National Center
for Earth and Space Science Education

Universities Space Research Association

Introduction to the *Journey through the Universe* Program and the *Earth Systems Science* Module's Grade 9-12 Lessons

1. The Program

Journey through the Universe (http://journeythroughtheuniverse.org) is a national science education initiative that engages *entire* communities—students, teachers, families, and the public—using education programs in space exploration and the space sciences to inspire and captivate. The initiative embraces the notion that—*it takes a community to educate a child.*

Journey through the Universe programming is tailored to a community's strategic needs in science, technology, engineering, and mathematics (STEM) education, and is a framework for partnership between school districts, museums and science centers, colleges and universities, civic and business organizations, and the public. The cornerstone philosophy for all programming is—*inspire… then educate.*

2. The Grade K-12 *Earth Systems Science* Education Module

Earth Systems Science is one of several Education Modules developed for the *Journey through the Universe* program. The Module contains activities at three grade levels (K-4, 5-8, 9-12). Each grade level package is called an **Education Unit.** Each Unit contains lessons comprised of content overviews, inquiry-based hands-on activities, assessment rubrics, resource listings, student worksheet masters, and answer keys.

The *Earth Systems Science* Education Module focuses on the interactions of Earth's four systems: biosphere, atmosphere, hydrosphere, and geosphere. The biosphere encompasses all life, from complex human beings to single-celled organisms. The atmosphere is the shell of gases surrounding the Earth. We live at the bottom of this dynamic ocean of air, which exhibits meteorological phenomena—weather—on both local and global scales. The gaseous water in the atmosphere—together with all Earth's water in every form: solid, liquid, and gas—comprise the hydrosphere. Finally, the vast rocky and metallic bulk of the Earth is defined as the geosphere.

Each of these systems is remarkably dynamic over both long and short timescales. It is also the case that no one system stands alone. Complex processes that shape and define the Earth we know are the means by which these four systems interact with one another. One cannot, for instance, study weather in the atmosphere, or atmospheric evolution, without understanding the dramatic impact on weather from processes involving the geosphere, hydrosphere, and biosphere.

The lessons contained in this Education Module, at every grade level, explore the nature of Earth's systems, and demonstrate that observed phenomena on Earth are not unique to a particular system but arise from the interaction of these systems. And a true understanding of any phenomenon requires an understanding of all four systems. It is a systems approach to Earth science.

The lessons were developed from the ground up from national science education standards and benchmarks. Lessons target core standards and benchmarks through inquiry-based, hands-on activities whose objective is deep conceptual understanding of both content and process.

3. The *Earth Systems Science* Grade 9-12 Lessons

This document provides a description of each lesson and the embedded inquiry-based activities for the *Earth Systems Science* **high school (grade 9-12)** Education Unit. Also provided are connections to grades 9–12 National Science Education Standards.

Earth Systems Science: The 9-12 Education Unit Progression		
Lesson Title	Lesson Description	Activities
Lesson 1: What Is Necessary for Life?	There are many different forms of life on Earth, but they all need the same things. What are they? Students perform two experiments intended to investigate varying conditions for growing plants and bacteria. In the first experiment, students strive for optimal growing conditions for plants. In the second experiment, students grow bacteria in illuminated and dark environments, and discover that life forms can survive without the presence of sunlight. As a result of the experiments, students realize that the necessary resources for life are water, nutrients, and a source of energy. These resources drive the basic biochemical process of life on Earth: the production of sugars through photosynthesis or chemosynthesis. Students examine the flow of resources—nutrients and energy—through food chains in an ecosystem. They discuss how interaction between the Earth systems is essential for maintaining a healthy biosphere.	*Activity 1: Optimal Conditions for Plant Growth;* In this activity, students experiment to determine the optimal growing conditions for plants. *Activity 2: Observing Bacterial Growth*; In this activity, students grow bacteria in light and dark environments, and discover that some forms of life can survive in the absence of sunlight.
Lesson 2: The Irony of Rust	In this lesson, students will investigate the chemistry of rust—the formation of iron oxide (Fe_2O_3)—within a modern context, by experimenting with the conditions under which iron oxide forms. Students will apply what they have learned to deduce the atmospheric chemistry at the time that the sediments, which eventually became common iron ore found in the United States and elsewhere, were deposited. Students will interpret the necessary formation conditions of this iron-bearing rock in the context of Earth's geochemical history and the history of life on Earth.	*Activity 1: Experimenting with Rust*; In this activity students develop and conduct experiments in order to determine what makes iron rust. *Activity 2: Rusting the Ocean Blue;* Students will apply what they have learned to deduce the atmospheric conditions present at the time when banded iron formations formed.
Lesson 3: How Old Is the Earth?	The Earth's age has been estimated using several techniques. Currently, the most accurate technique is radioactive dating. Students will carry out a simulation of radioactive decay and measure half-lives using sugar cubes (or dice). Then students will use an actual naturally-occurring radioactive isotope to measure the radioactivity and calculate its half-life. Finally, students will use radioactive decay data from rocks to calculate the actual age of the Earth.	*Activity 1: Simulate Radioactive Decay Using Sugar Cubes*; In this activity, students develop a model of a radioactive rock and use it to determine its half-life. *Activity 2: Measure the Radioactivity of Potassium;* In this activity, students use a Geiger counter to determine the half-life of an actual substance, No-Salt®. *Activity 3: Calculate the Age of the Earth;* In this activity, students use real radioactive data to determine the age of the Earth.
Lesson 4: Causes and Effects of ENSO	The El Niño Southern Oscillation (ENSO), a phenomenon that takes place every two to seven years in the tropical Pacific Ocean, refers to the occasional warming of surface waters resulting in a reduction of biological productivity in the central and eastern equatorial Pacific Ocean. The atmosphere-hydrosphere coupling that takes place in an ENSO event affects the global biosphere. ENSO events may result in droughts in Indonesia and Africa, forest fires in Australia and northwestern United States, severe tornadoes in southeastern United States, and hurricanes in South America. This lesson allows students to be science investigators by working with sea surface temperature data, interpreting satellite images, and taking the role of policy makers to plan Peru's economic activity in a given year.	*Activity 1: Uncovering Patterns in Satellite Images;* In this activity, students will analyze real satellite data to determine if an El Niño event, La Niña event, or no event will be occuring. *Activity 2: The ENSO Game;* Students will use their conclusion from Activity 1 to plan a budget for Peru.

Connection to Standards

This Education Unit has been mapped to the National Science Education Standards (National Research Council, National Academy Press, Washington, DC, 1996). A complete explanation of the Standards can be found at: http://www.nap.edu/html/nses/html/. Core standards for each lesson are indicated by a "√"; related standards are indicated by an "x."

	Education Standards In Earth Systems Science 9-12 Education Unit								
	National Science Education Standards, 9-12								
	Standard A: Science as Inquiry		Standard B: Physical Science		Standard C: Life Science		Standard D: Earth and Space Science		
	A1: Abilities necessary to do scientific inquiry	A2: Understandings about scientific inquiry	B1: Structure of atoms	B3: Chemical reactions	C4: Interdependence of organisms	C5: Matter, energy, and organization in living systems	D1: Energy in the Earth system	D2: Geochemical cycles	D3: Origin and evolution of the Earth system
Lesson 1: What Is Necessary for Life?	√	√			√	√			
Lesson 2: The Irony of Rust	√	√		√				√	√
Lesson 3: How Old Is the Earth?	√	√	√				x		x
Lesson 4: Causes and Effects of ENSO	√	√					√		