SUN EARTH UNIVERSE

SOL TIERRA UNIVERSO

K-12 Teacher Field Trip Guide

5. K-12 Teacher Field Trip Guide

Contents

(please see Chapter 1 - List of Host Resources for complete table of contents)

Exhibition Introduction for Field Trips

The *Sun, Earth, Universe* exhibition is well-positioned for K-12 field trips visiting your museum. This guide provides some basic information that may be useful to teachers and other formal education professionals arranging field trips from local schools. Please see Chapter 4 - Museum Educator Guide for exhibition visitor learning objectives, guiding frameworks, and relevant NASA resources for educators.

To quickly orient teachers, chaperones, and school administration interested in *Sun, Earth, Universe* field trips you may use the 11-minute walkthrough of exhibition components at this shareable link.

https://vimeo.com/283112123

Connections to Next Generation Science Standards

The STEM content and learner experiences in the *Sun, Earth, Universe* exhibition have multiple connections to Next Generation Science Standards (NGSS).

Please note: The Sun, Earth, Universe exhibition was not intentionally developed to align with NGSS. These connections are presented as a quick reference to show how the exhibition overlaps with the three dimensions of NGSS.

Practices for K-12 Science Classrooms

Students combine knowledge and skills into practices that mirror those of professional scientists and engineers. NGSS identifies 8 practices essential for learning science and engineering in grades K-12. While not all practices are relevant to the *Sun, Earth, Universe* exhibition, each component can be connected with at least one practice.

NGSS Practice	**Relevant *Sun, Earth, Universe* components**
1. Asking questions (for science) and defining problems (for engineering)	We ask questions about Earth, We ask questions about the Sun, We ask questions about the solar system, We ask questions about the universe, Design > Build > Test engineering activity,
2. Developing and using models	We ask questions about the universe, Mars landscape play table
3. Planning and carrying out investigations	Use tools to detect the invisible
4. Analyzing and interpreting data	We ask questions about the solar system, We ask questions about Earth, We ask questions about the Sun
5. Using mathematics and computational thinking	N/A

6. Constructing explanations (for science) and designing solutions (for engineering)	Design > Build > Test engineering activity
7. Engaging in argument from evidence	N/A
8. Obtaining, evaluating, and communicating information	Your mission to space board game, Companion website, Solar system stools, Reading and seating area

Crosscutting Concepts

NGSS also lists common themes that are present across multiple STEM disciplines. These themes provide students a cohesive view of the world based in science and engineering. Many of the *Sun, Earth, Universe* exhibition components are connected to these concepts.

NGSS Crosscutting Concept	**Relevant *Sun, Earth, Universe* components**
1. Patterns	We ask questions about Earth, We ask questions about the Sun
2. Cause and effect	Design > Build > Test engineering activity, Your mission to space board game
3. Scale, proportion, and quantity	We ask questions about the universe
4. Systems and system models	We ask questions about the solar system, We ask questions about the universe
5. Energy and matter: Flows, cycles, and conservation.	Use tools to detect the invisible
6. Structure and function	Design > Build > Test engineering activity
7. Stability and change	We ask questions about Earth, We ask questions about the Sun

Disciplinary Core Ideas (DCI)

NGSS also provides a core curriculum framework to streamline STEM content for instruction and assessments. Grouped in four domains: the physical sciences; the life sciences; the Earth and space sciences (ESS); and engineering, technology and applications of science (ETS); these fundamental ideas can serve as the basis for future high-quality STEM educational materials. The *Sun, Earth, Universe* exhibition highlights several of these content areas listed below. Primary School (K-2), Elementary School (3-5), and Middle School (6-8) levels for each area are indicated. Links are provided to the NGSS@NSTA website for descriptions of each relevant DCI.

Earth and Space Science

- ESS1: Earth's Place in the Universe
  - ESS1.A: The Universe and Its Stars (3-5, 6-8)
  - ESS1.B: Earth and the Solar System (6-8)
- ESS2: Earth's Systems
  - ESS2.A: Earth Materials and Systems (K-2, 3-5)
- ESS3: Earth and Human Activity
  - ESS3.C: Human Impacts on Earth Systems (K-2, 3-5)

Physical Science

- PS4: Waves and Their Applications in Technologies for Information Transfer
  - PS4.A: Wave Properties (3-5)

Engineering, Technology and the Application of Science

- ETS1: Engineering Design
  - ETS1.A: Defining and Delimiting Engineering Problems (K-2, 3-5)
  - ETS1.B: Developing Possible Solutions (K-2, 3-5, 6-8)
  - ETS1.C: Optimizing the Design Solution (K-2, 3-5, 6-8)

Connections to Science Literacy Benchmarks from AAAS

The Benchmarks for Science Literacy from the American Association for the Advancement of Science (AAAS) are statements of what all students should know or be able to do in science, mathematics, and technology by the end of specific grade levels. What follows are a selection of benchmarks related to the content of the *Sun, Earth, Universe* exhibition. To learn more about the benchmarks and see a full listing visit the project2061.org link here.

http://www.project2061.org/publications/bsl/online/index.php?home=true

Please note: The *Sun, Earth, Universe* exhibition was not intentionally developed to align with the Benchmarks for Science Literacy. These connections are presented as a quick reference to show how the exhibition overlaps with the categories and subcategories of the benchmarks.

1. The Nature of Science

A. The Scientific Worldview

Science is a process of trying to figure out how the world works by making careful observations and trying to make sense of those observations. 1A/E2

B. Scientific Inquiry

People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. 1B/P1

Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained by just observing things unaided. 1B/P2

C. The Scientific Enterprise

In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean. 1C/P2

Science is an adventure that people everywhere can take part in, as they have for many centuries. 1C/E1

3. The Nature of Technology

A. Technology and Science

Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things. 3A/P1

Technology enables scientists and others to observe things that are too small or too far away to be seen otherwise and to study the motion of objects that are moving very rapidly or are hardly moving at all. 3A/E2

Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information. 3A/M2

B. Design and Systems

Even a good design may fail. Sometimes steps can be taken ahead of time to reduce the likelihood of failure, but it cannot be entirely eliminated. 3B/E2

4. The Physical Setting

A. The Universe

There are more stars in the sky than anyone can easily count, but they are not scattered evenly, and they are not all the same in brightness or color. 4A/P1

Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye. 4A/E2

The earth is one of several planets that orbit the sun, and the moon orbits around the earth. 4A/E4

The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. 4A/M1bc

C. Processes that Shape the Earth

Change is something that happens to many things. 4C/P2

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms. 4C/M7

E. Energy Transformations

Energy can be transferred from one system to another (or from a system to its environment) in different ways: 1) thermally, when a warmer object is in contact with a cooler one; 2) mechanically, when two objects push or pull on each other over a distance; 3) electrically, when an electrical source such as a battery or generator is connected in a complete circuit to an electrical device; or 4) by electromagnetic waves. 4E/M2

F. Motion

*Human eyes respond to only a narrow range of wavelengths of electromagnetic waves-visible light. Differences of wavelength within that range are perceived as differences of color. 4F/M5**

There are a great variety of electromagnetic waves: radio waves, microwaves, infrared waves, visible light, ultraviolet rays, X-rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. 4F/M8

7. Human Society

D. Social Trade-Offs

Sometimes social decisions have unexpected consequences, no matter how carefully the decisions are made. 7D/E3

G. Global Interdependence

The global environment is affected by national and international policies and practices relating to energy use, waste disposal, ecological management, manufacturing, and population. 7G/M5

11. Common Themes

B. Models

A model of something is different from the real thing but can be used to learn something about the real thing. 11B/P2

Models are very useful for communicating ideas about objects, events, and processes. When using a model to communicate about something, it is important to keep in mind how it is different from the thing being modeled. 11B/E4

C. Constancy and Change

Some things change so slowly or so quickly that the changes are hard to notice while they are taking place. 11C/P4

Things change in steady, repetitive, or erratic ways—or sometimes in more than one way at the same time. 11C/E2a

Going Further with Standards and Earth and Space Science in the Classroom

WGBH's Bringing the Universe to America's Classrooms initiative is to develop instructional multimedia for educators and students across the U.S. via PBS LearningMedia, a free online K-12 digital media library. Resources include images, data visualizations, and videos drawn from NASA as well as WGBH's signature programs, to provide K-12 STEM teachers with high-quality digital resources for teaching topics in Earth and space science. Resources have been designed to be accessible for diverse learners and include support materials such as background essays, teaching tips, and student handouts for easy curricular integration. Lesson Plans have been developed to address the core ideas and practices of the Next Generation Science Standards.

- **PBS LearningMedia**
  https://pbslearningmedia.org/collection/universe/

Pre-Visit Discussion Prompts and Media

Educators and field trip assistants can prepare students visiting the *Sun, Earth, Universe* exhibition with some basic questions to encourage discussion. Scientists studying Earth and space begin missions by asking questions. The questions below reflect the wonder and tremendous scope of the NASA research showcased in the exhibition. What thoughts, opinions, and ideas will students bring to these topics?

- How is our planet changing?
- What does the surface of the Sun look like?
- Are we alone in the universe?
- Where would you send a spacecraft in the solar system?
- What tools do we need to study objects far away in space?

Inspiring Earth and space science media to prepare field trip participants

Use these amazing videos to stimulate interest and pre-visit discussions among students. See planets of the solar system up close, fly through a nebula, and gaze upon Earth from far above with real images and video from NASA spacecraft. These videos show the true spirit of exploration and discovery within Earth and space research of today. A field trip to the *Sun, Earth, Universe* exhibition will extend the content of these videos to hands-on interactives, real phenomena, and thought-provoking questions bringing out the scientist in all visitors.

- **NASA at Saturn: Cassini's Grand Finale**
  NASA Jet Propulsion Laboratory
  The final chapter in a remarkable mission of exploration and discovery, Cassini's Grand Finale is in many ways like a brand new mission. Twenty-two times, NASA's Cassini spacecraft will dive through the unexplored space between Saturn and its rings. What we learn from these ultra-close passes over the planet could be some of the most exciting revelations ever returned by the long-lived spacecraft. This animated video tells the story of Cassini's final, daring assignment and looks back at what the mission has accomplished.
  https://www.youtube.com/watch?v=xrGAQCq9BMU

- **Curiosity at Martian Scenic Overlook**
  NASA Jet Propulsion Laboratory
  Curiosity Project Scientist Ashwin Vasavada gives a descriptive tour of the Mars rover's view in Gale Crater. The white-balanced scene looks back over the journey so far. The view from "Vera Rubin Ridge" looks back over buttes, dunes, and other features along the route.
  https://www.youtube.com/watch?v=U5nrrnAukwI

- **Flight Through Orion Nebula in Visible and Infrared Light**
  NASA/Space Telescope Science Institute
  By combining the visible and infrared capabilities of the Hubble and Spitzer space telescopes, astronomers and visualization specialists from NASA's Universe of Learning program have created a spectacular, three-dimensional, fly-through movie of the magnificent Orion nebula, a nearby stellar nursery. Using actual scientific data along with Hollywood techniques, a team at the Space Telescope Science Institute in Baltimore, Maryland, and the Caltech/IPAC in Pasadena, California, has produced the best and most detailed multi-wavelength visualization yet of the Orion nebula.
  https://www.youtube.com/watch?v=fkWrjrdT3Zg

- **Earth 360 Video: The Call of Science**
  NASA Jet Propulsion Laboratory
  Join NASA Earth scientists for a 360-degree view of our planet as they head into the field to study ice in Greenland and coral reefs in Hawai'i. You can stand with scientists on Arctic ice, fly above the ice sheet, glaciers and sea ice as part of Operation IceBridge, then head to Hawaii as scientists dive into Kaneohe Bay as part of NASA's CORAL mission.
  https://www.youtube.com/watch?v=-kcKjmsCO8U

- **NASA | SDO: Year 5**
  NASA Goddard Space Flight Center
  In honor of SDO's fifth anniversary in 2015, NASA has released a video showcasing highlights from the last five years of Sun watching. Watch the movie to see giant clouds of solar material hurled out into space, the dance of giant loops hovering in the corona, and huge sunspots growing and shrinking on the Sun's surface.
  https://www.youtube.com/watch?v=GSVv40M2aks

- **One Year on Earth – Seen From 1 Million Miles**
  NASA Goddard Space Flight Center
  On July 20, 2015, NASA released to the world the first image of the sunlit side of Earth captured by the space agency's EPIC camera on NOAA's DSCOVR satellite. The camera has now recorded a full year of life on Earth from its orbit at Lagrange point 1, approximately 1 million miles from Earth, where it is balanced between the gravity of our home planet and the Sun.
  https://www.youtube.com/watch?v=CFrP6QfbC2g

- **The Known Universe by AMNH**
  American Museum of Natural History
  The known universe takes viewers from the Himalayas to the Moon's orbit, the orbits of the planets, the solar system, the galaxy and beyond.
  https://youtu.be/17jymDn0W6U

Post-Visit Reflection Questions

Students can use their experiences in the *Sun, Earth, Universe* exhibition and the featured Earth and space science content to answer the following questions.

Elementary school student level questions

- What can we learn about Earth by looking down from space?
- Are all planets in our solar system the same size? What are some of the largest and smallest ones?
- What does the Sun provide for us here on Earth? What might be some dangerous things we get from the Sun?
- Did you design and test a spacecraft at the exhibit? What was the easiest part of that process? What was really hard? How many tests do you think NASA engineers do on a spacecraft before they shoot it into space?
- After visiting the exhibit, what new questions would you like to have answered about space? What would scientists and engineers need to do to get the answer?

Middle school/high school student level questions

- Why is studying Earth from space so effective? What more could we be learning about our planet through space technology?
- Would you be willing to be part of a manned space mission to Mars? It will take at least 1.5 years to get there and a similar time to get back. What are negatives that would keep you from making the journey? What are the positives that would make you want to go?
- After exploring the four questions the exhibit asks about space science, what other questions do you have about space? How would answering those questions be of benefit for our lives here on Earth?
- Did you try any of the tools used to see invisible forces or phenomena? What surprised you? How can we use some of those tools in our daily life here on Earth?
- You have just been given a $300 million science exploration grant. What new question to you want to answer through a space mission? What tools would you need to use to answer that question? How would you divide up your $300 million between research, engineering, and tools?

Onsite Worksheets

Please see the Appendix for onsite worksheets suitable for use on a school field trip.

- Student Worksheet - Elementary
- Student Worksheet - Middle School
- Student Worksheet - Elementary - Teacher version
- Student Worksheet - Middle School - Teacher version

Acknowledgements

This material is based upon work supported by NASA under cooperative agreement award numbers NNX16AC67A and 80NSSC18M0061. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of the National Aeronautics and Space Administration (NASA).

Appendix - Onsite Worksheets

Student Worksheet - Elementary
Student Worksheet - Middle School
Student Worksheet - Elementary - Teacher version
Student Worksheet - Middle School - Teacher version