Students engage in science and engineering practices to conceptualize scientific understandings of our universe, galaxy, and solar system by asking questions, analyzing and interpreting data about these objects, and developing models to represent their evolving understandings.

Student Science Performance

6th Grade Earth Science	**Title**
Topic: The Solar System and Beyond	Modeling the Solar System and Beyond

Performance Expectation for GSE:

S6E1. Obtain, evaluate, and communicate information about current scientific views of the universe and how those views evolved.

a. Ask questions to determine changes in models of Earth's position in the solar system, and origins of the universe as evidence that scientific theories change with the addition of new information. (Clarification statement: Students should consider Earth's position in geocentric and heliocentric models and the Big Bang as it describes the formation of the universe.)

b. Develop a model to represent the position of the solar system in the Milky Way galaxy and in the known universe.

c. Analyze and interpret data to compare and contrast the planets in our solar system in terms of: size relative to Earth, surface and atmospheric features, relative distance from the sun, and ability to support life.

d. Develop and use a model to explain the interaction of gravity and inertia that governs the motion of objects in the solar system.

e. Ask questions to compare and contrast the characteristics, composition, and location of comets, asteroids, and meteoroids.

Additional notes on student supports

Students will continuously obtain, evaluate, and communicate information. This is not a linear process. Students will communicate through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.

Materials:

Investigating Gravity and Inertia: for each pair of students

- 1 clear plastic cup
- 1 marble
- 1 piece of paper
- Handout Investigating Gravity and Inertia

Engaging Learners

Phenomenon: Photos of Celestial Objects from Different Perspectives

PowerPoint presentation with pictures and guiding questions (search for "6th Grade Science Celestial Objects with Teacher Notes Slides")

Sample Photo from Photo Splash: 

Obtaining
[Planet Search]
Students obtain information about where the planets are located in the night sky. Students can achieve this via direct observation, online resources, or historical data. (See above resource.).

Communicating Students communicate their understandings via a graphic organizer or some other medium (e.g. interactive science notebook, “K” portion of a KWL chart, etc.)
Suggested Organizer:

	Photos from Earth	Photos from Space	Photos from other Planets
			
Things I Know about these images			
Questions Raised			

(This organizer is also found on Activity 1: Student Handout on Perspectives)

(Pre) Evaluating Students evaluate and communicate their initial understandings of how these perspectives were acquired and how we continue to gain understanding of the universe around us through a pre-assessment that has been modified from the resource (Beyond the Milky Way.)

Sample Prompts:

- True or False: There are no planets beyond our solar system (Answer: False. We have observed more than 200 planets beyond our solar system.)
- True or False: Engineers help us explore the universe by designing telescopes, spectroscopes and spacecraft. (Answer: True)
- True or False: We cannot send spacecraft into the universe beyond our solar system. (Answer: False. Voyager 1 is the first human-made spacecraft to leave our solar system to explore the Milky Way galaxy.)
- True or False: Our solar system is just a small part of the Milky Way galaxy. (Answer: True)

(This pre-assessment is also found on Activity 1: Student Handout on Perspectives)

Exploring the Universe	*Obtaining/Communicating* Given a scale model, such as the one found on page 2 of Activity 1 linked below, students calculate the size of the universe. Activity 1: Student Handout on Perspectives This activity is adapted from the resource: The Hidden Lives of Galaxies. *Communicating* Discussion continues in order to elicit student experiences with observations of the night sky. Students are encouraged to share and specify objects they know they have observed. *Teacher Hint:* Use A Retelling of the Story of Andromeda (PowerPoint presentation; search for "6th Grade Science A Retelling of the Story of Andromeda Slides.") You can research a PowerPoint from a resource: The Hidden Lives of Galaxies. This was adapted from the The Story of Andromeda, the story that accompanies the PowerPoint. This story is on page 2 of the Imagine the Universe booklet on the Hidden Lives of Galaxies. *Teacher Hint:* See lesson closure of Beyond the Milky Way for specific ideas and student friendly explanations.
Explaining the Universe	*Obtaining* Students obtain information about how the universe was formed and is explained within the Big Bang Theory. Resource: From within the OLogy website, Astronomy, several resources can be used. Specifically, *How Did the Universe Begin Article* can be used to set the context for creating a timeline of how astronomers figured out the organization of the universe. *Teacher Hint:* Provide students a framework for organizing obtained information: *Big Bang Theory Organizer*
Formative Assessment of Student Learning about the Universe	
	Evaluating Student evaluate their understanding of the Big Bang Theory in order to develop either a timeline with visual representations *or* a play that includes props, images, and historical figures/actors that retell the history. *Teacher Hint:* For students who require greater support, provide a mismatched timeline with captions for students to correct and/or provide a play script that contains inaccurate information that they must identify and correct. *Evaluating/Communicating* Students participate in a carousel walk of timelines and/or active participation in a play/story of the history of science. As students evaluate each other's timelines or watch peers act out history, they will provide peer feedback in terms of strengths (glows) and weaknesses (areas for growth). Suggestion for peer feedback: Peer Review of Big Bang Timeline

Elaborating the Universe	*Evaluating/Communicating* Revisit photo splash from engage phase. Students make connections between what they were able to observe of changes to the night sky to the important role of engineering and technology for making advancements/changes in the scientific understandings of the universe. Resource: Views of the Universe *Teacher Hint:* As an extension to this exploration, allow students to map the universe via modern engineering supports. See Article: Sloan Sweeps the Sky for one such extension.
Engaging in the Solar System	**Phenomenon: Thought Experiments -** Meet the Universe's Main Attraction. Transition from the universe to the galaxy to the solar system by engaging students in thinking about the unifying force: gravity. First use the above resource to elicit students' thoughts about gravity. Then engage students in a thought experiment. *Guiding Questions/Prompts for Thought Experiment:* *What forces are acting on you right now?* *Now close your eyes. You are going to participate in a thought experiment. A thought experiment is simply where you want to try to envision how things might work.* *Think again about the forces keeping you in your seat. Make a (mental) picture of these forces.* *Now think about how these same forces might be keeping earth in its orbit around the sun.* *Imagine the push and pull of the earth with the sun, the moon, and all the other planets.* *Think about how these battles play out to create the order of our solar system.* *Think about how these battles play out to keep us in a place in the Milky Way Galaxy…the universe.* *Now, open your eyes.* *Draw a model of your initial thoughts about earth's position in our solar system.* Engage students in a simple investigation that demonstrates how gravity and inertia play key roles in planetary orbits. After they have concluded the investigation, have them brainstorm how this is what is happening in our solar system. Investigating Gravity and Inertia *Obtaining/Evaluating/Communicating* Students obtain information about the mass, density, and gravity of planets in the solar system. Students evaluate the information to make explicit connections to the impact of gravity via mass to the organization of our solar system. Check out Resources: NASA's Space Place "What Is Gravity?" Planetary Mass and Gravity Worksheet from Teaching Engineering
Exploring the Solar System	*Obtaining* Students obtain additional information about the structure and function of the planets by making scale models of *one planet* and its *interior*. Upon completion of the model students also write a caption summarizing the planet's characteristics.

Teacher Hint: These are labeled drawings, pictures, or 3D examples of the composition of the planets. This is not a painted Styrofoam ball model of a planet.

One resource: Online Scale Model Calculator.

Background Knowledge:
Teacher can research: Composition and Structure of Planets

Planets of the Solar System Reviews the planets of the solar system with increasing distance from the sun, their orbits, and rotations.

Sample Student Caption:
Mercury's characteristics are still being explored. So far we know that Mercury is smaller than Earth's moon (~3,030 mi), is closest to the sun, and has a very thin, if any, atmosphere. It also doesn't tilt, which is one reason it doesn't experience seasons. We also know that its gravity is about ⅓ of Earth's. This is because of how dense the planet is since its composition includes a metallic iron core (like Earth), rocky mantle, and thin brittle crust. The iron core also gives Mercury its magnetic field and poles.

Evaluate Students use a Fact Sheet and Peer Evaluation form to evaluate their peer's scale model(s) of individual planets.

Teacher Hint: If a compiled fact sheet/organizer is preferred use the Organizer for Information about Planets.

	Distance from Sun	Size Relative to Earth	Atmosphere	Surface Features	Ability to Support Life
Mercury					
Venus					
Earth					
Mars					
Jupiter					

Saturn					
Uranus					
Neptune					

Evaluating/Communicating
Students evaluate what would be necessary in order to extend the model to compile the planets for one complete model and then also include other celestial bodies of the solar system (e.g. comets, asteroids, meteoroids). Students brainstorm which of their peers' models are better than others for including scale distances relative to each other and the sun, etc. If possible, use students' suggestions to produce an initial class model of the solar system.

Obtaining/Evaluating Students obtain additional information needed to transition their initial planet model to an entire solar system model. Students modify planets and set up scale model of solar system as needed to be most accurate.

Teacher Hint: Support students in thinking about the larger scale by working through various models. Teachers can research, for example, Solar System to Scale to a Football Field.

Rubric for Scale of Planets in our Solar System

	Exceeds Expectations	Meets Expectations	Approaching Expectations	Does not Meet Expectations
Distance from Sun	All celestial objects are accurately positioned to scale.	Most celestial objects are accurately positioned to scale.	Some celestial objects are accurately positioned to scale.	Celestial objects are not accurately positioned to scale.
Size Relative to Earth	All planets are represented to scale.	Most planets are represented to scale.	Some planets are represented to scale.	Planets are not represented to scale.
Surface Features and Atmos-phere of Planets	Models of all planets include surface features and atmosphere.	Models of most planets include surface features and atmosphere.	Models of some planets include surface features and atmosphere.	Models of planets do not include surface features and atmosphere.

Formative Assessment of Student Learning

<table>
<tr>
<td>Explaining
Finalizing Model</td>
<td>Communicating/Obtaining
Students are prompted to ask questions about how we have come to understand the solar system in this way. Students post responses to some of the questions as well as new questions they may now have. From posed questions, students then obtain information/evidence used to support historical models of the solar system.

Teacher Hint: Display questions/responses on the chart referenced in the engage phase.

Teacher Hint: Guiding questions for facilitating the students in asking questions:

How did thinking change as scientists figured out that the solar system is centered around the sun?
What kinds of observations do you think helped change their thinking?
What technology do you assume provides evidence to support a sun centered system?
In terms of these changing models, what are you wondering about right now?

Organizing Questions

<table>
<tr><th>Things We Know About the Solar System</th><th>Questions We Have About the Solar System</th><th>Where We Look for Answers</th><th>Answers to Our Questions</th><th>New Questions</th></tr>
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<td>Evaluating Students evaluate information/evidence to produce a timeline of contributions and associated changes to the model from geocentric to heliocentric.
Question: Which model, heliocentric or geocentric, is the current best fit to represent the organization of the planets in our solar system?

Student Organizer for CER of Models

Teacher Hint: Support students who need additional guidance with additional resources to use to record prepared names, contributions, and visual representations.
Additional Video Resource:
Geocentric to Heliocentric Video</td>
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	Communicating Students construct an evidence-based argument for why the heliocentric model is the current best fit, but also conjecture a possibility of what we might realize in the future that could change our thinking. *Teacher Hint:* Provide students a rubric. Additionally, consider providing students with a writing framework, such as CER, and support students in working through the writing process to include a peer check (provide a checklist of expectations). Samples/guidelines have been linked. Rubric for Model Organizer
Elaborating Applying Model to Solve a Problems	**Phenomenon** research comets and show picture(s) First Comet of 2016 Comet Catalina Visible at Sunrise
	Obtaining/Communicating After the video remind students that in the explain phase we learned that comets provided evidence for a heliocentric model of our solar system. Then transition via guiding questions so that students ask and post questions about not just comets, but also asteroids and meteoroids. *Guiding Questions: Have you ever seen a comet? Have you seen any movies that use comets, asteroids, or meteoroids as part of the story line? Do you think this is real? What do you know about these things?*
	Obtaining/Evaluating Students obtain general information about comets, asteroids, and meteorites via Less Than Five - What's the Difference Between Comets, Asteroids, Meteoroids, Meteors & Meteorites? Students then choose to become experts in one of the three- comets, asteroids, or meteoroids. As experts, students are responsible for obtaining and evaluating information about the characteristics, composition, and location of comets, asteroids, and meteoroids. Resources: Asteroids Comets
	Communicating In groups of three students share obtained information so that others learn about all three - comets asteroids, and meteoroids. Students organize all information into a provided organizer Organizer for Comparing

	Comets	Asteroids	Meteoroids
Characteristics			
Composition			

	Location				
	Visual Representation				
Evaluation	***Assessment of Student Learning***				
	Students are engaged in the assessment *Space Travel Guide* from the site Space Travel Guide. The site offers writing samples, story starters, guides, etc. *Teacher Hint: Use a writing rubric that correlates to CCGPS Science Literacy.*				
SEP, CCC, DCI	**Science Essentials**				
Science and Engineering Practices	• Asking questions and defining problems • Developing and using models • Analyzing and interpreting data				
Crosscutting Concepts	• Cause and Effect • System and System Models • Matter and Energy • Structure and Function				
Disciplinary Core Ideas	• The Universe and Its Stars • Earth and the Solar System				

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the activities.	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher should consider using guiding questions to get students discussing the images in the picture splash.
2. The teacher should have clear and consistent guidelines for discussion. These guidelines should help students feel more comfortable and be more likely to participate.
3. The teacher should consider providing students with sources to find information about the planets in the night sky.
4. The teacher should consider how students could access the material in the sources that are provided. It might be beneficial to students to provide different access points to the material such as articles, video and use of text-to-speech to assist students in accessing the materials.
5. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.

6. The teacher should consider a formative assessment to determine which students need reviewing, re-teaching or enriching.

Exploring the universe:

1. The teacher should consider explicitly teaching students how to use a model. Discuss what conclusions might come from a model and how it might be used to represent something.
2. The teacher should consider providing students with a calculator to assist students with the calculations.
3. The teacher may need to assist students in completing the calculations.
4. The teacher should have clear and consistent guidelines for discussions. These guidelines should assist students in feeling more comfortable participating in the discussion.
5. The teacher should consider how students could access the material in the sources that are provided. The teacher may need to assist students in accessing the material in A Retelling of the Story of Andromeda by leading a read aloud, showing a video or using text-to-speech.
6. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.
7. Students may need additional time to complete their assignment.

Explaining the universe:

1. The teacher should consider providing sources to students for use in research.
2. The teacher should consider providing students with an organizer to record their research.
3. The teacher should consider a formative assessment to determine which students need re-teaching, reviewing or enriching.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.
5. The teacher should consider having multiple ways for students to share their work.
6. The teacher should have clear and consistent guidelines for peer feedback. These guidelines should ensure that students give and receive respectful, positive, constructive and useful feedback.

Elaborating the universe:

1. The teacher may need to show the photo splash to students again to assist them in making observations and connections about the night sky and science.
2. The teacher should have clear and consistent guidelines for discussion to help students feel more comfortable and be more likely to participate.
3. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.

Engaging the Solar System:

1. The teacher should consider how students could access the material in the sources that are provided. The teacher may need to assist students in accessing the material by leading a read aloud, showing a video or using text-to-speech.
2. The teacher should prepare students for the thought experiment by describing what the students will be expected to do and what they are looking for during the thought experiment. Some students with sensory issues may find this difficult to accomplish because of the change in sensory input.

3. The teacher should be prepared to repeat directions as needed.
4. Teacher should consider providing resources for students to use in their research.

Exploring the Solar System:

1. The teacher should consider providing students with sources to use in the research about structure and function.
2. The teacher should consider providing students with an organizer to assist in the creation of a model.
3. The teacher should consider providing students with a rubric to self-evaluate their model. This should increase student ownership of the work.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.
5. The teacher should consider pointing out what type of model they are most interested in seeing the students create or what the most important points of the model should be.
6. The teacher should consider providing students with the scale model calculator to assist students in determining how to use scale in their model.
7. The teacher should consider using read aloud, text-to-speech of videos to assist students in accessing the material.
8. The teacher should have clear and consistent guidelines for peer feedback. These guidelines should ensure that students give and receive respectful, positive, constructive and useful feedback.
9. The teacher can lead a class brainstorming session to determine what might be necessary additions to the individual models to make a class or group model that includes all of the planets.

Explaining:

1. The teacher should consider providing students with question stems to assist students in generating questions.
2. The teacher may need to consider helping students narrow down their questions to the ones that most relate to the standard or lesson.
3. The teacher should consider providing students with an organizer to assist students in recording research.
4. The teacher should consider providing students with the CER template to begin formulating their claim and providing evidence to support their claim.
5. The teacher should consider showing a video that explains the history of the solar system model.
6. The teacher should consider explicitly teaching students the differences between the heliocentric and geocentric models of the solar system.
7. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.
8. Students may need additional time to complete their assignment.

Elaborating:

1. The teacher should consider using read aloud, text-to-speech of videos to assist students in accessing the material.
2. The teacher may need to show the video more than once to allow students to make observations.

3. The teacher should consider providing students with question stems to assist in generating questions.
4. The teacher should consider providing students with resources to use in their research.
5. The teacher should use intentional and flexible grouping to group students. Best practice is to use data to drive student groupings.
6. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include drawing, writing or designing a presentation.
7. Students may need additional time to complete their assignment.

Evaluating:

1. The teacher should consider giving students multiple options to express their knowledge. These options could include writing, drawing or designing a presentation.
2. The teacher should consider having students explain their models, data and reasoning as they move through the lesson.
3. The teacher should complete a formative assessment several times throughout the lesson and re-teach, review and enrich as needed.

Planet Search

Your Challenge:

The planets orbit the Sun in their own orbits. Each night the planets will be in a slightly different location. Your challenge is to discover where the planets are tonight.

Discovering:

1. Use a program or app that gives a view of the night sky.
2. Start with the 8PM view. Search North, South, East, West, and Zenith (Overhead). Record any planets you can see at 8PM on the chart below. Describe when to look, which direction to face and the name of the constellation in which you found the planet.
3. Next choose 5AM in the program in all directions. Record any additional planets you find.
4. Any planets that are NOT visible at either time are too close to the Sun in our sky - either in front of the Sun or behind it. Put "too close to the Sun" in the blanks.

Where it is tonight

Planet	How It Looks	Time	Direction	Constellation
Mercury	bright but always in twilight	________	________	____________
Venus	brightest in Earth sky, looks white	________	________	____________
Mars	red planet, bright as a bright star	________	________	____________
Jupiter	second brightest, brighter than stars	________	________	____________
Saturn	bright as a bright star, yellowish-white	________	________	____________
Uranus	faint, requires binoculars, greenish	________	________	____________
Neptune	faint, requires small telescope	________	________	____________
Pluto	very faint, requires large telescope		________	____________

5. Take this information outside tonight or tomorrow morning and record any planets you see. Remember that planets shine with a steady light and do not twinkle as the stars do.

Making Science Sense:

The orbits of the planets lie in almost the same plane (or disk). The Zodiac constellations are also in this plane. Use this information to explain why the planets are never in the Big Dipper.

Return to Instructional Segment

The Universe: Big Bang Theory (Scientific views of the universe and how those views have evolved)

Phenomena: Photos from Different Perspectives

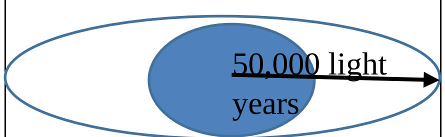
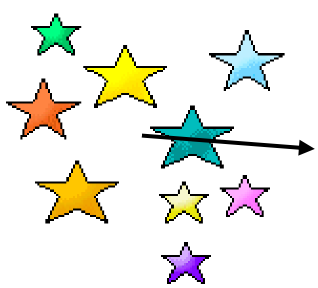
	Photos from Earth 	Photos from Space 	Photos from other Planets 
Things I Know about these images			
Questions Raised			

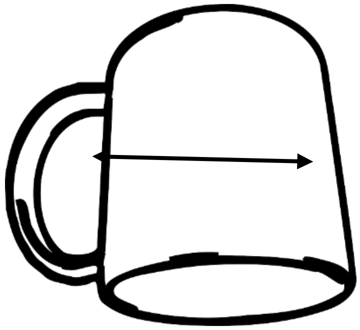
Statement	True or False: Circle your decision.	**Initial Explanation:** I think this way because….
There are no planets beyond our solar system.	True or False	
Engineers help us explore the universe by designing technology such as telescopes, spectroscopes, and spacecraft.	True or False	
We cannot send spacecraft into the universe beyond our	True or False	

solar system.		
Our solar system is just a small part of the Milky Way galaxy.	True or False	

How Big is the Universe?

(adapt from https://imagine.gsfc.nasa.gov/educators/galaxies/imagine/imagine_book_2009.pdf)

Measurement	Visual Representation: *Add appropriate values within the visuals. The first one has been modeled for you.*	Question
The Milky Way has a radius of about 50,000 light years.		What is the approximate diameter of the Milky Way Galaxy?
The visible universe has a radius of approximately 15 billion light years.		What is the approximate diameter of the visible universe?

Scale Model: An 8 cm wide coffee cup represents the diameter of the Milky Way Galaxy.		If the Milky Way is represented by an 8 centimeter wide coffee cup, how big would the rest of the universe be in kilometers?

Show your calculations:

Brainstorm: What other models could you develop to represent our Galaxy...our Universe?

Return to Instructional Segment

The Story of Andromeda

The constellation Andromeda contains our Galaxy's companion, the Andromeda Galaxy. Under clear skies on a dark night, it can be seen with the naked eye. At a distance of 2.2 million light years, it is the farthest object we can see without a telescope, and yet it is but the first stop in the vastness of the universe outside our Galaxy.

As a tribute to our search for knowledge about these objects in the universe, we recount an early story to explain what we see in the sky.

In Greek mythology, Andromeda was the daughter of Queen Cassiopeia and King Cepheus of Ethiopia. Andromeda's mother claimed she was more beautiful than the sea nymphs, the Nereids. The Nereids felt insulted by this and complained to the sea god Poseidon.

Poseidon threatened to send a flood and a sea monster, Cetus, to destroy the kingdom of Ethiopia. The king consulted the oracle of Ammon who advised him to sacrifice his daughter. Andromeda, dressed only in jewels, was chained to a seacliff. At this time, Perseus, a Greek hero was traveling along the coast of Africa to the north. He noticed the beautiful woman chained to a rock and instantly fell in love with her.

Perseus offered to rescue Andromeda in return for her hand in marriage. Andromeda had already been promised to a man named Agenor. However, hoping to save their daughter from the approaching sea monster, King Cepheus and Queen Cassiopeia consented in bad faith to Perseus' request.

Perseus was a valiant warrior and possessed some powerful weapons, including the head of the Gorgon Medusa, which had the capability to turn everything into stone. With the aid of the Gorgon's head, Perseus slew Cetus and freed Andromeda. On Andromeda's insistence, the wedding was then celebrated. Her parents, who had forgotten their promise to Perseus, informed Agenor of the wedding. He interrupted the ceremony with an armed party.

A violent fight took place with King Cepheus and Queen Cassiopeia siding with Agenor. Perseus prevailed, using the Gorgon's head to petrify his opponents. Finally, Andromeda left her country to live with Perseus, who later became the king of Tiryns and Mycenae. The goddess Athena placed the figure of Andromeda among the stars as a reward for keeping her parents' promise.

The Hidden Lives of Galaxies written by Dr. James C. Lochner NASA/GSFC Greenbelt, MD taken from **Imagine the Universe**: https://imagine.gsfc.nasa.gov/.

Return to Instructional Segment

Big Bang Theory Organizer

Scientist	***Ideas (in words)***	***Ideas (in visuals)***	***Related Terms***	***General Time frame***

Return to Instructional Segment

Peer Review of Big Bang Timeline Work

Directions: You must choose at least one of each to peer review.	Grows (Ways to improve)	Glows (How this is good)
Classmate 1: (Timeline or Play)		
Classmate 2: (Timeline or Play)		
Classmate 3: (Timeline or Play)		

Return to Instructional Segment

Article: Sloan Sweeps the Sky

A science bulletin from the American Museum of Natural History

The astronomers at Apache Point dislike clouds. On their 2,788-meter high, ponderosa pine-studded perch in the southernmost part of the Rockies, New Mexico's Sacramento Mountains, a perfect night must be perfectly clear. Humidity must be low, with light winds, and neither lightning nor a full moon. John Barentine, one of the eight telescope observers at Apache Point, considers himself an amateur meteorologist as much as an astronomer.

The Sloan telescope points skyward at the Apache Point Observatory in the Sacramento Mountains, New Mexico.

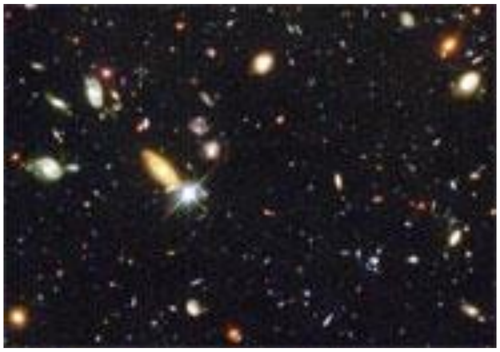
Jason Lelchuk for American Museum of Natural History

Such ideal conditions happen only one out of every three nights. That's when the 2.5-meter telescope unfurls from its aluminum-slatted wind baffle to press on with the Sloan Digital Sky Survey. The project is a systematic scan of every object visible--that is, visible to the telescope--in one-half of the northern celestial hemisphere. This has never been done before.

Seven years of observing at Apache Point has tallied over 100 million stars, galaxies, quasars, and other luminous space objects many unseen until now. "Huge amounts of data have come from this telescope," says Bruce Gillespie, the observatory's operations manager. "And when I say huge, I'm talking about more data than that contained by the digitized Library of Congress."

Other sky surveys have been done most notably by Caltech's Palomar Observatory between 1950 and 1957, of about 50,000 space objects but never with the scope, technology, and usefulness of Sloan's. The ultimate goal of the project, which is mostly philanthropically supported by the Alfred P. Sloan Foundation, is to create the first-ever map of one-quarter of the heavens in three dimensions. The task is now about 80 percent complete. When finished, the map will be consulted to help answer some of our thorniest questions about the structure and origins of the Universe. "It's an issue of statistics and volume," says Barentine. "A lot of the questions we have depend on that statistical information building up a picture of the Universe as a whole rather than just our particular little corner of it. The Sloan survey gives us access, for the first time, to the information that allows us to address the big-picture questions, which so far have only been the province of theorists."

Spotlight vs. Floodlight



A portion of the Hubble Deep Field's renowned 1996 image of 1,500 galaxies in a narrow "keyhole" view of the Universe. The image covers an area of sky as wide as a dime viewed from 75 feet away and as deep as the visible horizon of the Universe.

STScI/the Hubble Deep Field Team/NASA

No conventional telescope, or even the Hubble Space Telescope, could do Sloan's job. "The Hubble Deep Field has produced one of the most famous pictures in astronomy," says Michael Turner, a theoretician at the University of Chicago and the Fermi National Accelerator Laboratory. "It is a deep and narrow image of the Universe containing about 1,500 galaxies. But the Hubble Deep Field is only one forty-millionth of the total sky. With Sloan, you're seeing one-quarter of the sky."

With its perpetually cloud-free vantage point in space, Hubble spotlights details about select space objects. Sloan's much wider field of view casts a floodlight on the celestial landscape. As Earth's rotation causes the night sky to roll by, Sloan stands at a fixed position on Apache Point, shooting a continuous strip of the heavens with its specially built 142-million-pixel camera. The strips are composited side by side like cosmological wallpaper, creating a seamless map of all the sky available to the telescope.

One sacrifice for Sloan's wide field of view is its resolution. Its images aren't nearly as crisp as Hubble's (click to compare). But its sensitivity is such that many very dim objects, both inside and outside our galaxy, are being registered for the first time.

2D vs. 3D

Some of the panoply of luminous points in the night sky are bright because they are nearby stars. Others, such as quasars, are intrinsically bright, yet are billions of light-years from Earth. Sloan's digital picture-taking registers the precise brightness of objects shiny and dim, and measures their positions relative to one another in two dimensions. Determining an object's distance from Earth the added dimension of depth requires an extra step called spectroscopy.

Sloan observer John Barentine displays one of the survey's aluminum "plug plates." A plate is placed behind the telescope barrel to capture light from 640 selected galaxies in an area of space. The light is channeled to spectrographs via a fiber optic cable inserted in each hole. *Jason Lelchuk for AMNH*

Spectrographs act as prisms by measuring a space object's spectrum, or its light broken down into its constituent colors. "With spectra, you can measure very important physical parameters about the object, such as its distance, its temperature, chemical composition, and magnetic fields," says Gillespie. "You do real physics with the data that from a spectrograph, rather than just take a picture of something." Before Sloan, acquiring a single object's spectra could take about an hour. Sloan's spectrographs measure 640 spectra at once.

To save time, only a selected number of the 100 million space objects registered by Sloan get the extra spectrographic step: about 700,000 at current count. The distance data on the objects, acquired from the spectrum analysis, make up the points on the three-dimensional Universe map. A sample size of about a million objects is the minimum needed to get a sense of the overall distribution of the Universe. “Theorists want to understand the large-scale structure of the Universe, because our ideas about how the Universe began predict how galaxies are distributed in it today,” explains Turner. Turner and his colleagues at Fermilab are just one of the teams eager to test ideas about the early Universe against Sloan’s real-life, current-day data.

Then vs. Now

The Sloan survey team publicly releases its data in batches about 18 months after it acquires them. Using the data, astronomers have so far discovered the Universe’s most distant quasars, its dimmest stars and galaxies, a new class of dwarf stars, and even a previously unnoticed galaxy stuck right in our own Milky Way. “That aspect of the unknown of seeing things that no human being has ever seen before, of going to distances that no one has even really conceived of before is probably the most exciting aspect of this work,” says Barentine. The potential for going this distance has the scientists at Apache Point looking way beyond the clouds.

Related Links

Sloan Digital Sky Survey

Return to Instructional Segment

Gravity and Inertia Name ___________________________________

Introduction:

Gravity is the force of attraction where a planet or other body draws or tends to fall toward the center.

Inertia is the tendency of an object to either remain at rest or continue in a straight line unless that tendency is acted upon by an outside force.

These two acting together are what keep our planets in orbit around the sun.

Gravity is what pulled the atoms together right after the Big Bang to form stars, galaxies, planets, etc. It also keeps the atmosphere around a planet. Gravity causes the water to stay on our planet and things to fall to the ground.

One of Sir Isaac Newton's Laws of Motion states: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an outside force.

According to Newton, the planets are constantly moving in a straight line but the gravity from the Sun is pulling them toward it. The two working together is what keeps planets from being pulled into the Sun or shooting off into space.

Let's investigate this.

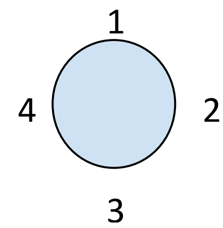
When a planet travels around the sun- it is called its orbital path or revolution. The time it takes for that to happen is called its year. For the Earth that is 365 ¼ days.

When a planet goes around on its axis, it is called rotation. The rotation on the axis is what gives day and night to that planet. The side of the planet that is facing the Sun is day and the side facing away from the Sun is night. This happens continuously as the planet rotates around on its axis and revolves around the Sun.

Lab

Materials: Per two students: 1 clear plastic cup, 1 marble, 1 piece of paper

1. Take the cup and turn it upside down on the paper and trace the circle it makes in the center of the paper.



Number 1-4 on the outside of the circle in the 12, 3, 6, 9 o'clock positions.

2. Rest the upside down cup on the traced circle. Put the marble inside the cup. Slowly rotate the cup to make the marble spin inside along the edges. Don't spin the marble too fast.

3. Once the marble is rolling around at a steady pace, tilt the cup up at point one keeping the other side of the cup as flat on the paper as you can. Watch what happens to the marble (Don't lose it!)

4. Draw a line on your paper next to your circle to show which way your marble went.

5. Repeat for the numbers 2, 3, and 4.

Answer these questions:

1. How would you describe the path that the marble took when you lifted the cup?

2. Is the path the marble took, the same for all 4 exit points? Explain your results.

3. As the marble traveled within the cup, what direction does the cup "push" the marble? (Hint: What keeps the marble from flying off?)

4. If we compare this model to an orbiting planet, what force does the cup represent?

5. How would you compare the marble within the cup to the forces that are on a satellite (natural or man-made) orbiting the Earth?

Return to Instructional Segment

Solar System: Student Fact Sheets and Peer Evaluations of Planet Models (Explore Phase)

Fact Sheet: Mercury

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Mercury

Direction: Use the fact sheet to answer each question with a YES or NO. <u>Give suggestions</u> for *at least* two factors. <u>Give praise</u> for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Venus

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc

Peer Evaluation: Venus

Direction: Use the fact sheet to answer each question with a YES or NO. Give suggestions for *at least* two factors. Give praise for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Mars

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Mars

Direction: Use the fact sheet to answer each question with a YES or NO. <u>Give suggestions</u> for *at least* two factors. <u>Give praise</u> for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Jupiter

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Jupiter

Direction: Use the fact sheet to answer each question with a YES or NO. Give suggestions for *at least* two factors. Give praise for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Saturn

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Saturn

Direction: Use the fact sheet to answer each question with a YES or NO. <u>Give suggestions</u> for *at least* two factors. <u>Give praise</u> for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Uranus

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Uranus

Direction: Use the fact sheet to answer each question with a YES or NO. <u>Give suggestions</u> for *at least* two factors. <u>Give praise</u> for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Fact Sheet: Neptune

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.

Peer Evaluation: Neptune

Direction: Use the fact sheet to answer each question with a YES or NO. <u>Give suggestions</u> for *at least* two factors. <u>Give praise</u> for *at least* two factors.

Size	Interior Structure	Atmosphere	Gravity	Temperature	Ability to Support Life	Misc.
Is this presented to scale?	Is this presented to scale?	Is this presented to scale?	Is this presented relative to Earth's gravity?	Is this presented based on relative distance from the sun?	Is this presented in a way that makes sense?	Is any misc. info presented?
	Is this presented based on composition?	Is this presented based on composition?				

Return to Instructional Segment

Organizer for Information about Planets

	Distance from Sun	Size Relative to Earth	Atmosphere	Surface Features	Ability to Support Life
Mercury					
Venus					
Earth					
Mars					
Jupiter					
Saturn					
Uranus					
Neptune					

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Rubric for Relative Scale of Planets

	Exceeds Expectations	Meets Expectations	Approaching Expectations	Does not Meet Expectations
Distance from Sun	All celestial objects are accurately positioned to scale.	Most celestial objects are accurately positioned to scale.	Some celestial objects are accurately positioned to scale.	Celestial objects are not accurately positioned to scale.
Size Relative to Earth	All planets are represented to scale.	Most planets are represented to scale.	Some planets are represented to scale.	Planets are not represented to scale.
Surface Features and Atmosphere of Planets	Models of all planets include surface features and atmosphere.	Models of most planets include surface features and atmosphere.	Models of some planets include surface features and atmosphere.	Models of planets do not include surface features and atmosphere.

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Organizing Questions

Things We **Know** About the Solar System	Questions We Have About the Solar System	Where We Look for Answers	Answers to Our Questions	**New** Questions

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Student Organizer for CER of Models

Question: Which model, heliocentric or geocentric, is the current best fit to represent the organization of the planets in our solar system?

Evidence 1	Evidence 2	Evidence 3	Evidence 4
↓	↓	↓	↓
Connected Reason	Connected Reason	Connected Reason	Connected Reason
↓	↓	↓	↓

CLAIM:
Critical Thinking: What possible information could be acquired that might change the way we view this current organization of the solar system?
1.
2.

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CER Writing Rubric

	Exceeds Expectations	Meets Expectations	Approaching Expectations	Does Not Meet Expectations
CLAIM	Claim is clearly and accurately stated with historical context.	Claim is clearly and accurately stated.	Claim is accurately stated, but somehow difficult to read.	Claim is either inaccurate or difficult to read.
EVIDENCE	4 pieces of supporting data with details of historical context are provided.	4 pieces of supporting data is provided.	2-3 pieces of supporting data are provided.	1 or less piece of supporting data is provided.
REASONING	Each piece of data is supported with a reason for its connection to supporting a heliocentric model.	Each piece of data is supported with a loosely connected idea to how it supports a heliocentric model.	Reasons are incomplete and/or not explicitly connected to supporting a heliocentric model.	Reasons are lacking and/or missing.
CRITICAL THINKING	Two potential additional pieces of data/information that could alter our heliocentric model is presented with explanation for how the scientific community would work to reconstruct our understandings.	Two potential additional pieces of data/information that could alter our heliocentric model is presented.	One potential piece of data/information that could alter our heliocentric model is presented.	No potential data is presented.

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Organizer for Comparing

	Comets	Asteroids	Meteoroids
Characteristics			
Composition			
Location			
Visual Representation			

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