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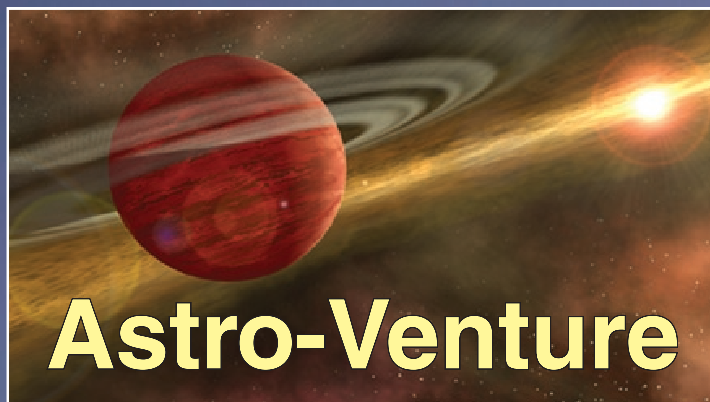

Astronomy

Educator Guide

Featuring Activities in Astrobiology

www.nasa.gov
http://astroventure.arc.nasa.gov

Educator Product
Educators | Grades 5-8
EG-2005-10-501-ARC

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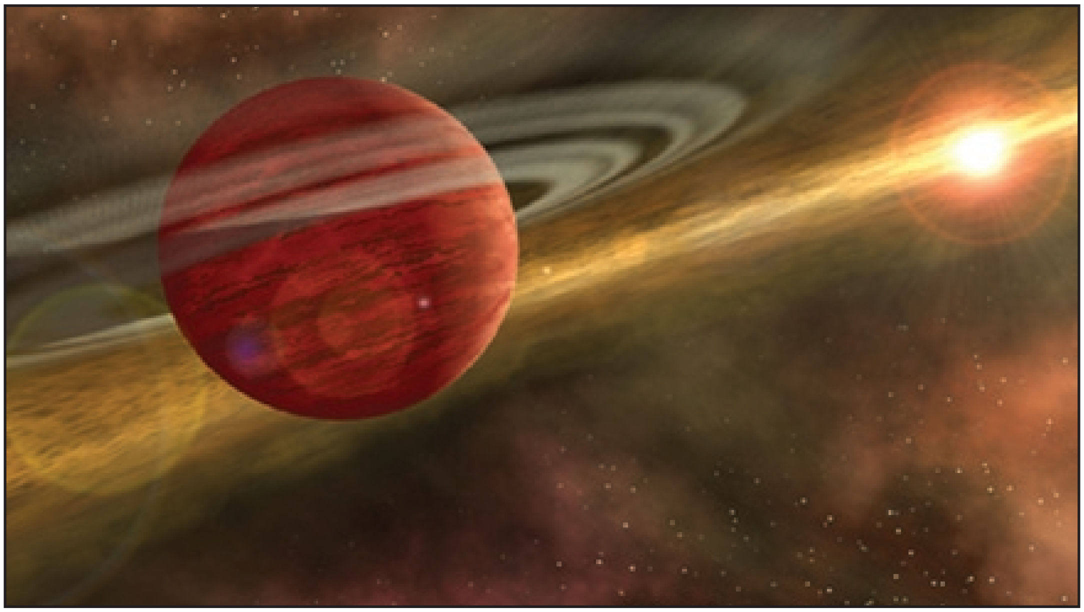

Astro-Venture

Astronomy

Educator Guide

Cover art: Background graphic: 8 inch refractor in the Crosby Ramsey Memorial Observatory dome atop the Maryland Science Center near Baltimore's Inner Harbor; NASA

Inset graphic: Conceptual illustration of planet orbiting a distant star; NASA

www.nasa.gov **http://astroventure.arc.nasa.gov**

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Acknowledgements

Christina O'Guinn
Instructional Design

Mike Wendling
Christina O'Guinn
Curriculum Development

Roger Margulies
Art Direction

Amberlee Chaussee
Jan Nicoara
John Nicoara
Design and Layout

Mariana Triviso
Bonnie Samuelson
Dorthy Starr
Deborah Bazar
Shelly Ericksen
Editing

Emma Bakes
Robbins Bell
Rita Briggs
Mitch Gordon
OSS Educational
Product Review
Scientific Review

NASA Quest

Astro-Venture is one of many teaching tools found at NASA Quest—a Web site connecting K-12 classrooms with NASA people, research, and science through mission-based challenges and explorations supported by NASA scientists, live Webcasts, Webchats, forums, and online publishing of student work. To find out more about these interactive multimedia products, visit:

http://quest.nasa.gov

NASA Educational Materials

The **Astro-Venture: Astronomy Educator Guide** is available in electronic format through NASA Spacelink—one of NASA's electronic resources specifically developed for the educational community.

This publication and other educational products may be accessed at the following address:

http://www.nasa.gov/audience/foreducators/topnav/materials/about/index.html

National Aeronautics and
Space Administration

Astro Venture: Astronomy Educator Guide

Table of Contents

Astro Venture: Astronomy Educator Guide

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Introduction

The Astro-Venture Astronomy Lessons have been developed by the National Aeronautics and Space Administration (NASA) for the purpose of increasing students' awareness of and interest in astrobiology and the many career opportunities that utilize science, math and technology skills. The lessons are designed for educators to use with students in grades 5 to 8 in conjunction with the Astro-Venture multimedia modules on the Astro-Venture Web site <http://astroventure.arc.nasa.gov>.

Astro-Venture Overview

Astro-Venture is an educational, interactive, multimedia Web environment highlighting NASA careers and astrobiology research in the areas of astronomy, geology, biology and atmospheric sciences. Students in grades 5 to 8 are transported to the future where they role-play NASA occupations and use scientific inquiry as they search for and build a planet with the necessary characteristics for human habitation. Supporting activities include chats and webcasts (live streaming audio and video) with NASA scientists, classroom lessons and NASA occupations fact sheets and trading cards.

Astro-Venture Overall Goal

Astro-Venture uses astrobiology content, the scientific inquiry process and critical thinking skills to increase awareness of NASA careers and to educate students in grades 5 to 8 on the requirements of a habitable planet.

Astro-Venture Overall Objectives

- Students in grades 5 to 8 will be able to identify and explain the vital characteristics of Earth that make it habitable to humans.

- Students will use the process of scientific inquiry to explain the methods scientists use to find planets that have characteristics necessary to sustain human life.

- Students will design a planet that has all of the necessary features to support human survival.

- Students will identify at least one NASA occupation that best fits their interests and skills and will identify methods for pursuing a similar career.

Astro-Venture Structure

Astro-Venture is composed of online, interactive, multimedia modules and off-line classroom lessons. The story line and technology components provide the overall purpose and motivation for teaching the standards and concepts in the off-line lessons. The technology components also help to connect students to real science and scientists at NASA.

Astro-Venture is divided into five sections or "Research Areas."
1. Astronomy
2. Geology
3. Atmospheric Sciences
4. Biology
5. Design a Planet

The first four sections have the following components:

Training (The "Whats")

In each of these interactive, online, multimedia modules, students make changes to aspects of our Solar System and make observations of the effects on Earth. They then draw conclusions about the conditions that are required for human habitation in that science content area. In these training modules, students learn ***what*** humans need in a planet and star system to survive.

Classroom Lessons (The "Whys")

Off-line, students engage in many classroom investigations in which they learn ***why*** humans need the requirements identified in the Training modules. These lessons have been developed to meet national education standards and build on each other to truly teach standards-based concepts such as: states of matter, systems, the geologic rock cycle, human health systems and atmospheric composition.

Missions (The "Hows")

After completing the training modules and lessons, students will engage in interactive, online, multimedia missions to simulate the methods scientists might use to search for a star system and planet that meet the qualifications identified in the training modules. In these modules, students learn ***how*** to go about finding a planet that would support human survival.

Design a Planet (Overall Assessment)

Once students have completed the first four sections, they will engage in the online, interactive, multimedia Design a Planet module in which they will design a simulated star system and planet that meets all human survival requirements in all four areas: astronomy, geology, atmospheric sciences and biology.

Project 2061

In addition to meeting the National Science Education Standards, International Society for Technology in Education Standards and National Council of Teachers on Mathematics standards, the Astro-Venture Astronomy Lessons are written to meet benchmarks from the ***Benchmarks for Science Literacy*** produced by the American Association for the Advancement of Science (AAAS) as part of their science, math and technology reform movement called Project 2061. The mission of Project 2061 is to "shape the future of education in America, a future in which all students [will] become literate in science, mathematics and technology by graduation from high school" (p. VII). "The Benchmarks for Science Literacy are statements of what all students should know or be able to do in science, mathematics and technology by the end of grades 2, 5, 8 and 12" (p. XI) and are based on extensive research of when and how it is developmentally appropriate to teach the concepts and skills described.

The table below shows how these benchmarks are identified for each lesson. There is a great deal of overlap between the ***Benchmarks for Science Literacy*** and the national science and math education standards. Therefore, we have also identified these standards, when appropriate. The first portion of the table entry identifies which standards or benchmarks are referenced. 2061 is a reference to the Benchmarks for Science Literacy. NSES is a reference to the National Science Education Standards. NCTM is a reference to the National Council of Teachers on Mathematics national mathematics education standards. ISTE is a reference to the International Society for Technology in Education standards. The second portion of the table entry identifies the specific standard referenced. In the case of Project 2061, the standard is referenced, the grade range is referenced and finally the number of the concept under this standard and grade range is referenced. We distinguish between "meeting" benchmarks or standards, and "addressing" them to alert educators to concepts that are taught in a lesson or lessons compared to topics or ideas that we might touch upon but do not really teach. Educators may note that often several lessons are required to truly teach a concept. We understand the time constraints of the classroom may not allow for the time that is really needed to truly teach a concept or benchmark; however, it is our goal to model effective instructional methods for science, math and technology. As stated in ***Benchmarks for Science Literacy***, "If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered" (p. XI).

Example of Lesson Objectives/Standards Table

Objectives	Standards
• Students will research and list the basic requirements for human survival in their Astro Journals. • They will write a survival story identifying these basic requirements, the consequences of not meeting them and how they are met. • After comparing characteristics of the Earth with other planets and moons, students will predict which features of the Earth they believe are crucial to human survival.	**Meets:** 2061: 6C (3-5) #1, 2 **Addresses:** 2061: 4B (6-8) #2

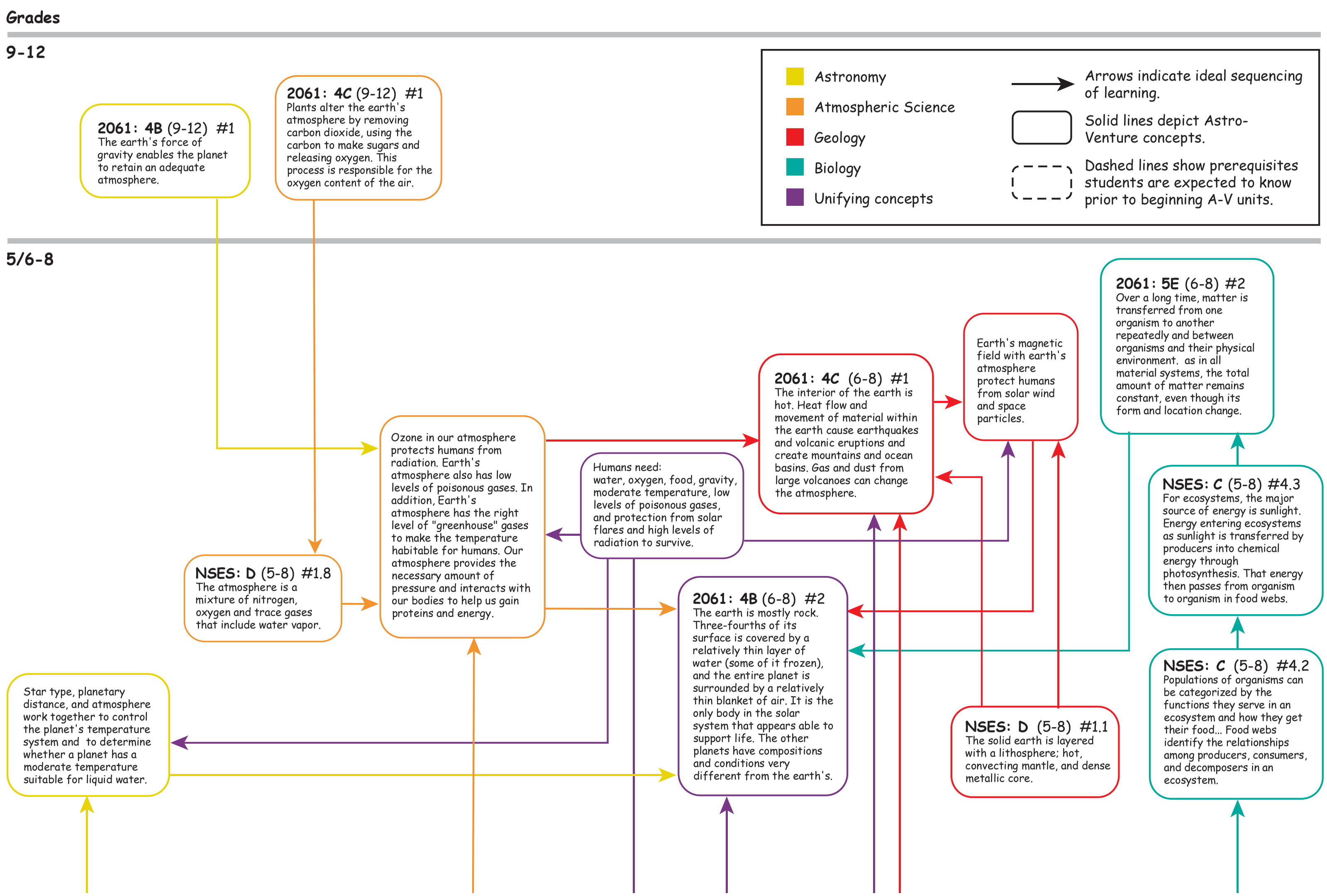
In addition to meeting benchmarks, the Astro-Venture Astronomy Lessons integrate some of the instructional methods that Project 2061 research has identified as being the most effective in teaching science, math and technology. These include:

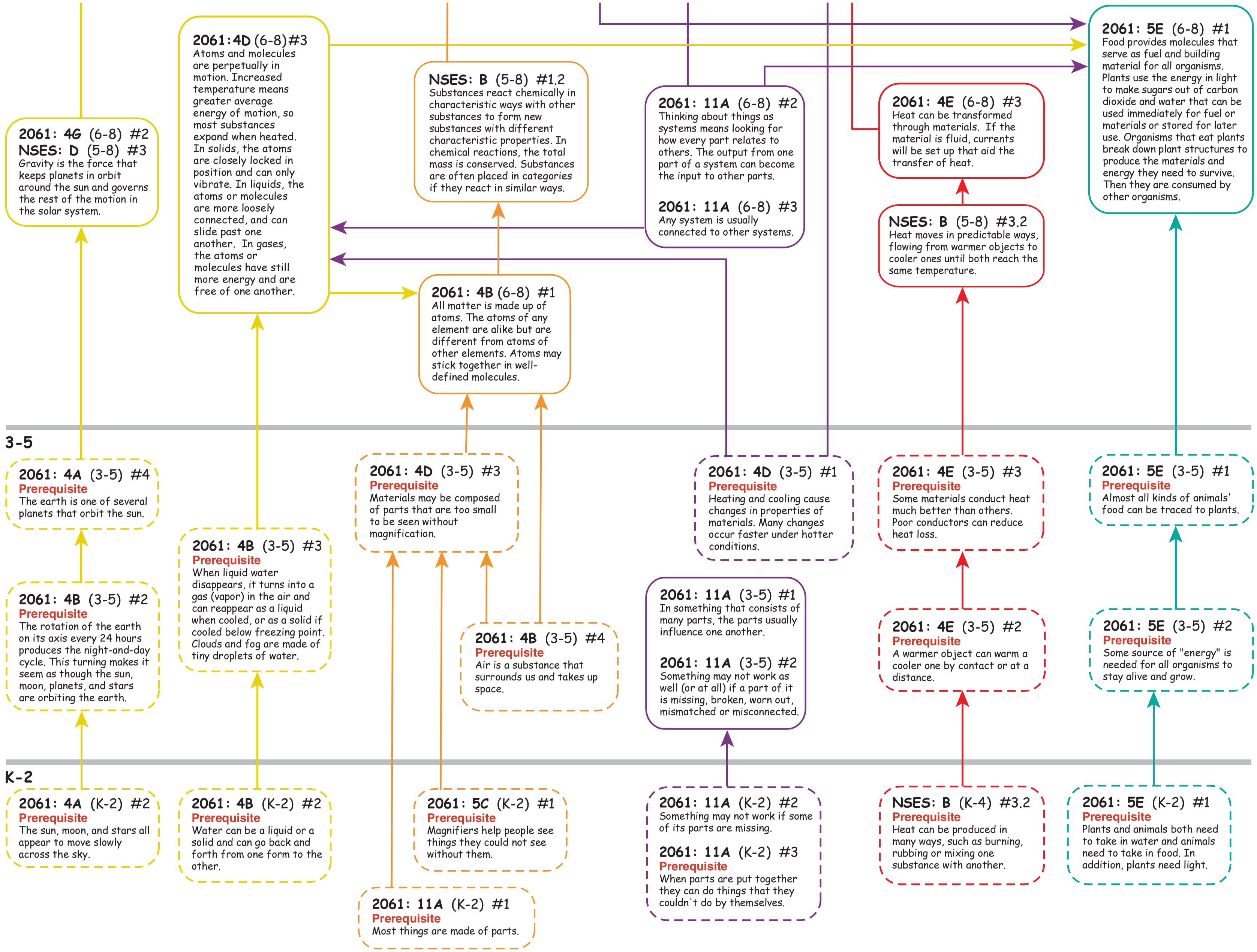
- **Overall Purpose:** We provide an overall purpose or goal and connect to this throughout. We base measurable objectives and assessments, which evaluate these objectives on the overall purpose.
- **Prerequisite Knowledge/Skills/Misconceptions:** We identify prerequisite knowledge and common misconceptions. We alert educators to these misconceptions and provide questions or suggestions on how these might be addressed.
- **Variety of Phenomena/Quality of Experiences:** We provide a variety of highly interactive experiences and questioning strategies that require higher order thinking skills.
- **Introducing Terms:** We limit the use of terms and introduce them within context once the concept is understood.
- **Welcoming All Students:** We strive to make the content accessible to all student populations by providing suggestions for Accommodations for students who might benefit from modifications and Advanced Extensions for students who can benefit from additional challenges. In addition, we incorporate cooperative learning, hands-on activities and total physical response activities to facilitate the learning of students who speak English as a second language and to address multiple learning styles.

Astro-Venture Concept Map

The following map (please see the following two pages) demonstrates the Benchmarks for Science Literacy and National Science Education Standards that have been identified for Astro-Venture. The map shows the overall concepts that are taught throughout Astro-Venture, as well as the benchmarks specific to the different sections. The map also shows the prerequisite benchmarks that students should have mastered prior to learning the benchmarks in Astro-Venture.

Astro-Venture Concept Map




2061: 4G (6-8) #2
NSES: D (5-8) #3
Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system.
2061:4D (6-8)#3
Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules are more loosely connected, and can slide past one another. In gases, the atoms or molecules have still more energy and are free of one another.
NSES: B (5-8) #1.2
Substances react chemically in characteristic ways with other substances to form new substances with different characteristic properties. In chemical reactions, the total mass is conserved. Substances are often placed in categories if they react in similar ways.
2061: 4B (6-8) #1
All matter is made up of atoms. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules.
2061: 11A (6-8) #2
Thinking about things as systems means looking for how every part relates to others. The output from one part of a system can become the input to other parts.
2061: 11A (6-8) #3
Any system is usually connected to other systems.
2061: 4E (6-8) #3
Heat can be transformed through materials. If the material is fluid, currents will be set up that aid the transfer of heat.
NSES: B (5-8) #3.2
Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature.
2061: 5E (6-8) #1
Food provides molecules that serve as fuel and building material for all organisms. Plants use the energy in light to make sugars out of carbon dioxide and water that can be used immediately for fuel or materials or stored for later use. Organisms that eat plants break down plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.
3-5
2061: 4A (3-5) #4
Prerequisite
The earth is one of several planets that orbit the sun.
2061: 4B (3-5) #2
Prerequisite
The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. This turning makes it seem as though the sun, moon, planets, and stars are orbiting the earth.
2061: 4B (3-5) #3
Prerequisite
When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below freezing point. Clouds and fog are made of tiny droplets of water.
2061: 4D (3-5) #3
Prerequisite
Materials may be composed of parts that are too small to be seen without magnification.
2061: 4B (3-5) #4
Prerequisite
Air is a substance that surrounds us and takes up space.
2061: 4D (3-5) #1
Prerequisite
Heating and cooling cause changes in properties of materials. Many changes occur faster under hotter conditions.
2061: 11A (3-5) #1
In something that consists of many parts, the parts usually influence one another.
2061: 11A (3-5) #2
Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected.
2061: 4E (3-5) #3
Prerequisite
Some materials conduct heat much better than others. Poor conductors can reduce heat loss.
2061: 4E (3-5) #2
Prerequisite
A warmer object can warm a cooler one by contact or at a distance.
2061: 5E (3-5) #1
Prerequisite
Almost all kinds of animals' food can be traced to plants.
2061: 5E (3-5) #2
Prerequisite
Some source of "energy" is needed for all organisms to stay alive and grow.
K-2
2061: 4A (K-2) #2
Prerequisite
The sun, moon, and stars all appear to move slowly across the sky.
2061: 4B (K-2) #2
Prerequisite
Water can be a liquid or a solid and can go back and forth from one form to the other.
2061: 5C (K-2) #1
Prerequisite
Magnifiers help people see things they could not see without them.
2061: 11A (K-2) #1
Prerequisite
Most things are made of parts.
2061: 11A (K-2) #2
Something may not work if some of its parts are missing.
2061: 11A (K-2) #3
Prerequisite
When parts are put together they can do things that they couldn't do by themselves.
NSES: B (K-4) #3.2
Prerequisite
Heat can be produced in many ways, such as burning, rubbing or mixing one substance with another.
2061: 5E (K-2) #1
Prerequisite
Plants and animals both need to take in water and animals need to take in food. In addition, plants need light.

More information on the benchmarks and standards referenced can be found at the following Web addresses:

Standard/Benchmark Title	Web Address
American Association for the Advancement of Science: Project 2061	http://www.project2061.org/
National Science Education Standards (NSES)	http://www.nap.edu/readingroom/books/nses/html/
National Council of Teachers on Mathematics (NCTM)	http://standards.nctm.org/index.htm
International Society for Technology in Education (ISTE)	http://cnets.iste.org/
International Technology Education Association (ITEA)	http://www.iteawww.org/TAA/TAA.html

Astro-Venture Astronomy Section

In the Astronomy section, students begin as Junior Astronomers where they identify human needs for survival and complete the online Astronomy Training module to discover the astronomical conditions of our Solar System that make Earth habitable to humans. When they have successfully completed their training, they earn their badge and are promoted to Senior Astronomer. They then engage in off-line Astronomy lessons to discover why we need the astronomical conditions identified in Astronomy Training. Finally, they proceed to their online Astronomy Mission where they work with NASA scientists to find a star system and planet with the astronomy features that will support human life. Before embarking on further research in other areas, they must summarize their research findings and convince the World Science Foundation (a fictional group made up of their peers) that the planet they have found is worthy of further exploration.

Astro-Venture Astronomy Educator Guide includes fourteen lessons divided into four units:
Part 1: Unit Introduction Lessons
Part 2: States of Matter
Part 3: The Planetary Temperature System
Part 4: Unit Conclusion and Evaluation

Each lesson requires two to four class periods of 45 minutes in length for completion. Unit one requires a total of seven full class periods. Unit two requires eleven full class periods. Unit three requires sixteen full class periods, and unit four requires eight full class periods. Thus, a total of 42 class periods are required if the entire educator guide is completed in class. These requirements are estimates and will depend on each individual class and teacher. It is anticipated that teachers will modify lessons to fit the needs and constraints of their students and individual situations.

Units two and three are developed such that they can stand alone, and unit three is not dependent upon unit two. Furthermore, the concepts begin from a basic level and increase in sophistication. Thus, it is anticipated that teachers will identify the concepts that best fit with the needs of their students and their curriculum and will use some subset of the lessons included in the guide.

It should be noted that Astronomy Lesson 1: Unit Introduction and Astronomy Lesson 7: Thinking in Systems are two lessons that set up unifying concepts referred to throughout all four educator guides.

If students are unfamiliar with the solar system or need a review, there are many resources available that can be used to support this need. References to some of these resources are included at the end of this introduction section.

The objective and standards of Astro-Venture Astronomy are broken down into fourteen lessons, as shown in the following tables.

Astro-Venture Astronomy Lessons, Objectives and Standards Alignment

Unit Concept: For a planet to support human life, it must have liquid water at or near the surface all of the time. There are astronomical factors, which affect the ability of a planet to have these conditions.

Part 1: Unit Introduction

Overview of Part 1: Students are introduced to the basic requirements for human survival. Using an online, multimedia module, they change factors of our Solar System and draw conclusions about which factors are necessary for human survival.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
1. Unit Introduction	Humans need water, oxygen, food, gravity, a moderate temperature and protection from poisonous gases and high levels of radiation to survive.	What do humans need to survive? Why?	Students will research and list the necessities for human survival in their Astro Journals.	**Meets:** 2061: 6C (3-5) #1, 2 NSES: F (5-8), #1 **Addresses:** 2061: 4B (6-8) #2 NSES: A (5-8) #1 ISTE: 3, 5
			They will write a story about human survival identifying these necessities, the consequences of not meeting them and how they are met.	
			After comparing characteristics of the Earth with other planets and moons, students will predict the features of Earth that they believe are crucial to human survival.	
2. Astronomy Training Module	Certain astronomical conditions help to meet some of our human survival needs.	What astronomical conditions allow for human survival?	Students make descriptive, unbiased observations of the effects of changes to our solar system on Earth.	**Meets:** NSES: A (5-8) #1 ISTE: 3, 5 **Addresses:** 2061: 4B (6-8) #2 2061: 4A (6-8) #1 NSES: D (5-8) #3
			Students will identify the characteristics of our solar system that allow for human survival.	

Part 2: States of Matter

Overview of Part 2: Students explore the conditions required for water to be in a liquid state. They discover that temperature is the essential variable. They then explore how temperature affects the motion of molecules and molecular bonds.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
3. Properties of Matter	Matter can exist in three states: solid, liquid and gas. Each state has unique properties.	What are the similarities and differences between the properties of solids, liquids, and gases?	Students will identify the properties of solids, liquids and gases and will cite similarities and differences in those properties.	**Meets:** NSES: B (K-4) #1 **Addresses:** NSES: A (5-8) #1
4. Matter and Molecules	The properties of matter derive from the bonds between the molecules and the motion of the molecules that make up the matter.	Why do the states of matter have the properties that they have?	Students will explain and illustrate that the properties of matter derive from the connections between molecules. They will demonstrate their learning in a poster.	**Meets:** 2061: 4D (6-8) #3 NSES: B (9-12) #1 **Addresses:** NSES: A (5-8) #1
5. Changing States of Matter	Matter changes state when temperature changes.	What causes matter to change its state and how is this accomplished?	Students will use an inquiry process to identify temperature as the variable that causes a substance to change from one state to another. The will then identify between temperature and the molecular bonds and movement in a substance. Students will explain the temperature conditions of a planet necessary for human life.	**Meets:** 2061: 4D (6-8) #3 NSES: B (9-12) #5 NSES: A (5-8) #1 **Addresses:** NCTM: 4, 5, 9
6. Measuring Temperature	Temperature is a measurement of the movement of atoms and molecules in a substance. Thermometers using various temperature scales measure temperature.	What does temperature actually measure and how do we measure it?	Students will identify that temperature measures the movement of atoms in a substance. Students will identify the thermometer as the tool and the Fahrenheit, Celsius, and Kelvin scales as the means by which we measure temperature.	**Meets:** 2061: 4D (6-8) #3 NSES: B (9-12) #5 **Addresses:** NSES: A (5-8) #1 NCTM: 4

Part 3: The Planetary Temperature System

Overview of Part 3: Students explore the planetary temperature system. They further explore how each part influences the system and the consequences of disrupting that system.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
7. Thinking in Systems	Systems consist of many parts. The parts usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems.	What are the characteristics of a system?	Students will explain: how a system is made up of interacting parts, that when parts of a system change it affects the system, and that systems are often related to other systems.	**Meets:** 2061: 11A (3-5) #1 2061: 11A (3-5) #2 2061: 11A (6-8) #2 2061: 11A (6-8) #3 NSES: UCP (K-12) #1 **Addresses:** NSES: A (5-8) #1
8. The Solar System	The solar system is a system. One of the ways that the parts of the solar system interact with each other is through gravity.	How do the parts of the solar system interact with each other?	Students will explain the solar system as a system. Students will explain how gravity affects the solar system.	**Meets:** 2061: 11A (3-5) #1 2061: 11A (3-5) #2 2061: 11A (6-8) #2 2061: 11A (6-8) #3 2061: 4G (6-8) #2 NSES: UCP (K-12) #1 NSES: D (5-8) #3 **Addresses:** NSES: A (5-8) #1 NCTM: 2, 5, 9 ISTE: 3, 5
9. Planetary Temperature as a System	The type of star and the distance of a planet from the star affect two major parts of the system that controls the surface temperature of a planet (planetary temperature system). The hotter the star is, the further the planet needs to orbit in order to maintain liquid water on its surface.	What are two important parts of the planetary temperature system? How do these parts work together to determine a planet's surface temperature?	Students will explain how the star type and the distance of a planet from its star affects the planetary temperature system. Students will categorize stars on a Hertzsprung-Russell (HR) Diagram. They will also model the relationship of star type and orbital distance and will draw conclusions about the stars most suitable for supporting human life.	**Meets:** 2061: 11A (6-8) #2 NSES: UCP1 (K-12) **Addresses:** NSES: A (5-8) #1 NCTM: 2, 5, 9

Part 3: The Planetary Temperature System (Cont.)

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
10. Atmosphere and Temperature	The atmosphere of a planet affects the planetary temperature system, which determines the temperature of that planet.	How does atmosphere affect the planetary temperature system?	Students will explain and illustrate that atmosphere can raise the temperature of a planet. Students put together a concept map that shows the parts of a planetary system. Students will explain why atmosphere is important to habitability and how star type, distance and atmosphere all work together to determine a planet's temperature system.	**Meets:** 2061: 11A (6-8) #2 NSES: UCP (K-12) #1 NSES: A (5-8) #1 **Addresses:** NSES: A (5-8) #1 NCTM: 4, 5, 9
11. Atmospheric Mass	The amount of atmosphere on a planet depends on the planet's gravity, which is determined by the planet's mass.	What determines the amount of atmosphere on a planet?	Students will explain and illustrate how planetary mass affects atmosphere to effect a change in the temperature of a planet. Students will explain why a planet 1/4 to 4 times Earth's mass is a requirement for habitability.	**Meets:** 2061: 11A (6-8) #2 NSES: UCP (K-12) #1 **Addresses:** NSES: A (5-8) #1 NCTM: 2, 5, 9
12. Disrupting the System	If Jupiter were in an elliptical orbit at 1 AU, it could cause a change in Earth's orbit, which would have consequences for the planetary temperature system.	What could happen if Jupiter was in an elliptical orbit at 1 AU?	Students explain how a planet's orbit could be disrupted. Students explore the implications of such a disruption on the planetary temperature system and on human habitability.	**Meets:** 2061: 11A (6-8) #2 NSES: UCP (K-12) #1 **Addresses:** NSES: A (5-8) #1 ISTE: 3, 5

Part 4: Unit Conclusion and Evaluation

Overview of Part 4: Students use an online, multimedia module to simulate the techniques that scientists might use to find a star system and planet that meet the astronomical conditions required for human habitability. Students then summarize their learning from this unit in a final project.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
13. Astro-Venture Mission Module Training	Scientists use methods such as spectroscopy, Doppler Shift, photometry and Kepler's Third Law to collect data from a star. They then interpret this data to determine if the star system has the astronomical conditions required for human habitability.	What are the chances that there is a star system other than our own that has the astronomical conditions required for human habitability? Explain.	Students will use the scientific inquiry process to describe the methods scientists use to find a star system that has the astronomical conditions required for human habitability. Students will compare and analyze data to find a star system that meets the astronomical conditions required for human habitability.	**Addresses:** 2061: 1B (6-8) #1 NSES: A (5-8) #1 NCTM: 5, 9 ISTE: 3, 5, 6
14. Final Project	The astronomical requirements for habitability are not sufficient for sustaining human life on a planet, Additional requirements must be met.	What other requirements must a planet meet to be habitable to humans and how might a scientist determine if a planet meets these requirements?	Students will write a proposal to convince the "World Science Foundation" that the star and planet they found is worthy of further study and exploration. They will include a description of how the planet meets astronomical requirements for habitability, additional requirements that must be met, the benefits of conducting this study and the type of further study they would recommend for determining if the planet meets these additional requirements.	**Addresses:** NSES: A (5-8) #1

Guide to the Parts of the Lessons

Lesson Introduction and Preparation

Each lesson begins with an Overview, the Main Concept of the lesson and the Scientific Question associated with the concept. The lesson breaks down the Objectives as they are aligned with the National Education Standards and describes how these objectives will be evaluated in the Assessment. It further gives an Abstract of the lesson, breaks down the Major Concepts of the lesson and Prerequisite Concepts that students are expected to have mastered before engaging in the lesson. All of this gives the educator a good overview of what will be covered, how it will be taught and assessed.

The first part of each lesson also gives an outline of a Suggested Timeline that is based on 45-minute class periods. Time will vary depending on the educator's pacing and the student levels and dynamics of the class; however, the timeline provides some basic guidelines for the educator. Materials and Equipment and the Preparation of these materials and equipment are also described and listed so that teachers can easily see what they will need to prepare for the lesson ahead of time. Finally, a table provides suggestions on Accommodations for students that may need more support as well as Advanced Extensions for students who may need to be further challenged.

The Five "E's"

The Astro-Venture Astronomy Lessons intend to model the scientific inquiry process by using the Five "E's". These stand for Engage, Explore, Explain, Extend/Apply and Evaluate. The important factor that distinguishes this lesson format from lessons of other content areas is that students are not told a concept, but are led to explore and discover the concept so that once they reach the Explain section they have an experience on which to base the concept. They are then asked to apply this new concept to other situations and are evaluated on their ability to do so.

Throughout the lessons, a Question and Answer dialogue is modeled. Of course, no class will follow this script; however, the dialogue models the kinds of discussions educators should facilitate in an effort to help guide students toward developing their own understanding of the concepts and toward drawing their own conclusions. The dialogue also models questions that stimulate higher order thinking skills rather than rote memorization of facts.

In addition, the lessons also include periodic Notes to Teacher and cues to Misconceptions. The Notes to Teacher provide additional background information or suggestions that may be helpful to the educator. The educator may determine that some of the information is appropriate to share with their students, while other information is not. It is hoped that by alerting the educator to Misconceptions that educators will try to bring out these misconceptions with their students and help their students to address the misconceptions. Misconceptions are one of the most challenging areas for science educators, because research shows that we must disprove our own misconceptions before we can accept new concepts. We cannot be told these concepts, but must discover them ourselves.

Engage

The Engage section of each lesson provides guidelines for drawing on students' prior knowledge, building on previous lesson concepts, introducing the purpose of the lesson and the Scientific Question that will be explored.

Explore

In the Explore section, students make Predictions or Hypotheses in response to the Scientific Question and are given an activity that will help them to collect data and evidence to answer the Scientific Question.

Explain
In the Explain section, students reflect on the explore activity by recording their Results and Conclusions. They discuss these as a class or in small groups and receive feedback on their ideas. They may also engage in readings or additional demonstrations that provide further explanation of the concepts they have explored.

Extend/Apply
In the Extend/Apply section, students are given an activity or assignment in which they demonstrate their understanding of the concept and/or apply it to another situation. Again they receive feedback on their learning.

Evaluate
In the Evaluate section, students are evaluated on their understanding of the concept. Often rubrics are provided for evaluation of this learning. In addition, students discuss and summarize the main concepts of the lesson, which is posted on the wall so students can see how the concepts build on each other.

Lesson Blacklines
The end of each lesson includes the blacklines needed for class set duplication or for creating transparencies for that particular lesson. These can be printed out and duplicated, as needed. Astro Journals are included for most lessons and model the scientific inquiry process used throughout each lesson.

Rubrics
Almost all of the assignments in Astro-Venture have a rubric for evaluation. Generally, these rubrics are included directly on the assignment sheets so that students know what they are expected to do. Before the students begin the assignment, the teacher should go over the rubric so that everyone understands the expectations.

When using the rubrics to evaluate student work, there are a few things to keep in mind that will make the process easier and more effective.

1. The teacher should spend some time thinking about the assignment and the rubric before reviewing it with the students. The teacher's thoughts may change after discussing it with the students, but everyone will benefit from the teacher knowing what she is expecting.

2. The four levels of the rubric describe general levels of proficiency. Few assignments will ever be exactly a '3' or exactly a '2'. Certain expectations will be met more proficiently than others. To assign a score, the teacher should identify the score that "best fits" the work. If there is a great discrepancy, then the teacher can consider multiple scores although this will create more work and difficulties in reporting.

3. Written assignments such as essays focus on content and reasoning. The teacher may also use district standards for evaluating the writing process.

4. Visual assignments such as illustrations do include expectations for the appearance of the illustration. The focus of these expectations is the clarity of the information being presented in the illustration. Despite the great advancements in digital imaging technology, botanists, entomologists, and archeologists (among others) still rely on specially trained artists to record new findings. The ability to express visual information clearly and accurately is a skill worth developing. Appearance cannot substitute for the accuracy of the information, but it can enhance the expression of this information. That enhancement is worth acknowledging.

Scientific Inquiry Evaluation Rubric For Evaluating Astro Journal Entries

There are many ways of approaching rubrics for assessment, each with its own strengths and weaknesses. Whatever the approach the goal is the same, providing feedback for students so that they can meet or exceed the standards or other expectations upon which they are focusing.

With this goal in mind, it is essential that students have many opportunities to work with the rubric: clarifying and analyzing the expectations, going over assessed work to understand the scores, evaluating their own work and their peers' work, and coming up with evidence to explain and justify those scores. Rubrics are only useful as long as they help students to understand how to improve their work and aid in their learning process.

The following rubric for inquiry in the Astro Journal divides the Astro Journal steps into four components and states expectations for each of those components. Scoring is done for each component in reference to the degree to which the expectations are met.

Component	Expectations
Hypothesis/ Prediction	• Clearly stated • Specific enough to be testable/observable and give a meaningful result • Has basis in solid information or observations and a logical reasoning process
Materials, Procedures, and Data	• Clearly stated • Complete • Accurate and tied directly to hypothesis and scientific question
Results	• Clearly stated • Refers directly to Scientific Question and data • Draws a reasonable conclusion from that data
Conclusions	• Clearly stated • States how hypothesis/prediction was confirmed and/or altered • Refers directly to findings, observations, and/or data to explain why thoughts were changed.

Scores:

4: Expectations Exceeded
3: Expectations Met
2: Expectations Not Quite Met
1: Expectations Not Met

The score of '3' indicates that the expectations were met. The score of '4' indicates that the expectations were exceeded. The difference between those two scores is somewhat subjective and should be worked on by each teacher (or group of teachers trying to use the rubric in a standard fashion). The score of '2' indicates that expectations were not quite met while the score of '1' indicates that the expectations were not met. The difference between those two scores is again somewhat subjective, but some thought into the implications of these scores might be helpful in distinguishing between the two. A '2' indicates that the student needs some assistance and work in meeting the expectations. A '1' indicates the student needs much assistance and work in meeting the expectations.

For this reason, just providing the students with a score, especially students with scores of '2' or '1' is not enough feedback. The student needs to know the reasons why a particular score was given. (Note: Even students with scores of '3' and '4' benefit from learning why their work received the scores that it did. Many of these students are not conscious of what they did to receive those scores and might not repeat what they did, if it is not made explicit to them.)

Consider the following example. In Lesson 5: Properties of Matter, the students have to develop a hypothesis about what causes matter to change state. Here are three sample (fictional) responses.

(A) Heat causes matter to change its state. I've watched ice cubes melt outside of the freezer and I've watched water turn to steam when you heat it up.

(B) Temperature causes matter to change its state.

(C) Particles go into stuff and energize it because matter is just energy.

Response 'A' is clearly stated and specific enough to be tested leading to a meaningful result. It also has an explanation that is based on solid observation and reasoning. The fictional student is saying that she has made two observations that show a consistent pattern that explains the phenomena – a logical reasoning process. Notice that the hypothesis is not quite correct. Regardless of that fact, the hypothesis should score at least a '3' and possibly a '4' depending on how the teacher and students understand the rubric.

Response 'B' is not grounded in any information or observations and shows no evidence of a reasoning process. In certain ways, it is not even clear. In short, this hypothesis should score only a '2,' and the student should be told to base his hypothesis in more solid information or observations and to indicate how the hypothesis was reasoned from those sources.

Response 'C' is not very clear. The student may or may not have based this hypothesis on solid information, observations, and reasoning. You, as the teacher, just do not know. The hypothesis should score only a '2' or possibly even a '1'. In the long run, the actual score of the hypothesis is less important than the student learning what is needed in order to meet the expectations and put together a good hypothesis.

In conclusion, using this rubric will require an investment of time and energy by teacher and students in creating an understanding of what these expectations mean and how they will be demonstrated in student work. If that process leads to changes in the rubric, so much the better. All the participants in that process will have a richer understanding of the process and will be better poised to engage in authentic inquiry experiences.

Astrobiology and Astronomy Resources

Astrobiology Resources

Name	Description	URL
NASA Astrobiology Institute	The NASA Astrobiology Institute (NAI) is a virtual organization that represents a partnership between NASA and competitively selected NAI Lead Teams to promote, conduct, and lead integrated multidisciplinary astrobiology research. It provides research information and links to educational resources including "Ask An Astrobiologist."	http://nai.arc.nasa.gov
NASA Origins Education Forum	NASA's Origins Program, a group of space-based missions, ground-based observatories, and research programs, focuses on: 1) observations of the earliest stars and galaxies, 2) the search for planets around other stars, and 3) the search for life elsewhere in the universe. It provides mission information and links to related educational resources.	http://origins.stsci.edu/
PlanetQuest	PlanetQuest follows NASA missions that are searching for planets outside our solar system. The site provides information for the public and related educational activities.	http://planetquest.jpl.nasa.gov/
Astrobiology: The Search for Life in Other Worlds	This is an interdisciplinary yearlong course for middle and high school students using astrobiology as its unifying, underlying structure. The course is being developed by TERC (a nonprofit research and development organization committed to improving mathematics and science learning and teaching), NASA, and an advisory group of scientists and educators. Students use an inquiry-based, interdisciplinary approach to explore astrobiology.	http://astrobio.terc.edu/
ExoQuest	ExoQuest is a multimedia educational product for grades 7 to 9. With ExoQuest, students travel on virtual journeys to destinations in the solar system and beyond. Their trips are based on past, present, and future NASA missions. At each destination students conduct investigations that include hands-on and simulated experiments. Each investigation poses problems that focus on different areas of research, providing an interdisciplinary approach to science and the scientific method. The ExoQuest curriculum includes twelve activity modules.	http://www.cet.edu/products/exoquest/overview.html

Astrobiology Resources (Cont.)

Name	Description	URL
SETI Institute (Search for Extra-Terrestrial Intelligence)	The SETI Institute is a private, nonprofit organization dedicated to scientific research, education and public outreach. The mission of the SETI Institute is to explore, understand and explain the origin, nature and prevalence of life in the universe. Provides information on SETI research and educational resources including Astrobiology Summer Science Experience for Teachers (ASSET) and a high school integrated science course, Voyages Through Time.	http://www.seti.org/
Life Beyond Earth PBS Film	Information and resources related to this PBS special are located at this Web site.	http://www.pbs.org/lifebeyondearth/
The Astrobiology Web	Astrobiology articles and links are available here.	http://www.astrobiology.com

Astronomy Resources

Name	Description	URL
NASA Science Mission Directorate	Visit this site to get information about NASA's many science missions.	http://science.hq.nasa.gov/index.html
Space Telescope Science Institute Home Page — Hubble Space Telescope	This is THE place to go to find information about the Hubble telescope missions. Check out the latest news and a wonderful gallery of pictures.	http://hubble.stsci.edu
SOFIA (Stratospheric Observatory for Infrared Astronomy) Homepage	SOFIA is an airborne observatory that will study the universe in the infrared spectrum.	http://sofia.arc.nasa.gov
NASA Educational Materials	Links to NASA educator guides and lithographs listed by topic, including astrobiology, astronomy, solar system and stars can be found here.	http://www.nasa.gov/audience/foreducators/topnav/materials/listbysubject/index.html
NASA JPL Solar System	This is the JPL Solar System Web site with links to missions, information and images.	http://www.jpl.nasa.gov/solar_system/

Astrobiology Resources (Cont.)

Name	Description	URL
NASA Quest Question and Answer	Search answers to questions in an extensive searchable database, or pose a new question to NASA personnel.	http://quest.nasa.gov/qna/glimpse/index.html
Ask A Space Scientist	Email questions about the Sun and Earth to NASA space scientist, Dr. Sten Odenwald.	http://image.gsfc.nasa.gov/poetry/ask/askmag.html
Ask An Astronomer	Email questions to astronomer, Paul Mortfield.	http://www.backyardastronomer.com/
Bad Astronomy	Astronomer Phil Plait's site seeks to correct common astronomy misinformation and misconceptions.	http://www.badastronomy.com
American Astronomical Society	The American Astronomical Society (AAS), established 1899, is the major organization of professional astronomers in North America. The basic objective of the AAS is to promote the advancement of astronomy and closely related branches of science. Provides career services, grants, publications and educational resources.	http://www.aas.org
Astronomical Society of the Pacific (ASP)	ASP is an international nonprofit scientific and educational organization founded in 1889 that works to increase the understanding and appreciation of astronomy. The Astronomy Clubs link provides links to Amateur Astronomy Clubs and Organizations all over the world. Many offer educational resources and events.	http://www.astrosociety.org http://www.astrosociety.org/resources/linkclubs.html
The Planetary Society	The Planetary Society is a public organization that supports astronomy research and public education. This site provides news and educational resources.	http://www.planetary.org
KidsAstronomy.com	Find kid friendly information on the solar system, universe and space exploration.	http://www.kidsastronomy.com
The Astronomy Net	The Astronomy Net contains articles, forums, clubs, vendors, manufacturers and other resources important to those interested in Astronomy.	http://www.astronomy.net
Astronomy Magazine	Astronomy Magazine offers daily astronomy and space news, star charts, pictures of planets, space missions, eclipse and much more.	http://www.astronomy.com
About Space/Astronomy	Articles, homework help, demonstrations, news, educational resources, suppliers, and annotated links all related to astronomy.	http://space.about.com/
Yahoo Astronomy Links	Links to a wide variety of astronomy resources on Yahoo.	http://dir.yahoo.com/science/astronomy/

Educational Standards List

Benchmarks for Science Literacy (2061)

1. The Nature of Science
A. The Scientific World View
B. Scientific Inquiry
C. Scientific Enterprise

2. The Nature of Mathematics
A. Patterns and Relationships
B. Mathematics, Science and Technology
C. Mathematical Inquiry

3. The Nature of Technology
A. Technology and Science
B. Design and Systems
C. Issues in Technology

4. The Physical Setting
A. The Universe
B. The Earth
C. Processes That Shape the Earth
D. Structure of Matter
E. Energy Transformations
F. Motion
G. Forces of Nature

5. The Living Environment
A. Diversity of Life
B. Heredity
C. Cells
D. Interdependence of Life
E. Flow of Matter and Energy
F. Evolution of Life

6. The Human Organism
A. Human Identity
B. Human Development
C. Basic Functions
D. Learning
E. Physical Health
F. Mental Health

7. Human Society
A. Cultural Effects on Behavior
B. Group Behavior
C. Social Change
D. Social Trade-Offs
E. Political and Economic Systems
F. Social Conflict
G. Global Interdependence

8. The Designed World
A. Agriculture
B. Materials and Manufacturing
C. Energy Sources and Use
D. Communication
E. Information Processing
F. Health Technology

9. The Mathematical World
A. Numbers
B. Symbolic Relationships
C. Shapes
D. Uncertainty
E. Reasoning

10. Historical Perspectives
A. Displacing the Earth from the Center of the Universe
B. Uniting the Heavens and Earth
C. Relating Matter and Energy and Time and Space
D. Extending Time
E. Moving the Continents
F. Understanding Fire
G. Splitting the Atom
H. Explaining the Diversity of Life
I. Discovering Germs
J. Harnessing Power

11. Common Themes
A. Systems
B. Models
C. Constancy and Change
D. Scale

12. Habits of the Mind
A. Values and Attitudes
B. Computation and Estimation
C. Manipulation and Observation
D. Communication Skills
E. Critical-Response Skills

National Science and Education Standards (NSES)

Unifying Concepts and Processes (UCP)

K-12
1. Systems, order and organization
2. Evidence, models and explanation
3. Change, constancy, and measurement
4. Evolution and equilibrium
5. Form and function

Content Standard A: Science as Inquiry

K-12
1. Abilities necessary to do scientific inquiry
2. Understanding about scientific inquiry

Content Standard B: Physical Science

K-4
1. Properties of objects and materials
2. Position and motion of objects
3. Light, heat, electricity and magnetism

5-8
1. Properties and changes of properties in matter
2. Motions and forces
3. Transfer of energy

9-12
1. Structure of atoms
2. Structure and properties of matter
3. Chemical reactions
4. Motions and forces
5. Conservation of energy and increase in disorder
6. Interactions of energy and matter

Content Standard C: Life Science

K-4
1. Characteristics of organisms
2. Life cycle of organisms
3. Organisms and environments

5-8
1. Structure and function in living systems
2. Reproduction and heredity
3. Regulation and behavior
4. Populations and ecosystems
5. Diversity and adaptations of organisms

9-12
1. The cell
2. Molecular basis of heredity
3. Biological evolution
4. Interdependence of organisms
5. Matter, energy and organization in living systems
6. Behavior of organisms

Content Standard D: Earth and Space Science

K-4
1. Properties of earth materials
2. Objects in the sky
3. Changes in earth and sky

5-8
1. Structure of the earth system
2. Earth's history
3. Earth in the Solar System

9-12
1. Energy in the earth systems
2. Geochemical cycles
3. Origin and evolution of the earth system
4. Origin and evolution of the universe

Content Standard E: Science and Technology

K-4
1. Abilities to distinguish between natural objects and objects made by humans
2. Abilities of technological design
3. Understanding about science and technology

5-12
1. Abilities of technological design
2. Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

K-4
1. Personal Health
2. Characteristics and changes in population
3. Types of resources
4. Changes in environments
5. Science and technology in local challenges

Content Standard F: Science in Personal and Social Perspectives (Cont.)

5-8

1. Personal Health
2. Populations, resources and environments
3. Natural hazards
4. Risks and benefits
5. Science and technology in society

9-12

1. Personal and community health
2. Population growth
3. Natural resources
4. Environmental quality
5. Natural and human-induced hazards
6. Science and technology in local, national and global challenges

Content Standard G: History and Nature of Science

K-4

5. Science as a human endeavor

5-8

1. Science as a human endeavor
2. Nature of science
3. History of science

9-12

1. Science as a human endeavor
2. Nature of scientific knowledge
3. Historical perspectives

National Council of Teachers of Mathematics (NCTM) Standards

STANDARD 1: NUMBER AND OPERATION

Mathematics instructional programs should foster the development of number and operation sense so that all students —

- understand numbers, ways of representing numbers, relationships among numbers, and number systems;
- understand the meaning of operations and how they relate to each other;
- use computational tools and strategies fluently and estimate appropriately.

STANDARD 2: PATTERNS, FUNCTIONS, AND ALGEBRA

Mathematics instructional programs should include attention to patterns, functions, symbols, and models so that all students —

- understand various types of patterns and functional relationships;
- use symbolic forms to represent and analyze mathematical situations and structures;
- use mathematical models and analyze change in both real and abstract contexts.

STANDARD 3: GEOMETRY AND SPATIAL SENSE

Mathematics instructional programs should include attention to geometry and spatial sense so that all students—

- analyze characteristics and properties of two- and three-dimensional geometric objects;
- select and use different representational systems, including coordinate geometry and graph theory;
- recognize the usefulness of transformations and symmetry in analyzing mathematical situations;
- use visualization and spatial reasoning to solve problems both within and outside of mathematics.

STANDARD 4: MEASUREMENT

Mathematics instructional programs should include attention to measurement so that all students—

- understand attributes, units, and systems of measurement;
- apply a variety of techniques, tools, and formulas for determining measurements.

STANDARD 5: DATA ANALYSIS, STATISTICS, AND PROBABILITY

Mathematics instructional programs should include attention to data analysis, statistics, and probability so that all students—

- pose questions and collect, organize, and represent data to answer those questions;
- interpret data using methods of exploratory data analysis;
- develop and evaluate inferences, predictions, and arguments that are based on data;
- understand and apply basic notions of chance and probability.

STANDARD 6: PROBLEM SOLVING

Mathematics instructional programs should focus on solving problems as part of understanding mathematics so that all students—

- build new mathematical knowledge through their work with problems;
- develop a disposition to formulate, represent, abstract, and generalize in situations within and outside mathematics;
- apply a wide variety of strategies to solve problems and adapt the strategies to new situations;
- monitor and reflect on their mathematical thinking in solving problems.

STANDARD 7: REASONING AND PROOF

Mathematics instructional programs should focus on learning to reason and construct proofs as part of understanding mathematics so that all students—

- recognize reasoning and proof as essential and powerful parts of mathematics;
- make and investigate mathematical conjectures;
- develop and evaluate mathematical arguments and proofs;
- select and use various types of reasoning and methods of proof as appropriate.

STANDARD 8: COMMUNICATION

Mathematics instructional programs should use communication to foster understanding of mathematics so that all students—

- organize and consolidate their mathematical thinking to communicate with others;
- express mathematical ideas coherently and clearly to peers, teachers, and others;
- extend their mathematical knowledge by considering the thinking and strategies of others;
- use the language of mathematics as a precise means of mathematical expression.

STANDARD 9: CONNECTIONS

Mathematics instructional programs should emphasize connections to foster understanding. Of mathematics so that all students—

- recognize and use connections among different mathematical ideas;
- understand how mathematical ideas build on one another to produce a coherent whole;
- recognize, use, and learn about mathematics in contexts outside of mathematics.

STANDARD 10: REPRESENTATION

Mathematics instructional programs should emphasize mathematical representations to foster understanding of mathematics so that all students—

- create and use representations to organize, record, and communicate mathematical ideas;
- develop a repertoire of mathematical representations that can be used purposefully, flexibly, and appropriately;
- use representations to model and interpret physical, social, and mathematical phenomena.

International Society for Technology in Education (ISTE) Standards

TECHNOLOGY FOUNDATION STANDARDS FOR STUDENTS

1. *Basic operations and concepts*
   - Students demonstrate a sound understanding of the nature and operation of technology system.
   - Students are proficient in the use of technology.

2. *Social, ethical, and human issues*
   - Students understand the ethical, cultural and societal issues related to technology.
   - Students practice responsible use of technology systems, information and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.

3. *Technology productivity tools*
   - Students use technology tools to enhance learning, increase productivity and promote creativity.
   - Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications and produce other creative works.

4. *Technology communications tools*
   - Students use telecommunications to collaborate, publish and interact with peers, experts and other audiences.
   - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. *Technology research tools*
   - Students use technology to locate, evaluate and collect information from a variety of sources.
   - Students use technology tools to process data and report results.
   - Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6. *Technology problem-solving and decision making tools*
   - Students use technology resources for solving problems and making informed decisions.
   - Students employ technology in the development of strategies for solving problems in the real world.