National Center
for Earth and Space Science Education

Universities Space Research Association

Introduction to the *Journey through the Universe* Program, the MESSENGER Education and Public Outreach Program, and the MESSENGER Education Module *Staying Cool* Grade 9–12 Lessons

1. The Programs

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.*

NASA's MESSENGER Spacecraft Mission to Mercury (http://messenger.jhuapl.edu} includes education programs delivered by organizations nationally. The National Center for Earth and Space Science Education oversees a number of these programs, including: 1) the development of middle and high school components for grade pre-K-12 MESSENGER Education Modules—each a theme-based compendium of inquiry-based lessons on Solar System science and exploration (the Carnegie Institution of Washington is responsible for the grades pre-K-4 component); 2) delivery of Solar System content through community initiatives such as *Journey through the Universe*, and 3) the creation, training, and support of a cadre of master science educators—the MESSENGER Educator Fellows—which in turn train 3,000 teachers a year on the Modules, corresponding to 27,000 teachers trained over the mission lifetime (through 2012), and translating into experiences for over 1 million students.

2. The Grade pre-K-12 MESSENGER Education Module *Staying Cool*

The MESSENGER Education Module *Staying Cool* focuses on the process of scientific inquiry as applied to engineering problems in planetary exploration. The lessons specifically address the extreme conditions of the space environment, the problems these conditions pose for spacecraft, and the engineering solutions to these problems. Lessons explore how MESSENGER—or any other spacecraft—can use sunlight and other forms of radiation to meet the scientific goals of the mission, while still protecting the instruments and other sensitive parts of the spacecraft from too much sunlight and radiation.

The MESSENGER Education Module *Staying Cool* includes grade level components at three grade levels: elementary (pre-K–4); middle (5–8); and high school (9–12). Each component contains lessons comprised of content overviews, inquiry-based hands-on activities, assessment rubrics, resource listings, student worksheet masters, and answer keys.

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 *Staying Cool* Grade 9-12 Lessons

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

Staying Cool: The 9-12 Grade Level Component Progression		
Lesson Title	Lesson Description	Activities
Lesson 1: Star Power! Discovering the Power of Sunlight	Students estimate the energy output of the Sun using a simple device and discover how much power sunlight provides to Earth. They also estimate what the effect closer to the Sun—at the distance of Mercury—might be. Sunlight and the rest of the electromagnetic spectrum are the main tools with which we study objects in the Solar System.	*Activity:* Students will measure the temperature change in a bottle of water as it is exposed to sunlight. Using this data and other parameters of the experiment, they calculate the solar constant, which is the amount of energy the Earth receives from the Sun per square meter per second.
Lesson 2: Dangers of Radiation Exposure	Radiation can affect living and mechanical things on Earth as well as in space. By estimating their yearly exposure rate to harmful high-energy radiation and cumulative effects over time, students can evaluate the various sources of radiation that are of greatest concern. Since MESSENGER will be subjected to much more intense radiation near Mercury than what a spacecraft near Earth experiences, students also discuss how solar radiation can be an important source of damage and destruction.	*Activity:* Students calculate their exposure to ionizing radiation during the previous year. They are given a list of various types and the amount of ionizing radiation they may experience throughout the year. They are asked to estimate their exposure and discuss their results. This will help the students determine whether high-energy radiation is something they should be concerned with in their daily lives.
Lesson 3: Cooling with Sunshades	After discussing basic properties of temperature and heat, and different ways in which heat can affect substances, students design a simple protective device (sunshade) against excessive sunlight. They also discuss how MESSENGER uses a sunshade to keep comfortable at Mercury's distance from the Sun.	*Activity:* Students will construct a simple device to examine how substances can be protected from sunlight. They place an ice-water mixture in a coffee can and use a sunshade to protect the contents from sunlight. Based on the amount of ice that melts during the experiment (and their understanding that this is a way to measure how much heat energy the ice-water mixture receives), the effectiveness of their shade can be estimated.
Design Challenge: How to Keep Items Cool in Boiling Water?	Design Challenges provide motivating experiences for students by incorporating problem-solving, scientific approach, and cooperative teamwork into a standards-based activity. Focusing on real-life situations, Design Challenges give students the chance to deal with many of the same issues with which scientists and engineers are confronted when they plan spacecraft missions such as MESSENGER. In this Design Challenge, students will design and construct a container that can keep items cool when placed in boiling water.	*Activity:* Students will design and construct a container that will be placed in boiling water. A pat of butter will be placed in the container, and the container then submerged in boiling water. The goal is to keep the temperature inside the container as cool as possible and prevent the butter from melting.

Connection to Standards

This Education Unit has been mapped to the National Science Education Standards (National Research Council, National Academy Press, Washington, DC, 1996) and to the Benchmarks for Science Literacy, (American Association for the Advancement of Science, Project 2061, Oxford University Press, New York, 1993). A complete explanation of the Standards can be found at: http://www.nap.edu/html/nses/html/. A complete explanation of the Benchmarks can be found at: http://www.project2061.org/tools/benchol/bolintro.htm. Core standards for each lesson are indicated by a "√"; related standards are indicated by an "x."

Education Standards In Staying Cool
9-12 Grade Level Component

	National Science Education Standards								AAAS Benchmarks for Science Literacy					
	Standard A: Science as Inquiry		Standard B: Physical Science		Standard D: Earth and Space Science	Standard E: Science and Technology	Standard F: Science in Personal and Social Perspectives		Benchmark 1: The Nature of Science		Benchmark 4: The Physical Setting	Benchmark 8: The Designed World	Benchmark 10: Historical Perspective	Benchmark 12: Habits of Mind
	Abilities necessary to do scientific inquiry	Understanding about scientific inquiry	Conservation of energy and increase in disorder	Interactions of energy and matter	Energy in the Earth system	Abilities of technological design	Nature and human-induced hazards	Science and technology in local, national, and global challenges	Scientific inquiry	The scientific enterprise	Energy transformations	Materials and manufacturing	Splitting the atom	Values and attitudes
Lesson 1: Star Power! Discovering the Power of Sunlight	x	x	x	√	x						√			
Lesson 2: Dangers of Radiation Exposure	x	x					√			√			√	
Lesson 3: Cooling with Sunshades	x	x	√			x		x			√	√		
Design Challenge: How to Keep Items Cool in Boiling Water?		√				√			√					√