

GRADE 5	Author: J. Haase	Lesson #: 1
	Unit Title: Earth System Science	Time Frames: Two 50-Minute Periods

What Is Earth System Science?

ABSTRACT

This lesson introduces the Earth system science spheres through model making and discussion. Students will work within an Earth system science notebook to chronicle their work and learning. In small groups students will examine photographs and conduct a photo sort of examples from the geosphere, biosphere, hydrosphere and atmosphere. Student groups will classify these examples into categories and provide category titles as they are introduced to the scientific vocabulary. Students will then construct two types of conceptual ESS models. Classroom discussions will deepen this conceptual understanding by comparing and contrasting the models and discussing the advantages of each as tools for understanding the complexities of our Earth system.

PLANNING	INSTRUCTION	ASSESSMENT	STANDARDS	REFERENCES
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BACKGROUND INFORMATION FOR TEACHERS

Historically, it has been challenging for humans to observe and think about the Earth as a whole because humans are small and the Earth is so large to us. Yet, with the advancement of science and views of the Earth from space, scientists have been able to think more about the Earth working together as a system. 5th grade students will make and explore two different models of Earth system science, then use their critical thinking skills to compare the attributes of their two different models.

NASA's (2003) definition of Earth system science explains:

Earth is a dynamic planet; the continents, atmosphere, oceans, ice, and life ever changing, ever interacting in myriad ways. These complex and interconnected processes comprise the Earth system, which forms the basis of the scientific research and space observation that we refer to as Earth system science. (p. 7)

Satellite data and images have changed our understanding of Earth, humans are now better able to see and study the Earth in its entirety. Scientists increasingly understand that the Earth functions together as a single system and this newly accepted understanding is bridging the discrete fields of science that were developed in the 1800s and 1900s. NASA is now looking at data collected by satellites orbiting the Earth to monitor the vital signs of the Earth and measure the changes that are occurring on a global scale. Closely

monitoring these interconnected Earth spheres of the hydrosphere, atmosphere, geosphere, and biosphere is a way to understand patterns, monitor changes, and make predictions to plan for the future.

Introducing the concepts of ESS to children at the elementary level, provides them with the opportunity to develop a conceptual understanding of the Earth as a single functioning system. This interdisciplinary approach has been supported with Next Generation Science Standards specifically addressing the elementary students' need to understand the basics of ESS. Later, in high school and college many science students may enter courses that study single disciplines such as biology, hydrology, chemistry, and meteorology. With the foundation they were given at the elementary level to understand Earth as a single functioning system, they will perceive the interconnections and approach problem-solving from the viewpoint of the integration of the four Earth spheres.

PLANNING

Essential Questions

- How can a model of the Earth's four spheres deepen our understanding of Earth system science?
- How does understanding the Earth as a system affect our human behavior?
- How can daily observations of the natural world help you be an Earth system scientist?

Instructional Objectives

Students will:

- Identify and sort images of the four spheres that comprise Earth system science.
- Collaborate to build different models to represent ESS.
- Compare and discuss the usefulness of each model for understanding the interconnections of the four spheres in ESS.
- Use their science notebooks to explain ideas and vocabulary by recording, illustrating and labeling their thinking.

Key Vocabulary

- Earth system science (ESS)
- System
- Model
- Biosphere
- Hydrosphere
- Geosphere
- Atmosphere

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INSTRUCTION

Materials

- Image of Earth from space
- Whiteboard for writing notes on ESS model whole class discussion.
- Student science notebooks
- ESS Graphic Organizer printed for each student science notebook (below)

Per group

- "ESS Picture Sort" worksheet
- Sorting page

- Colored picture sheet
- Scissors
- Glue stick
- Tape

Paper model supplies:

- Four strips of construction paper: dark blue, green, brown, and light blue
- Two cap circles made of card-stock, staples or brads, markers

Balloon model supplies:

- One round balloon
- Multiple 60 cm. yarn pieces in four colors; dark blue, green, brown, and light blue

Preparation

- Organize students into groups of two or three students.
- Print the ESS picture sort sheet and sorting page for each group.
- Print ESS Graphic Organizer for each student
- Prepare materials as listed above, each group may make one or two models
- Build samples of each model to gently guide student work
- Review the background information and the NASA resources below.
- Familiarize yourself with the vocabulary words.
- Designate a bulletin board in the classroom called Earth System Science to post resources and share learning examples collected over time during the unit.

Resources

NASA:

- *Earth System Science* - This short NASA video from 2007 explains Earth system science to the teacher. It is a NASA Connect segment that explores how modern technology studies the many different areas of Earth system science:
<https://www.youtube.com/watch?v=ciV6Uaeobxk>
- NASA Wavelength - *Earth Systems Science*
http://www.globe.gov/documents/356823/356958/earth_chapintro.pdf
- GLOBE - *Earth Systems Play*
http://www.globe.gov/documents/348830/350113/ElementaryGLOBE_EarthSystemsActivity3_en.pdf
- *Elementary GLOBE Earth Systems Storybook*
http://www.globe.gov/documents/348830/350113/ElementaryGLOBE_EarthSystems_en.pdf
- NASA Earth Observatory Satellite -
<http://www.earthobservatory.nasa.gov/?eocn=topnav&eoci=logo>
- The NASA *Earth Observatory* website has satellite images of Earth that can be projected in the classroom to reinforce the ideas of the four spheres of Earth system science.

ENGAGE

Session One:

1. Engage the students by asking the question:
 - *What is an example of a system?*
 - *When have you heard this term?*
2. Discuss student answers and analyze the parts of their system examples, the functions, and interactions. Highlight these two new terms: function and interactions. Look for ways to explain them within the context of student responses. Continue the discussion with your own example:

- *Why is a forest an example of a system?"*

Give students time to discuss the questions in small groups and circulate to ask.

- *What are the different components of a forest and how do they work together as a system?*

Give students a chance to share out loud. Share your thinking with the class to reinforce the ideas that cycles and parts working together make a system. They can be complex.

3. Pass out materials for the ESS picture sort. Have the students cut, discuss, and glue the ESS pictures onto the sorting page. Have the students write titles on the sorting page; they may use the words water, land, air, life.
4. Project the "ESS Picture Sort Game" from the Bishop Museum website and complete it together as a class. Ask for student input and observe any misconceptions. If no computer or projector is available, come back together and discuss the picture sort as a whole group. Complete the diagram with appropriate titles. Ask the question:

- *Do any of the pictures fall into more than one section of the sorting page? Why?"*

5. Now that students have explored these examples and ideas, ask them to take notes in their science notebooks:

- *What is Earth system science?*

Today begins a new investigation about this field of science called Earth System Science or ESS.

6. Write these words on the board:

- Biosphere
- Hydrosphere
- Geosphere
- Atmosphere

Have students examine how Earth system scientists organize their thinking with these terms.

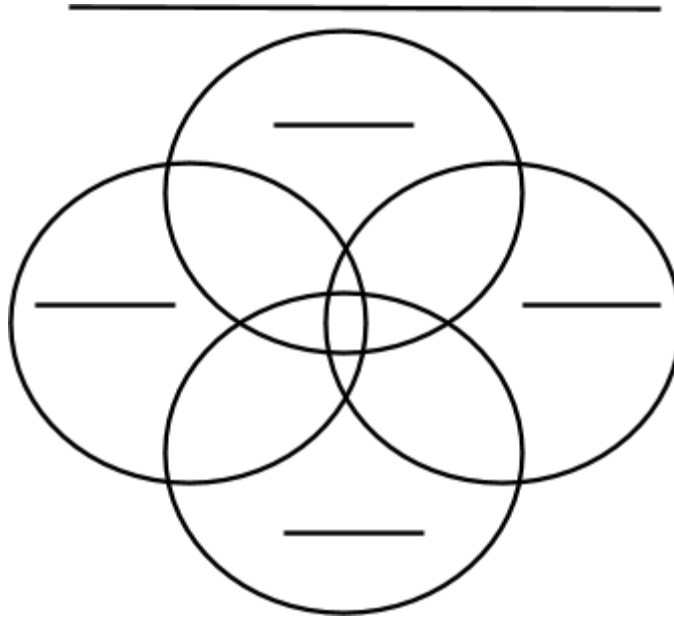
- *What do you notice about these words?*

In each of these words there are two word parts. By putting them together new words have been formed to explain ideas about how the Earth is organized into parts.

7. Allow the students to discover the word parts and infer their meaning when possible. Have students use their science notebook to write and record their ideas about these words.
 - Bio: Greek for life
 - Hydro: Greek for water
 - Geo: Greek for land
 - Atmos: Greek for gas or vapor
 - Sphere: Greek/Latin for a rounded shape. It can also mean an area of activity or an aspect of life distinguished and unified by a particular characteristic.
8. Encourage students create their own working definition for Earth system science based upon what they have done so far. Offer the EES definition below and have students check their own work to

see what they had included and what they can add. Remind students that scientists add ideas to improve their work when they learn something new.

9. Student Definition: Earth System Science (ESS) is the study of relationships between air, land, and water, in all its forms, on our planet. All parts of the Earth - the oceans, air, land, and all living and nonliving things are all connected. Earth system scientists work to understand these interconnected systems.
10. Observations/Data: Have the students draw and label the image below with the new vocabulary. Illustrate each sphere with an appropriate icon or picture.

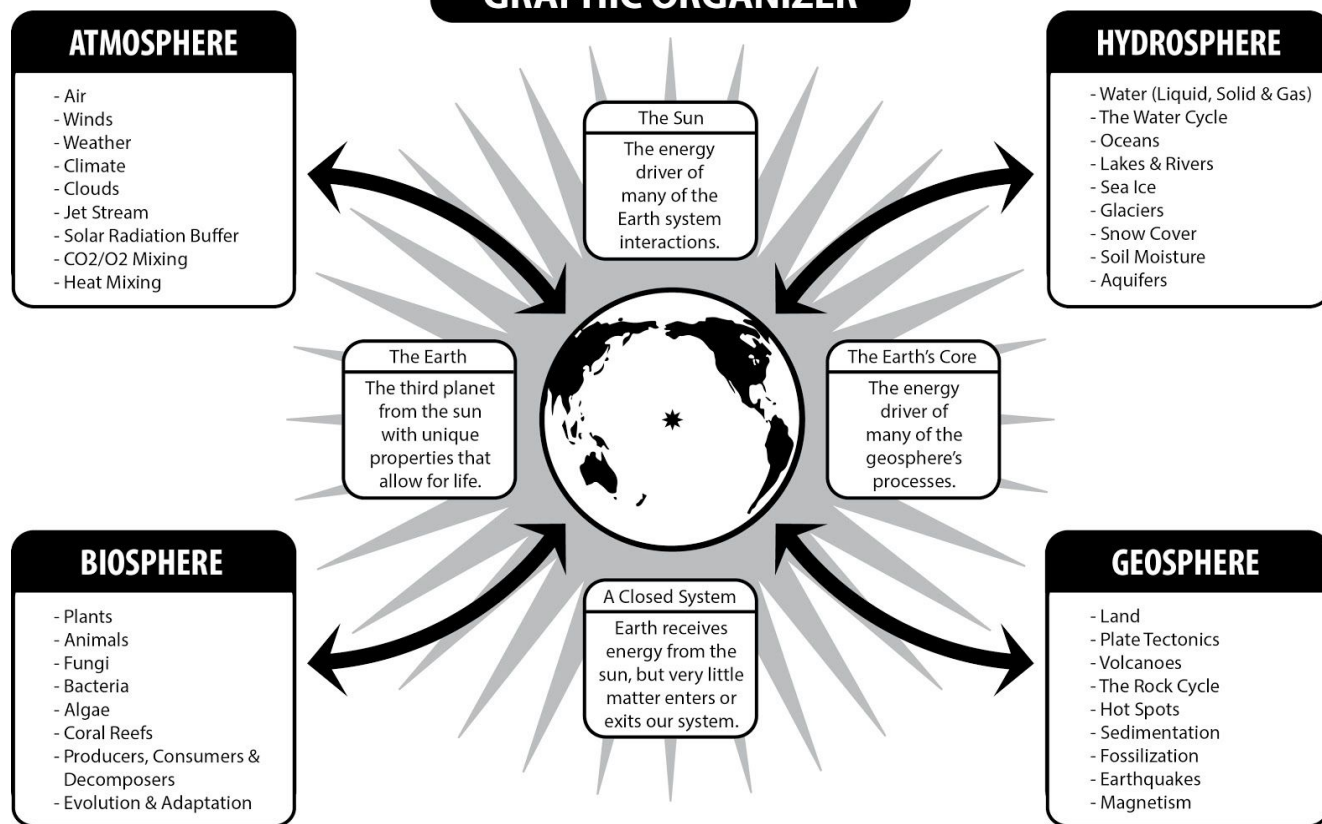


11. Have the students answer the question:

- *How can your daily observations of the natural world help you be an Earth system scientist?*

12. Pass out the “ESS Graphic Organizer” for students to consider, refer to and add to their science notebook.

EARTH SYSTEM SCIENCE GRAPHIC ORGANIZER



Earth system science is the study of the **relationships** between air, land, life, and water, *in all its forms*, on our planet. Earth system scientists work to understand these interconnected systems.

EXPLORE

Session Two:

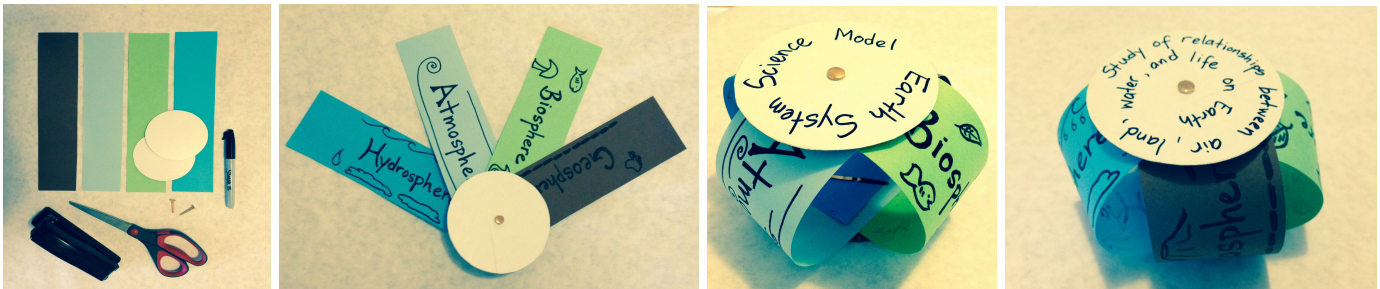
1. Start the class by projecting the image of Earth taken from space for student observations. Ask the questions below. Allow time for the students to turn and talk and share out to the class.

- *What do you notice?*
- *How does this photo relate to our previous explorations?*
- *What kind of science are we learning about in class?*
- *Using previous vocabulary, what spheres can you observe?*
- *How do you know those spheres are there?*



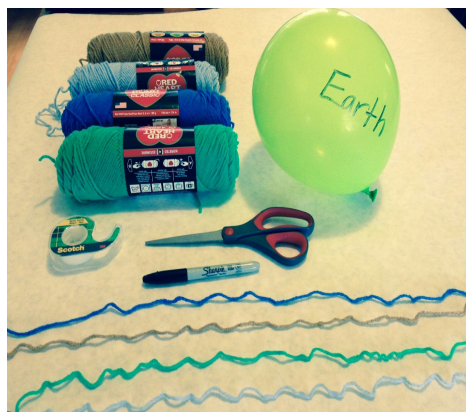
Image courtesy of NASA.

2. Introduce the task. Students will be creating two different models to help think more about Earth system science. They will compare and contrast their completed models. Looking at the whole entire Earth as one great functioning system is very complex and creating models helps us have a better understanding.
3. Highlight the examples, encourage students to devise ways to create their own models if they would like to do so.
 - Model 1 uses paper strips and is a great way to see the vocabulary and illustrate each sphere. Have students notice the labels on each on a strip of paper with a related picture or icon. “Earth system science” is written on the top and “study of relationships between air, land, and water and life on Earth” on the bottom. Students may use brad fasteners to hold the strips, cap and the base together or staple the pieces.



Images courtesy of J. Haase.

- Model 2 uses a balloon and colored yarn. Notice the title ‘*Earth system science*’ and the key phrase ‘*study of relationships between air, land, and water and life on Earth*’ on the balloon. See how the model shows the thinking of the the complex interactions of air, land, and water and life on Earth by twisting and weaving the yarn together around the balloon.



Images courtesy of J. Haase.

4. Show the classroom areas where students can get the model building materials. Let them get their supplies and begin the construction of their own models. They may help each other as needed.

EXPLAIN

1. Have the students tour the room observing models from other groups, remind students to offer constructive feedback and thoughtful questions like “I noticed...” and “I was wondering...”. After just a few minutes of touring, have the students return to their group and discuss this question and write notes in a T-chart in their science notebook:

How does each model help us understand more about the relationships in Earth system science?

Balloon ESS Model	Paper ESS Model

EXTEND

1. Come together for a whole class discussion, have groups share out their ideas on the question:
 - *How does each model help us understand more about the relationships in Earth system science?*
2. Facilitate a discussion highlighting advantages/disadvantages of each ESS model:
 - Paper model clearly shows the names of the spheres with pictures, but does not show the complex interactions of the spheres.

- Balloon model shows the complex interactions of the spheres but does not clearly show the science vocabulary.
- Both models give an interpretation of the ideas in Earth system science.

Continue the discussion:

- *How does understanding the Earth as a system affect human behavior?*
- *Think of ways we affect different spheres. Explain your ideas.*

3. Wrap up the discussion by reviewing the earlier question:

- *How can your daily observations of the natural world help you be an Earth system scientist?*

4. Have them explain their additional ideas in their science notebook constructing a deeper answer involving evidence from their explorations.

EVALUATE

1. Have the students select and answer a focusing question with quiet writing time, encourage them to include a labeled diagram or colored illustration to reinforce the introduction to Earth system science.

- *How can your daily observations of the natural world help you be an Earth system scientist?*
- *How can a model of the Earth and the four spheres deepen our understanding of Earth system science?*
- *How does understanding the Earth as a system affect human behavior?*

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ASSESSMENT OPTIONS

Formative Assessment

- A formative assessment can be based upon student participation in the ESS picture sort. The teacher may also use the whole class discussion participation and science notebook entries for formative assessment. Recording student progress in a gradebook or clipboard will help the teacher track student progress and growth during the unit.

Summative Assessment

- The summative assessment may be based upon science notebook entry answer to the final focusing question.

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CULTURE CONNECTION



Image courtesy of B. Haase.

‘Ōlelo No ‘eau

A collection of Hawaiian proverbs, translated and annotated by Mary Kawena Pukui, offers a unique opportunity to savor the wisdom, poetic beauty, and earthy humor of finely crafted expressions.

‘A ‘ohe pau ka ‘ike i ka hālau ho‘okāhi. (Hawaiian proverb)

All knowledge is not taught in the same school. (English translation)

One can learn from many sources. (Interpretation from Mary Kawena Pukui’s book)

This ‘Ōlelo No ‘eau frames the first lesson introducing Earth system science to fifth graders with more than one model used to demonstrate the concepts of Earth system science. This proverb invites students to think of the world as their classroom and look outside to study the relationships between air, land, water, ice and life on Earth.

DIFFERENTIATION

Emerging Learners

- Chunk information into smaller pieces written on the board for this lesson. Print the science notebook work onto a worksheet for the student or students to preview the night before the lesson and complete with guidance. Arrange student groups with different skill levels so student help is given by peers.

Advanced Learners

- Have advanced students collect images online or on their own and then make posters for the room showing the new scientific/academic vocabulary. Arrange student groups with different skill levels so student help is given by peers. Have advanced students design and build another model to represent the concepts of ESS. Have advanced students make a collage at home showing the five spheres using magazine pictures and words.

English Language Learners

- Give English Language Learner students a glossary of Earth System Science words to use throughout the unit. There are several glossaries available digitally from NASA. Print the Science Notebook work onto a worksheet for the student or students to preview the night before the lesson and complete with guidance. Arrange student groups with different skill levels so student help is given by peers.

EXTENSIONS

- Digital Picture Book:

- Read the digital picture book to the class or have students do this in small groups.
Elementary GLOBE Earth Systems Storybook
http://www.globe.gov/documents/348830/350113/ElementaryGLOBE_EarthSystems_en.pdf
- NASA interactive media:
 - Students can access the ESS picture sort game on their computers, where they sort 15 Earth system science pictures into five spheres.
- S.T.E.M. Challenge:

Have students design and build a third model to represent the concepts of ESS and explain why their new model is a better representation of ESS.
- S.T.E.A.M Challenge:
 - For an art connection, have students make a collage at home showing the five spheres using magazine pictures and words.
 - For a collaborative art connection, have students each make a collage at home showing ONE sphere using magazine pictures and words. Have the children bring their spheres together at school and make a five sphere group art project.
 - For a performing arts connection, have students read through and perform the GLOBE: Earth Systems Play.

STANDARDS

Next Generation Science Standards

Crosscutting Concepts:

- Systems and System Models - In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.

Science and Engineering Practices:

- Asking questions (for science) and defining problems (for engineering).
- Developing and using models.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Constructing explanations (for science) and designing solutions (for engineering).
- Obtaining, evaluating, and communicating information.

Disciplinary Core Idea:

- 5-ESS2-1 Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

Common Core

- 5.L.6 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships (e.g., however, although, nevertheless, similarly, moreover, in addition).
- 5.L.6 Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- Standards for Mathematical Practice:
 - Reason abstractly and quantitatively.

Hawaii Content & Performance Standards

- SC.5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

General Learner Outcomes

- Complex Thinker
- Effective Communicator

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ADDITIONAL RESOURCES

- *Global Precipitation Mission* (GPM) <http://pmm.nasa.gov/node/243>
- At the *GPM* website there is an Education link that has many resources that would be appropriate for teacher background information or for 5th grade classroom activities and background information.
- Earth System Science Video <https://www.youtube.com/watch?v=ciV6Uaeobxk>
 - This short video from 2007 explains Earth System Science to the teacher who may be new to teaching it. It is a NASA Connect segment that explores how modern technology studies the many different areas of Earth System Science.
- Foton Labs Earth System Science Video <https://www.youtube.com/watch?v=BJgE7O0i0vk#t=12>
 - This five minute video is an excellent introduction to the interdisciplinary science of ESS. This video is valuable to use as teacher background information, yet would be too difficult and not appropriate for 5th grade students.
 - This storybook can serve as a classroom resource for students or can be used by the teacher as a background information source to see how other educators have introduced Earth system science to their classrooms in the past.
- GLOBE - *Earth Systems Play*:
http://www.globe.gov/documents/348830/350113/ElementaryGLOBE_EarthSystemsActivity3_en.pdf
- *Elementary GLOBE Earth Systems Storybook*:
http://www.globe.gov/documents/348830/350113/ElementaryGLOBE_EarthSystems_en.pdf

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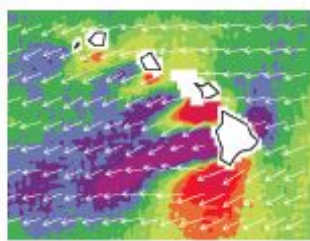
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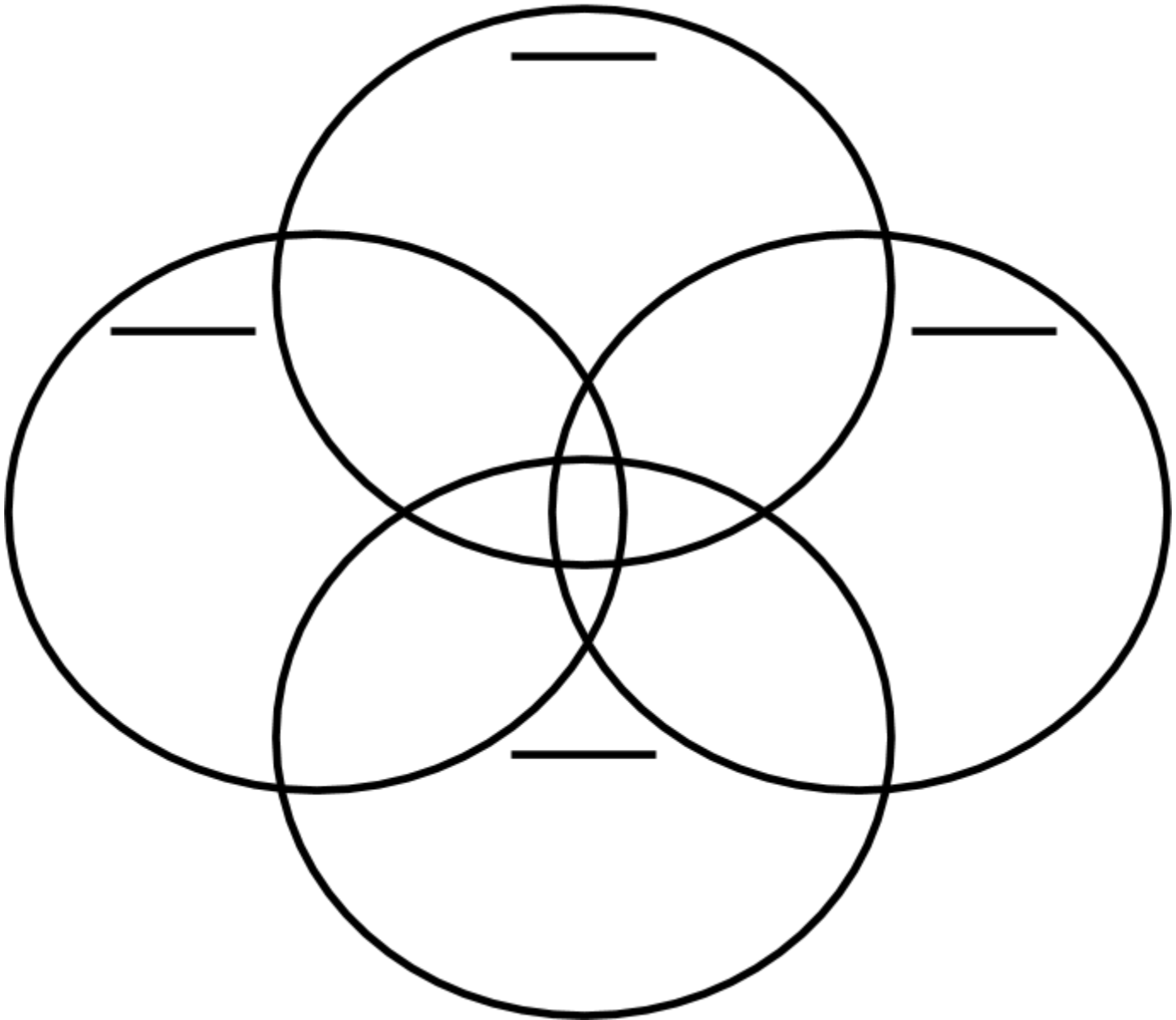
Earth System Science Picture Sort

1. Discuss the ESS pictures with your group and sort them into four categories or spheres.
2. Cut and glue the ESS pictures into the four different spheres on the sorting page.
3. Name each sphere and write the name on the line in the circle.
4. Be prepared to share out with your classmates.



Name: _____ Date: _____

Sorting Page *(not all pictures will fit, do your best)*



EARTH SYSTEM SCIENCE GRAPHIC ORGANIZER

ATMOSPHERE

- Air
- Winds
- Weather
- Climate
- Clouds
- Jet Stream
- Solar Radiation Buffer
- CO₂/O₂ Mixing
- Heat Mixing

HYDROSPHERE

- Water (Liquid, Solid & Gas)
- The Water Cycle
- Oceans
- Lakes & Rivers
- Sea Ice
- Glaciers
- Snow Cover
- Soil Moisture
- Aquifers

The Sun

The energy driver of many of the Earth system interactions.

The Earth

The third planet from the sun with unique properties that allow for life.

The Earth's Core

The energy driver of many of the geosphere's processes.

A Closed System

Earth receives energy from the sun, but very little matter enters or exits our system.

BIOSPHERE

- Plants
- Animals
- Fungi
- Bacteria
- Algae
- Coral Reefs
- Producers, Consumers & Decomposers
- Evolution & Adaptation

GEOSPHERE

- Land
- Plate Tectonics
- Volcanoes
- The Rock Cycle
- Hot Spots
- Sedimentation
- Fossilization
- Earthquakes
- Magnetism

Earth system science is the study of the relationships between air, land, life, and water, *in all its forms*, on our planet. Earth system scientists work to understand these interconnected systems.