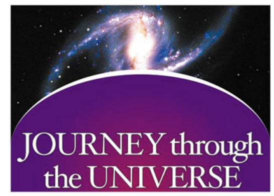
Introduction to the *Journey through the Universe* Program, the *Voyage* Program, and the *Voyage* Grade 5-8 Lessons

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.*

Voyage: a Journey Through Our Solar System (http://voyagesolarsystem.org) is a one to ten billion scale model of the Solar System exhibition that was permanently installed on the National Mall in Washington, DC, in October 2001. The greater *Voyage* Program includes the exhibition on the National Mall; replicas of the exhibition available for permanent installation in communities worldwide—designated *Voyage Communities*; and programming in Solar System science and exploration for thousands of students, educators, and families available to each of the *Voyage Communities*. The programming is provided through *Journey through the Universe*, and supported by a grade K-12 compendium of lessons—the ***Voyage* Education Module**.

2. The Grade K-12 *Voyage* Education Module

The *Voyage* Education Module includes an **Education Unit** at four grade levels: lower elementary (K-2); upper elementary (3-4); middle (5-8); and high school (9-12). Each Unit 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, and are comprehensive enough to be adopted by school districts as the space science curriculum. Lessons target core standards and benchmarks through inquiry-based, hands-on activities whose objective is deep conceptual understanding of both content and process. The lessons are also meant to work in concert with a trip to a *Voyage* exhibition, serving as pre- and post-visit activities.

3. The *Voyage* Grade 5-8 Lessons

This document provides a description of each lesson and the embedded inquiry-based activities for the *Voyage* **middle school (grade 5-8)** Education Unit. Also provided are connections to National Science Education Standards for grades 5-8, and AAAS Benchmarks for Science Literacy for grades 6-8.

VOYAGE for Education: The 5-8 Unit Progression		
Lessons 1-3 are found in the *Voyage* Education Module for the *Journey through the Universe* Program. Lessons 4-10 are additional lessons found in *The Voyage Continues*. Lesson 9 is not yet available.		
Lesson Title	The 5-8 Story	Activities
Lesson 1: Our Solar System	In this lesson, students tour the Solar System. They examine and define its various components—the Sun, planets, moons, comets, asteroids, and Kuiper Belt Objects. They recognize that the Solar System is the family of the Sun, an average star, and other stars have families of their own. Taking a close look at the planets they find that characteristics like size, location, composition, and presence of rings and moons, reveal two major categories of planets—terrestrial (Earth-like) and Jovian (Jupiter-like). But tiny Pluto seems to be in a class all its own, perhaps the largest of the many ice worlds discovered beyond Neptune.	*Activity 1: Solar System Catalog*; Students will create a catalog for the components in the Solar System. Through their research and class discussion, students will come up with a class-wide definition of each component. *Activity 2: What a Wonderful World*; Students will research one planet in depth. Students will use their research to create a travel brochure for that planet.
Lesson 2: *Voyage* of Discovery	Models are powerful tools of exploration, especially as students investigate the size and distance relationships between the Sun and the planets in the Solar System. Examining the relative sizes of the planets using models at a one to ten billion scale, students realize that the Earth, the biggest thing they have ever touched, is quite small in comparison to the Sun and some of the other planets. Moving outdoors, students then create a one to ten billion scale model of the Solar System. Walking through their model as cosmic giants, students are awed by the tiny worlds in a vast space, and gain a new appreciation for Earth, their home.	*Activity 1: Exploring Planet Sizes;* Students will make predictions about the sizes of the planets in the Solar System, including the Earth, on a one to ten billion scale using models. Students will compare the size of the Earth to the other planets, and realize that the Earth is a rather small planet. *Activity 2: Making a Scale Model of Our Solar System*; Students will create a scale model of the Solar System that is one 10-billionth actual size to investigate the relative sizes of the Sun and planets, and the distances between them.
Lesson 3: How Far Is Far?	Students will determine the actual distance to the Sun and the Moon without ever leaving the Earth, and in doing so will gain a better understanding of the huge distances in the Earth-Sun-Moon system. In order to determine these distances, students will apply their understanding of mathematical models in two different ways, using a single mathematical principle.	*Activity 1: Sun – Ruler of the Solar System;* In this activity, students create a pinhole tube and use it to make a model of the Sun. They will then use this model and similar triangles to determine the distance from the schoolyard to the Sun. *Activity 2: A Model Moon;* In this activity, students will create a Moon-viewer and use it, along with models and the principle of similar triangles (which they learned in Activity 1), to determine the distance to the Moon.
Lesson 4: Going through a Phase	The varying appearance of the Moon over the course of a month results from changes in the relative positions of the Earth, Moon, and Sun. In the first Activity, daily observations of the Moon over many weeks allow the phase cycle to be observed and characterized, and an explanation to be hypothesized. The hypothesis is tested in the second Activity where students construct a working model of the Earth-Moon-Sun system and determine if they can recreate the observed phase cycle. To truly develop a conceptual understanding of the phenomenon, students explore whether the Earth should exhibit a phase cycle as seen from the Moon, and whether an Earth observer should see other planets exhibiting phase cycles.	*Activity 1: Viewing the Moon;* This activity focuses students' attention on the appearance of the Moon, and the observed changes over a month. Most students only have a rudimentary understanding of this obvious phenomenon in the night sky. After observing the phase cycle they will hypothesize why it occurs, and see if their hypothesis is correct in Activity 2. *Activity 2: The Earth-Moon-Sun System;* Students will construct a small model of the Moon's orbit around Earth. Light from an overhead projector will be used to represent light from the Sun. By moving a model Moon in its orbit around Earth, students will be able to see the phases of the Moon and gain a conceptual understanding of the phenomenon.

VOYAGE for Education: The 5-8 Unit Progression		
Lesson Title	The 5-8 Story	Activities
Lesson 5: Round and Round We Go – Exploring Orbits in the Solar System	To appreciate the complexity of the Solar System requires an understanding that it is a dynamic system—a system in motion. Objects bound to the Sun by gravity—planets, dwarf planets, comets, asteroids, and Trans-neptunian (or Kuiper Belt Objects)—follow elliptical orbits around the Sun. Students first explore the geometric nature of ellipses, and the circle as a special case. These newly developed mathematical skills are then used to plot an accurate model of the outer Solar System, which contains the size, eccentricity, and orientation in space of the orbits for different classes of objects. Students are then able to understand how orbits can be used to help categorize objects in the Solar System.	*Activity 1: Ellipses Are Eccentric!*; Students will learn how to draw ellipses using a length of string whose ends are connected to two points in space (the foci). Students will explore how the geometry of an ellipse changes by varying the length of the string (equal to the length of the ellipse's major axis) and varying the distance between the foci. *Activity 2: The Eccentricity of Solar System Objects—How Crazy Are They?*; Students will plot the elliptical orbits of different classes of objects in the outer Solar System. Students will then examine how the orbits of the planets are different from one another, and how planetary orbits are different from other classes of objects.
Lesson 6: Where To Look For Life?	It is the most exciting question one can ask of the Solar System—is life unique to Earth, or are there abodes of life on other planets—even moons? A starting point is concluding that life as we know it requires liquid water. Given this constraint, in the first Activity students explore a mathematical model for how temperature varies with distance from the Sun. It allows them to find the 'happy place' for possible life—the range in distance from the Sun within which a planet might contain liquid water. At first glance, it appears only Earth exists within this range. Students then plot the actual observed temperatures for planets and moons, which demonstrates that more than just distance from the Sun accounts for planetary temperature, leading to potentially many abodes of life in the Solar System. In the second Activity students research the broader requirements for an abode of life, and whether these requirements are found on other worlds.	*Activity 1: Happy Places;* Students will first predict, then graph, the expected temperature of an object at increasing distances from the Sun. Students then identify the range in distance from the Sun within which liquid water can exist, and determine which planets are found in this range. On their graphs students then plot the actual observed temperatures of planets and moons, and determine that temperature on these worlds does not behave as predicted—which allows for the possibility of many abodes of life in the Solar System. *Activity 2: Earth vs. Other Worlds;* Students will identify the characteristics of Earth that are important for life as we know it, in addition to the presence of liquid water. They then research the planets and some of the moons of the Solar System to see if these worlds also possess the necessary characteristics, and might therefore be promising places to look for life.
Lesson 7: Is There Anyone Out There?	Once scientists have determined where they want to look for life in the Solar System, the next step is to figure out how it is to be done. In this lesson, students first create an operational definition of life, and put it to the test by observing a mystery object. They then define and conduct an experiment, modeled after the life science experiments performed by the Viking Landers on the surface of Mars, to determine if they have discovered life forms in simulated Martian soil samples. The experiment is a simple but dramatic model exploring the differences between chemical and biochemical reactions—which is key to revealing the presence of life.	*Activity 1: Is It Alive?;* Students will be given mystery objects that they tend for several days. Students will observe their objects, note any changes, and conclude whether or not the objects are alive. Students then use these observations to refine their original list of characteristics possessed by life. *Activity 2: Searching for Signs of Life;* Students will perform experiments on simulated Martian soil samples to try and determine if life is present. Students "feed" the samples and observe them for signs of any reaction. The nature of the observed reaction is then used to discern if it is a telltale sign of life. This activity is modeled after the life science experiments conducted by the Viking 1 and 2 Landers on the surface of Mars in the mid- to late 1970s.

VOYAGE for Education: The 5-8 Unit Progression		
Lesson Title	The 5-8 Story	Activities
Lesson 8: Comets: Bringers of Life?	Comets are an important class of objects found in the Solar System. Created at the time of Solar System formation, these "dirty snowballs"—each the size of a city—have remained virtually unchanged for billions of years in the cold outer reaches of the Solar System. Their composition therefore provides clues as to how the Solar System was born, and comet impacts on the early Earth may have been the source of the molecules needed for the formation of life—organic molecules. In the first Activity, students explore the relative abundance of different atoms in the universe, and the molecules that are created from these atoms. In the second Activity, students combine ingredients composed of these molecules to build a good physical model of a comet. The model provides an understanding of cometary composition and structure, and how comets behave when some make a rare trip into the inner Solar System and interact with the Sun.	*Activity 1: A Handful of the Universe;* Students will use a model of the composition of the universe to determine the relative abundance of different atoms. Students then explore which molecules can be created from these atoms. *Activity 2: Cookin' Up a Comet;* Students will create a physical model of a comet from ingredients representing the molecular composition of the cloud from which the Solar System was born—the solar nebula. The model will provide an understanding of cometary composition and structure, and how comets behave when they interact with the Sun.
Lesson 9: Asteroids and Meteorites	Asteroids are a class of small rocky and metallic bodies in the Solar System located mostly between the orbits of Mar and Jupiter in the "Asteroid Belt". They are believed to be remnants of the Solar System's formation billions of years ago. Meteorites are rocks picked up on the surface of Earth that are known to have arrived from space, and most are believed to be asteroidal debris. The study of asteroids and meteorites therefore provides clues to the formation and evolution of the Solar System.	*Activities TBD*
Lesson 10: Impact Craters: A Look at the Past	The countless craters, big and small, that are found on the surfaces of planets and moons record a violent history of collisions across the entire Solar System. It is a story that spans billions of years. Studies of craters—their shapes, sizes, number in a given area, and whether they are superimposed upon or beneath other geologic features—provide an understanding of how this story may have unfolded. In the first Activity students simulate how impact craters are formed, and how the appearance of a crater depends on the energy of the impacting object. In the second Activity, photographs of the cratered surfaces of other worlds are examined to reveal information about a world's history, and the history of the entire Solar System.	*Activity 1: Creating Craters;* Students will simulate crater impacts by dropping pebbles or marbles into a pan of flour and cocoa. The effect of increasing the energy of impact—by dropping the same object from a greater height—on crater appearance will be explored. Students then identify the basic characteristics of their impact craters, and compare their craters to the picture of a crater on the Moon. *Activity 2: Craters in the Solar System;* Students will examine impact craters on different worlds in the Solar System and discover that craters can reveal a great deal about the nature and history of the worlds' surfaces.

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 Voyage: A Journey Through Our Solar System: 5-8 Education Unit												
	National Science Education Standards, 5-8							AAAS Benchmarks for Science Literacy, 6-8					
	Standard A: Science as Inquiry	Standard B: Physical Scienced	Standard C: Life Science		Standard D: Earth and Space Science			Benchmark 1: The Nature of Science	Benchmark 2: The Nature of Mathematics	Benchmark 4: The Physical Setting			Benchmark 5: The Living Environment
	A1: Abilities necessary to do scientific inquiry	B3: Transfer of Energy	C3: Regulation and Behavior	C5: Diversity and adaptations of organisms	D1: Structure of the earth system	D2: Earth's HIstory	D3: Earth in the Solar System	1B: Scientific Inquiry	2B: Mathematics, Science, and Technology	4A: The Universe	4B: The Earth	4C: Processes that Shape the Earth	5C: Cells
Our Solar System							√			√			
Voyage of Discovery							√			x	√		
How Far is Far?	√						√		√	√			
Going through a Phase							√	√			√		
Round and Round We Go—Exploring Orbits in the Solar System							√			√			
Where to Look for Life?		√					√				√		
Is There Anyone Out There?			√	√									√
Comets: Bringers of Life?						√	√			√			
Asteroids and Meteorites													
Impact Craters: A Look at the Past					√	√						√	