaceLink. *Water*. Available: http://spacelink.nasa.gov/NASA.Projects/Earth.Science/Water/ NOAA. *Satellites.* Available: http://www.noaa.gov/satellites.html On your Sphere graphic organizer, add the name of the tool or illustrate the tool next to the sphere(s) where it is used. INTEREST CENTER Athena Curriculum. *Earth Satellites.*

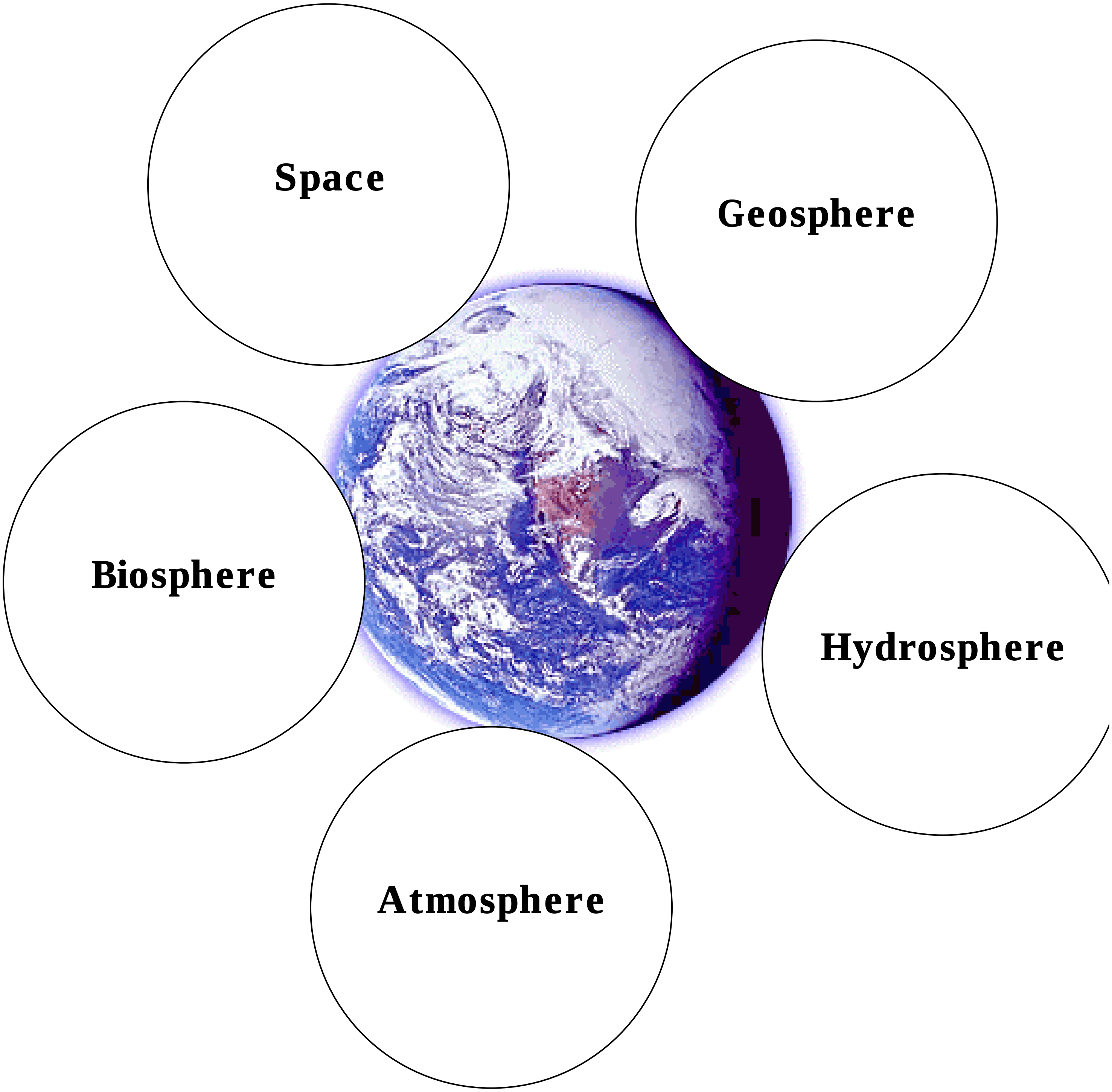
	Available: http://vathena.arc.nasa.gov/curric/orbit.html Gulf of Maine Aquarium. *How Satellites Work* Available: http://octopus.gma.org/surfing/satellites/ Surrey Satellite Technology, Ltd. *Small Satellite Home Page.* Available: http://www.ee.surrey.ac.uk/SSC/SSHP/ Discussion: What tools do scientists use to study the earth? *Mostly Satellites and computers* Show the number and position of satellites by visiting NASA Marshall Space Flight Center. *J-Track 3D.* Available: http://liftoff.msfc.nasa.gov/RealTime/JTrack/3D/JTrack3D.html
EVALUATE	***Journal Write:*** How do the tools of Earth Science allow us to investigate the interactions among Earth's spheres? Be sure to use information from your graphic organizer to support your answer.

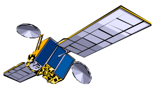
Materials:

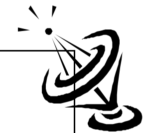
- Unlined paper
- Colored markers, pencils, or crayons
- Tape
- Magazines
- Scissors

Personal Spheres




Space
Geosphere
Biosphere
Hydrosphere
Atmosphere





Name of Tool	Description or Drawing	Purpose of Tool	Sphere (s)

Resources:

NASA. *Earth Sciences Sentinels.*
Available: http://www.gsfc.nasa.gov/gsfc/earth/sentinel/earthsen.htm

NASA Marshall Space Flight Center. *J-Track 3D.*
Available: http://liftoff.msfc.nasa.gov/RealTime/JTrack/3D/JTrack3D.html

NASA. SpaceLink. *Water*.
Available: http://spacelink.nasa.gov/NASA.Projects/Earth.Science/Water/

NOAA. *Satellites.*
Available: http://www.noaa.gov/satellites.html

Lunar and Planetary Institute. *Shuttle Views of the Earth: Clouds From Space.*
Available: http://www.lpi.usra.edu/images/sclo/sclo_S02.gif

INTEREST CENTER
Athena Curriculum. *Earth Satellites.*
Available: http://vathena.arc.nasa.gov/curric/orbit.html

Gulf of Maine Aquarium. *How Satellites Work*
Available: http://octopus.gma.org/surfing/satellites/

Surrey Satellite Technology, Ltd. *Small Satellite Home Page.*
Available: http://www.ee.surrey.ac.uk/SSC/SSHP/