JOURNEY through the UNIVERSE

Voyage: A Journey Through Our Solar System

Supplementary Grade 5-8 Lessons for the Voyage Education Module

On October 17, 2001, a one to ten billion scale model of the Solar System was permanently installed on the National Mall in Washington, DC. The *Voyage* exhibition stretches nearly half a mile from the National Air and Space Museum to the Smithsonian's Castle Building. *Voyage* is a celebration of what we know of Earth's place in space and our ability to explore beyond the confines of this tiny world. It is a celebration worthy of the National Mall. Take the *Voyage* at www.voyageonline.org, and consider a Voyage exhibition for permanent installation in your own community.

A grade K-12 compendium of lessons—the *Voyage Education Module*—was developed to bring the *Voyage* experience to classrooms across the nation through the *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier.

This document provides supplementary grade 5-8 lessons for the *Voyage Education Module*.

Voyage and Journey through the Universe are programs of the National Center for Earth and Space Science Education, Universities Space Research Association (www.usra.edu). The Voyage Exhibition on the National Mall was developed by Challenger Center for Space Science Education, the Smithsonian Institution, and NASA.

Journey through the Universe Program Team

National Center for Earth and Space Science Education
1101 17th Street NW, Suite 1004, Washington, DC, 20036
202-689-1295 Fax: 202-689-1297
Jeffrey J. Goldstein, Ph.D., Center Director
Stacy Richards, Co-Director, Education Programs
John P. Hamel, Program Manager
Timothy Livengood, Ph.D., Senior Space Science Researcher
Harri A.T. Vanhala, Ph.D., Space Science Researcher
Elizabeth A. Miller, Science Education Specialist
Kenneth Pulkkinen, M.S., Science Content Specialist

Voyage: A Journey Through Our Solar System
Education Module Development Team

Jeffrey J. Goldstein, Ph.D., Center Director
Harri A.T. Vanhala, Ph.D., Co-principal Author, 5-8 Education Unit
Elizabeth A. Miller, Co-princvipal Author, 5-8 Education Unit
Kenneth Pulkkinen, M.S., Co-principal Author, 5-8 Education Unit
Mary L. Radnofsky, Ph.D., Principal Author, K-2, 3-4 Education Units
Matthew Bobrowsky, Ph.D., Principal Author, 9-12 Education Unit
Amy Wolfe, Ed.M., Co-principal Author, 5-8 Education Unit
Timothy A. Livengood, Ph.D., Science Review
Leisa Clark, M.A., Education Review
Jason W. Smith, M.S., Education Review
Karen Offringa, M.Ed., Writer/Editor
Jennifer King, Graphics Design

Special Thanks

Many thanks to the following educators for field-testing and reviewing lessons in this Education Module:

Cora Kelly Magnet School, Alexandria, VA
Ms. Melissa Cerami
Mrs. Markell Thorne
Mr. Timothy Grasso
Ms. Caryn Sonberg
Ms. Kathy McElvain
Mrs. Katy Pattarini

Patrick Henry Elementary School, Arlington, VA
Mr. Kim-Scott Miller

Williamsburg Middle School, Arlington, VA
Katherine Templin, M.Ed.

T.C. Williams High School, Alexandria, VA

Minnie Howard Ninth Grade Center, Alexandria, VA

Thomas Jefferson High School for Science & Technology, Alexandria, VA

Central Middle School, Iron Mountain, MI
Mr. Milt Wirth

Introduction to Journey through the Universe, The Voyage Program, and the Voyage Education Module

Journey through the Universe is an initiative launched in 1999 to establish and support a network of communities through the use of educational programming and curricular resources in the Earth and space sciences, and human space flight. Each community uses these resources to address their strategic educational goals in STEM disciplines (science, technology, engineering, and mathematics) in both formal (classroom) and informal (public) venues. The systemic and sustainable programming resulting from this partnership is meant to engage thousands of teachers, students, and families across the community, reflect the strengths and capabilities of the community, and provide access to resources that would otherwise be unavailable.

Voyage: a Journey Through Our Solar System 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 in 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*. Take the *Voyage* at www.voyageonline.org, and consider becoming a *Voyage Community*.

The *Voyage Education Module* contains lessons for grades K-2, 3-4, 5-8, and 9-12. 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. Activities for families extend the experience to the home.

This document provides supplementary grade 5-8 lessons for the *Voyage Education Module*.

This section provides the lesson layout and associated definitions; the story behind each lesson and across each grade level; and the lessons' connections to the standards.

Voyage and *Journey through the Universe* are programs of the National Center for Earth and Space Science Education, Universities Space Research Association (www.usra.edu). The Voyage Exhibition on the National Mall was developed by Challenger Center for Space Science Education, the Smithsonian Institution, and NASA.

The Journey through the Universe Program

Program Overview

Each year, the National Center for Earth and Space Science Education's *Journey through the Universe* program launches tens of thousands of everyday people—teachers and students, moms, dads, and caregivers—on a fantastic journey through our Universe.

Funded by grants from NASA's Minority University Research and Education Program, and Science Missions Directorate, *Journey through the Universe* uses the Earth and space sciences, and human space flight, within an interdisciplinary context, to engage entire communities in the wonders of the cosmos. This journey is not meant to be simply inspirational—this unique and innovative program is used to increase scientific awareness community-wide with programs for the K-12 classroom and for the general public.

On an ongoing basis, the National Center for Earth and Space Science Education (NCESSE) provides communities with original programming, comprehensive materials, and a supportive network of scientists and educators. Participants integrate these offerings in a manner that best complements the strengths, needs, and resources of their community. Furthermore, they are networked with other *Journey through the Universe* participants in a manner that encourages intercommunity mentoring and communication. *Journey through the Universe* communities are empowered to develop sustainable and lasting collaborations between area schools, museums, science centers, businesses, and civic organizations.

Core Program Goals

Journey through the Universe embraces a set of core goals that are integrated into all program components. These are:

1. Use human space flight and the Earth and space sciences to take entire communities on a journey of exploration by providing students, educators, and families a window on the Universe, the nature of science, and the lives of modern-day explorers.

2. Provide participants a conceptual understanding of what we know about Earth's place in space and how we've come to know it, and in a manner fully consistent with national science, technology engineering, and mathematics standards, and curricular reform efforts.

3. In the context of science, mathematics, and technology education, facilitate sustainable intra-community linkages between school districts. This includes links to museums, science centers, and planetaria. This would also include links between grade K-12 educators, and with local area researchers, amateur astronomers, business and civic organizations, and with the general public.

4. Facilitate family learning, with extensive participation by mothers, as well as reaching groups such as women and minorities, historically under-represented in the fields of science and technology.

5. Target communities either with limited assets in human space flight and Earth and space science education, or with assets that are not utilized community-wide. This includes, but is not limited to rural and low-income urban settings.

6. Create a deep sense of community-wide ownership in the *Journey through the Universe* initiative, and facilitate joint programming between participating communities.

7. Provide communities ongoing access to national networks and resources relevant to space flight and space science education.

Journey through the Universe Week Overview

What would it be like to take an entire community on a journey from spaceship Earth to places unknown? Imagine:

- Parents and their children exploring the great frontiers, as families.
- Teachers from across a region learning how to bring the Universe and human exploration alive in the classroom.
- Scientists and engineers, gifted at communicating their passion to kids and adults alike, sharing stories of their own explorations during classroom visits and unique after-school field trips designed for families.

These elements are all central to *Journey Week*, a community-wide celebration of exploration on the great frontiers, which serves as the launch pad for a community's involvement with the program. The week is conducted by a national team of space scientists, engineers, and educators who travel to the community. Featuring educator workshops, Family Science Nights, and in-school visits by space scientists and engineers, *Journey Week* immerses an entire community in science education.

Educator Workshop

Typically, at the beginning of each *Journey Week*, an NC-SEFSE researcher and educator conduct Educator Workshops on space-themed Education Modules for 100-200 K-12 educators. Each Education Module contains units for elementary, middle, and high school students, and includes a series of activities for use in the classroom and at home. Each Module is framed around cross-disciplinary space flight or space science themes (e.g., building a permanent human presence in space, the search for life in the Universe).

During the Educator Workshop, the Modules' inquiry-based content is reviewed, hands-on activities from the Module are conducted by teachers, and a researcher reviews the science content in the lessons.

Family Science Nights

Two to three Family Science Nights during *Journey Week* provide a journey to the frontier for thousands of parents and their children. It is a family learning experience dealing with exciting space science topics that are connected to the curriculum. A space scientist or engineer on the National Team who is gifted at talking to audiences of all ages and who is passionate about exploration takes families to the stars. The presenter engages and interacts with the audience in a program that is more akin to a performance than a presentation.

Family Science Nights are usually held in museums, science centers, or high school auditoria, for audiences of 500-1,000. With the curricular connection, Family Science Night provides parents a window on the education of their children. Family Science Night also gives schools a wonderful opportunity to build bridges to the community, and gives researchers a chance to share what it's like working on the space frontier.

Classroom Visits

During *Journey Week*, 4,000-8,000 K-12 students meet and talk with scientists and engineers involved in the study of human space flight and the space sciences. These 'Visiting Researchers' travel to dozens of schools during school hours to discuss the nature of their research, the process of science, and what it is like to work on the frontier. Students are actively engaged and encouraged to ask questions of the Visiting Researcher. These visits enhance the space science curriculum taught in the classroom, provide a human face to research, and foster attendance at the Family Science Nights.

The Voyage Program

Voyage, a Journey Through Our Solar System

Voyage, a Journey Through Our Solar System is a 1:10-billion scale model of the Solar System that was permanently installed in Washington, DC, in October 2001. Stretching 600 meters (650 yards) from the National Air and Space Museum to the Smithsonian Castle, *Voyage* illustrates that Earth is but one small body within a vast system of worlds bound to the Sun. On the *Voyage* scale, the Sun is about the size of a large grapefruit; Earth is 15 meters (50 feet) away, and smaller than the head of a pin. The entire orbit of the Moon fits comfortably in the palm of your hand. Pluto, the farthest planet, is 600 meters (approximately 2000 feet or 6.5 football fields) away from the Sun. The nearest star to the Sun would be the size of a cherry in coastal California.

The entire *Voyage* project actually consists of:

- The permanent 1:10-billion scale model exhibition of the Solar System on the National Mall.
- Replicas of the exhibition to be installed in communities across the world.
- A *Voyage* web site.
- A grade K-12 *Voyage* Education Module which contains a number of inquiry-based, hands-on lessons which align with the National Science Education Standards and Project 2061's Benchmarks for Science Literacy.

The mission of the *Voyage* project is:

- To change people's perspectives of Earth's place in the Solar System and the Sun's place among the stars;
- To change people's perspectives of the human capability to explore;
- To change people's perspectives of themselves as individual explorers.

All the different aspects of the *Voyage* project address these mission goals. First, the outdoor educational exhibition of *Voyage* offers a new perspective of our Solar System at a time when space exploration is progressing at a rapid pace, and when a permanent human presence in Earth orbit is forthcoming. *Voyage* is framed around a highly accurate model that maintains the same scale for both planetary size and distance, fostering a clear understanding of Earth's place in the Solar System. People can walk through the model and experience the relative sizes of the model worlds in relation to the vast distances between them. (Other model Solar Systems often present the planetary sizes in one scale and the distances in another, thus perpetuating common misconceptions.)

Fundamental to the *Voyage* exhibition is the use of a model as a powerful tool of exploration. Just as a globe of Earth provides a context for understanding our planet, *Voyage* places Earth itself in a greater context. By portraying the great distances humans have traveled, and by placing Earth within the "geography" of local space, *Voyage* can dramatically change our perspective of our place in the cosmos and of human capabilities to explore. Replicas of *Voyage*, as well as the *Voyage* web site, will help spread this understanding to communities around the globe.

The grade K-12 *Voyage* Educational Module grew out of an understanding of children's propensity to ask questions about the natural phenomena they encounter on a daily basis. Scientists are explorers of their world just as are children, forever asking new questions of each other, of themselves, and of the phenomena they observe. Scientists risk being wrong, but they persevere in seeking possible explanations for human behavior, natural phenomena, and the workings of machines in both the visible and the invisible realms. Children must learn the same fearlessness in seeking to understand this world, even at the risk of developing an hypothesis that may be overturned by another discovery someday. It is all a part of the path to understanding who we are, why we do what we do, and where we fit into the scheme of things.

Voyage has been carefully correlated to national educational standards, which stress the value of using an investigative approach to learning science. This includes recognizing diverse methods of inquiry, developing a scientific "habit of mind" through the critical and logical processes of induction and deduction, and constructing a firm understanding of the practice of science as a "human endeavor."

Models as Powerful Tools of Exploration

Central to the *Voyage* project is the idea of enhancing students' understanding of our place in the Universe through the exploration of models. We recognize that this work begins with young children as they navigate their own personal spheres of family, school, neighborhood, and beyond.

For example, if we wanted to explore our state, we could go out and do extensive driving and hiking. Alternatively, we could look at a map. A map is quite simply a model of the state. All the information we might learn from our drive could, in fact, be placed on the map. The point is that studying a model of the real thing or place gives us the power to explore it without necessarily going there. In addition, the model can rapidly provide a wealth of information, allowing us to efficiently identify what interests us.

Generally speaking, when we create models of something vastly bigger or smaller than ourselves, we make the model to be about our size, so that we can move it around and interact with it comfortably. The scale of the model indicates how much smaller or larger the model is compared to the real thing. Scale in the classical sense is a ratio of the model's size to the real object's size, or by extension, any model dimension to any real dimension. In the case of *Voyage*, the 1:10,000,000,000 scale is actually a compromise. The worlds of the Solar System are quite small compared to the space between them, and yet *Voyage* can still portray them visibly on the same scale as their distances from the Sun.

Voyage serves as the foundation for creating a "community of science learners" by providing an innovative space science curriculum, accompanied by expert-recommended teaching strategies and developmentally-appropriate K-12 activities for children. In each *Voyage* educational unit, we offer ideas for creating a classroom that ensures children participate in a physical and intellectual environment conducive to safe and interesting investigations, discovery, evaluations, and reflection in science. We give teachers the choice between a variety of instructional sequences and assessment options for special populations including Talented and Gifted, English as a Second Language, and Special Education students.

Most important, the *Voyage* curriculum includes daily strategies to facilitate transfer of knowledge, wherein students use their conceptual understanding in a given context to construct new knowledge that will help them make sense of—and even be able to predict—new phenomena and situations. This "transfer" element of the curriculum is essential in confirming the true acquisition of knowledge, as opposed to the mere memorization of facts and figures.

Teacher's Role

The *Voyage* materials allow teachers to fulfill their responsibility to create an environment conducive to helping children better understand science through safe exploration, experimentation, learning from mistakes, discovery, individual and team work, and reflection. Teachers serve as facilitators, guides in asking the right questions as well as finding the best answers. They model the behavior of a real investigator who does not always have all the answers. In their investigative roles, teachers are also responsible for gathering classroom data on the teaching and learning processes. These data should be shared with other teachers and educational experts by electronic means (email, chat rooms, bulletin boards, etc.) or in conferences, committee meetings, publications, and focus groups.

Students' Responsibilities

Voyage offers multiple opportunities for children to work both individually and in groups, as they take an active role in their own education. Such a role is necessary for high quality learning, facilitated by teachers who introduce students to strategies of investigation, exploration, constructing meaning, documenting, demonstrating, and reflecting on results as they move along their educational journey.

How to Use This Education Module

This Education Module provides detailed lesson plans for teachers, and the core content for *Journey Week* activities. The Module is consistent with the National Research Council National Science Education Standards and the American Association for the Advancement of Science Benchmarks for Science Literacy. Each developmentally appropriate lesson requires skills relevant to students' lives. The lessons cover a variety of learning styles and knowledge acquisition processes, while encouraging students through hands-on learning and inquiry-based activities.

Each Lesson within the Education Module has been instructionally designed with a variety of components, each serving a specific function as a means of delivering a comprehensive and powerful inquiry-based lesson. The following pages offer teachers an explanation of each section in a Lesson.

Lesson Layout

Lesson with One Activity

I. Lesson at a Glance
- Grade Level
- Lesson Duration
- Lesson Overview
- Education Standards
- Essential Question(s)
- Concepts
- Objectives

II. Science Overview

III. Conducting the Lesson
- Warm-Up & Pre-Assessment
  - *Materials*
  - *Preparation & Procedures*
- Activity: Title
  - *Description of Activity*
  - *Materials*
  - *Preparation & Procedures*
  - *Reflection & Discussion*
  - *Transfer of Knowledge*
  - *Assessment Criteria*
  - *Extensions (Optional)*
  - *Placing the Activity Within the Lesson*
- Lesson Wrap-Up
  - *Lesson Closure*

The following are floating components that may be placed throughout the lesson as needed.
- *Teaching Tips*
- *Lesson Adaptations*
- *Curriculum Connections*

IV. Resources
- Internet Resources & References
- Acknowledgments (Optional)
- Additional Resources (Optional)
- Teacher Answer Keys
- Student Worksheets

Lesson Layout

Lesson with Two Activities

I. Lesson at a Glance

- Grade Level
- Lesson Duration
- Lesson Overview
- Education Standards
- Essential Question(s)
- Concepts
- Objectives

II. Science Overview

III. Conducting the Lesson

- Warm-Up & Pre-Assessment
    - *Materials*
    - *Preparation & Procedures*
- Activity 1: Title
    - *Description of Activity*
    - *Materials*
    - *Preparation & Procedures*
    - *Reflection & Discussion*
    - *Transfer of Knowledge*
    - *Assessment Criteria*
    - *Extensions (Optional)*
    - *Placing the Activity Within the Lesson*
- Activity 2: Title
    - *Description of Activity*
    - *Materials*
    - *Preparation & Procedures*
    - *Reflection & Discussion*
    - *Transfer of Knowledge*
    - *Assessment Criteria*
    - *Extensions (Optional)*
    - *Placing the Activity Within the Lesson*

Lesson Wrap-Up

Transfer of Knowledge for the Lesson

Assessment Criteria for the Lesson

Lesson Closure

Extensions for the Lesson (optional)

The following are floating components that may be placed throughout the lesson as needed.

Teaching Tips

Lesson Adaptations

Curriculum Connections

IV. RESOURCES

Internet Resources & References

Acknowledgments (Optional)

Additional Resources (Optional)

Teacher Answer Keys

Student Worksheets

Definitions for the Lesson Layout

I. LESSON AT A GLANCE – This section contains the educational background information for the lesson.

Grade Level – Provides the grade level range in which the lesson would be cognitively appropriate.

Lesson Duration – Gives the approximate time range required for the lesson.

Lesson Overview – Provides a short description of the lesson's goals and activities.

Education Standards – Lists the standards addressed in the lesson and identifies the source of the standards (e.g. NRC National Science Education Standards). This section may be divided into Core Education Standards and Related Education Standards, if necessary.

Essential Question(s) – The overarching question that provides teachers with the main focus of the lesson. These questions are the starting point of the exploration contained in the lesson.

Concepts – States the concepts that students will learn during the course of the lesson.

Objectives – Measurable tasks students should be able to do by the completion of the lesson.

II. SCIENCE OVERVIEW – Provides the science background information and terminology needed for teachers to deliver the lesson successfully. This section may include common misconceptions to address.

III. CONDUCTING THE LESSON – This section provides the information needed to conduct the lesson in the classroom.

Warm-Up & Pre-Assessment – Strategies for getting students interested and motivated to participate in the lesson and to determine what students already know, including misconceptions they may have. Pre-assessment is always present and can function as a warm-up, but in some cases separate warm-up and pre-assessment categories may be needed.

Materials – States the materials that will be needed by teachers and students during the Warm-up & Pre-assessment.

Preparation & Procedures – This section provides detailed procedures that assist teachers in preparing and conducting the Warm-Up & Pre-Assessment.

Activity – The first of possibly two inquiry-based activities embedded in the lesson.

Description of Activity – A short description of the activity, the concepts to be addressed, and the connection to the lesson as a whole.

Materials – States the materials that will be needed by teachers and/or students during the activity.

Preparation & Procedures – This section provides detailed procedures that assist teachers in preparing and conducting the activity.

Reflection & Discussion – This section allows students to reflect on what they have learned after they complete an activity.

Transfer of Knowledge – Tasks designed to allow students to demonstrate conceptual understanding through the construction of new knowledge based on what they have learned in the activity.

Assessment Criteria – Provides a rubric for teachers to verify student understanding of learned knowledge and skills throughout the activity.

Extensions (Optional) – Suggested activities or discussion points that will allow students to continue to explore the concepts presented within the activity.

Placing the Activity Within the Lesson – Identifies ways in which the teacher can facilitate students' understanding of how the activity fits into the greater context of the lesson.

Lesson Wrap-Up – This section contains strategies to end the lesson.

Transfer of Knowledge for the Lesson – Tasks designed to allow students to demonstrate conceptual understanding through the construction of new knowledge based on what they have learned across the entire lesson. This capability empowers students to make sense of, and be able to predict, new phenomena and apply knowledge to new situations.

Assessment Criteria for the Lesson – Provides a rubric to verify student understanding of learned knowledge across the entire lesson.

Lesson Closure – Provides ways of ending a lesson to include teacher and student reflection on both content and skills learned throughout the lesson, including the warm-up and activities. It provides an opportunity for students to incorporate the knowledge and skills learned into a coherent story.

Extensions for the Lesson (Optional) – Suggested activities or discussion points that will allow students to continue to explore the concepts presented within the lesson.

The following are floating components that may be placed throughout the lesson as needed.

Teaching Tips – Helpful hints for teachers to make the lesson or activity run smoothly.

Lesson Adaptations for SPED, TAG, ESL, or Learning Styles – Offers variations on the lesson plan to accommodate the varied needs of students.

Curriculum Connections – Describes the nature of the relationship between the science lesson and other traditional subject areas such as mathematics, history, geography, art, music, language arts, physical education, technology, etc.

IV. RESOURCES – This section provides teachers with additional materials they may need.

Internet Resources & References – Provides web sites for teachers to obtain more information on the topic or view more activities regarding the concepts addressed in the lesson. Also provided are student-friendly sites where students can research the concepts presented in the lesson, if necessary.

Acknowledgements (Optional) – Identified the source(s) from which the lesson was modified if appropriate.

Additional Resources (Optional) – Provides additional resources for teachers or students needed to conduct the lesson or to obtain more information on the topic of the lesson. These will be identified by name in the lesson itself.

Teacher Answer Keys – Provides the teacher with answers to student worksheets and additional fact sheets if necessary.

Student Worksheets – The worksheets required by the students to complete an activity. The worksheets may contain procedures, data tables, or questions. Additional worksheets may be provided for Extensions, Lesson Adaptations, etc.

The Middle School Voyage Story: An Overview of the Lessons

The *Voyage* Education Module unfolds through a story at each grade level that includes a central theme of Solar System science, as well as the use of models as powerful tools of exploration. At all grade levels the story is essentially the same, but the lessons chosen explore phenomenology relevant to the specific science standards and benchmarks associated with that grade level. The middle school (grades 5-8) *Voyage* story is told through the lessons listed and described on the following pages. Also included is how each of these lessons are aligned with the National Science Education Standards and Project 2061's Benchmarks for Science Literacy.

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	In this lesson, students investigate many aspects of our nearest celestial neighbor, the Moon. Students begin the lesson by observing the Moon and watching how it appears on a daily basis. They hypothesize a reason for the phases of the Moon, and then they test that idea in Activity 2, in which they simulate the phases of the Moon with a hands-on model and are able to explain the reason for the phases. Students conclude the lesson by discussing phases of other Solar System objects.	*Activity 1: Viewing the Moon;* In this activity, students will make observations of the phases of the Moon. The activity is designed to make students start paying more attention to the Moon than they would otherwise, and to think about why the Moon might go through phases. They will then hypothesize why phases occur, and see if their hypothesis is true by conducting Activity 2. *Activity 2: The Earth-Moon-Sun System;* In this investigation, students will be making a model of the orbit of the Moon around the Earth; an overhead projector is used to represent the light from the Sun. By having the model Moon to orbit the model Earth, students will be able to see the phases of the Moon and learn why the phases occur.

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	In order to have an appreciation for the complexity of the Solar System students must understand that the Solar System is a dynamic machine made of many moving parts. Students explore the nature of circles versus ellipses and how they relate to orbits in the Solar System. After creating a model of the Solar System, in which students plot the orbits of Solar System objects around the Sun, students begin 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 based on the major axis and the distance between the foci. *Activity 2: The Eccentricity of Solar System Objects—How Crazy Are They?;* Students will plot the elliptical orbits of some of the Solar System objects and examine how the orbits of the planets are different from one another and also different from the rest of the objects in the Solar System.
Lesson 6: Where To Look For Life?	One reason scientists study the Solar System is to determine whether life could exist elsewhere. Students come to the conclusion that one of the essential conditions for life is liquid water. Students create a mathematical model of the temperatures in the Solar System, and discover that there are several worlds on which the temperature range could allow liquid water to exist. Students then discover there are other requirements for hosting life, and not all worlds possess those.	*Activity 1: Happy Places;* Students predict and graph the temperature of a blackbody at various distances from the Sun. Students then analyze the graphs and determine the reasons why the worlds do not behave like blackbodies. *Activity 2: Earth vs. Other Worlds;* In this activity, students identify characteristics of Earth that are important for life as we know it, in addition to the presence of liquid water. They will then research the planets and some of the moons in the Solar System and compare their characteristics with those of the Earth.
Lesson 7: Is There Anyone Out There?	Once scientists have determined where they want to look for life in the Solar System, the next question they ask is how will they do it? In this lesson, students create an operational definition of life by observing a mystery object. They then conduct an experiment, modeled after the ones performed by the Mars Viking Landers, to determine if they have discovered life forms in simulated Martian soil samples.	*Activity 1: Is It Alive?;* In this activity, students will be given a mystery object that they must take care of for several days. Students must observe their objects in order to determine if they are alive. Students will use their observations to create a definition for identifying the presence of life. *Activity 2: Searching for Signs of Life;* In this activity students perform experiments on simulated Martian soil samples (sand) to determine the presence of life. Students "feed" the samples and watch their reactions to determine which (if any) of the sample contain life. This activity is modeled after the Viking Landers' experiments of the 1970s.
Lesson 8: Comets: Bringers of Life?	In this lesson, students will discover why comets are thought to be important in Earth's development. They will examine how a comet's composition relates to the composition of the entire Universe, and to life on Earth, by creating a model of a comet nucleus. By the conclusion of the lesson, students will understand why comets are sometimes said to be bringers of life.	*Activity 1: A Handful of the Universe;* Students will understand the average composition of the Universe through a model. *Activity 2: Cookin' Up a Comet;* Students will create a model of a comet and compare their model to a real comet.
Lesson 9: Asteroids and Meteorites	Asteroids and meteorites are a class of small rocky bodies in the Solar System, often overlooked in a study of the Solar System. They are important, however, because they are leftovers of Solar System formation. By studying these rocks, especially when we get samples of them here on Earth as meteorites, we can get a better understanding of the formation and evolution of the Solar System.	*Activities TBD*
Lesson 10: Impact Craters: A Look at the Past	In this lesson, students discover that it is possible to learn a lot about objects in the Solar System and their history, as well as the history of the entire Solar System, just from looking at the craters on their surfaces. Students simulate how impact craters are formed, and how craters can look different based on the amount of energy they had during impact. They also examine pictures of cratered surfaces of other worlds in the Solar System and discover that impact craters can provide a lot of information about a world's history, and the history of the entire Solar System.	*Activity 1: Creating Craters;* In this activity, students will simulate crater impacts by dropping pebbles or marbles into a pan of flour and cocoa. Students will identify the characteristics of impact craters and compare them to the picture of a lunar crater. *Activity 2: Craters in the Solar System;* In this activity, students will examine impact craters on different worlds in the Solar System and discover that the craters can tell us a lot about the world on which they formed.

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					√	√						√	