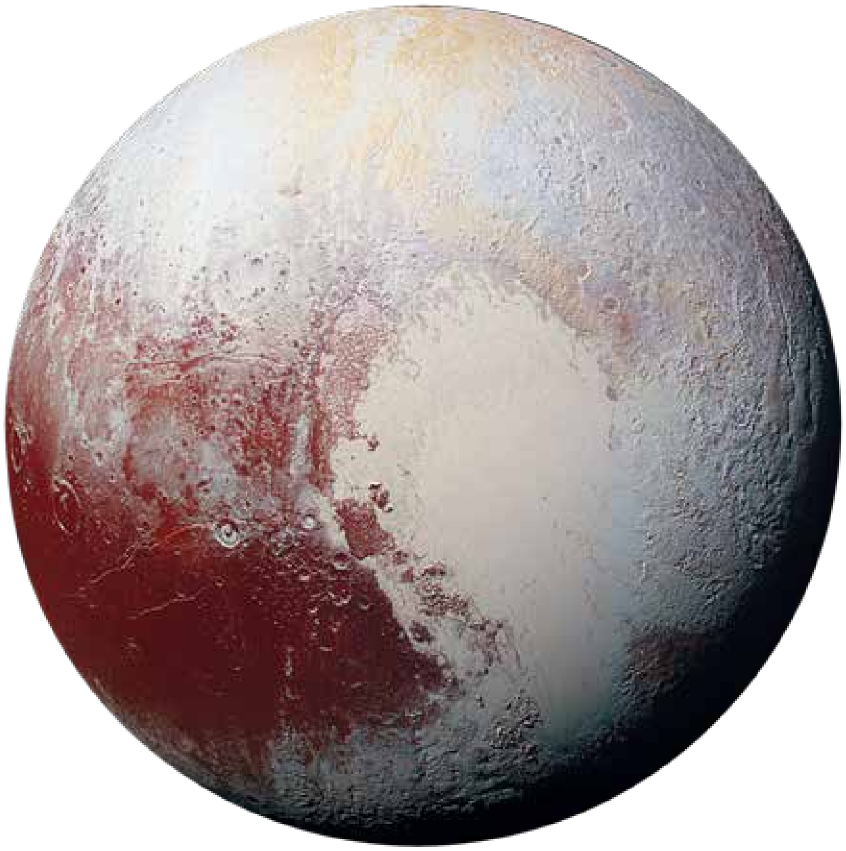
Science News

IN HIGH SCHOOLS | EDUCATOR GUIDE



A world like no other COMES INTO VIEW

JHU-APL, NASA, SWRI

SOCIETY FOR SCIENCE & THE PUBLIC

SN EDUCATOR GUIDE

A world like no other COMES INTO VIEW

About the article

The *Science News* article "A world like no other comes into view" recaps what researchers have learned about Pluto since the New Horizons mission flyby in July. The mission, which *Science News* named the top science story of 2015, reminds us that there is still much to discover about our solar system.

"A world like no other comes into view" can be used across a wide range of curricula, with a focus on **earth science** and **engineering design**. The activities, questions and discussions in this educator guide can be used to support the following education standards:

Next Generation Science	Common Core
Forces and Interactions: HS – PS2-4 (with a focus on gravitational attractions)	ELA Standards: Reading Informational Text (RI): 1, 7
Engineering Design: HS-ETS1-3	ELA Standards: Writing (W): 2, 3, 6, 7, 8, 9
Space Systems: HS-ESS1-4	ELA Standards: Speaking and Listening (SL): 1, 2, 4
	ELA Standards: Language (L): 1, 3, 6
	ELA Standards: Reading for Literacy in History/Social Studies (RH): 2, 3, 7, 8, 9
Reinforcement for Middle School: Space Systems: MS-ESS1-2, MS-ESS1-3	ELA Standards: Reading for Literacy in Science and Technical Subjects (RST): 2, 3, 4, 5, 6, 7, 9
	ELA Standards: Writing Literacy in Historical/Social Studies and Science and Technical Subjects (WHST): 2, 6, 7, 8, 9

Prior to reading

Guide student reading by pointing out connections between this article and what students are learning in class. Here, find ideas for standard-aligned paths to follow while reading:

- Ask students what they know about our solar system. If they were going to take a trip through the solar system, what destinations might they visit? *(Students might mention planets, moons, dwarf planets, asteroids, comets, rings, geysers, etc.)* Encourage students working alone or in small groups to predict the distances between major destinations in the solar system. Provide students with more information to help guide their thinking: For example, if they were to drive a car from Earth to the sun, it would take about 193 years driving at 55 miles per hour (92.96 million miles divided by 55mph, then divide by the number of hours in a year). If you drive from Earth to Mars when the two are at their average distance from each other, it would take about 290 years. How long would it take to reach Pluto? Use Blackline Master 1 to introduce astronomical units and have students chart distances on cash register tape. This activity will help students focus on the distances between solary system objects.
- Do students know the relative sizes (diameters) of the planets? Which is biggest? Which is smallest? Using estimation, how close can the students get to the planets' actual sizes? Present students with a variety of foods (honeydew melons, cantaloupes, lemons, limes, grapes, macadamia nuts, peppercorns, for example) or use Blackline Master 2 (which depicts their relative sizes). Have students work in teams to decide which foods represent which solar system objects and justify their answers. You may choose to give them additional instructions. (Do they need to use all of the foods just once, for example, or can they use foods more than once?) If using the images provided, students can position their foods on the cash register tape created in the above activity. Have students compare their choices and discuss the strategies used to predict, model and revise their thinking.
- Ask students to consider what makes something newsworthy. To what extent are newness, importance, proximity, human interest and visual appeal relevant? Are these factors the same across all areas of news coverage, or do they differ for coverage of politics versus science, crime versus technology, pop culture versus public health? All of *Science News'* top stories of the year are available for free at this link. Examine the top stories for evidence of newsworthiness, or have students debate the order and suggest alternate stories.

After reading: Comprehend

You can adapt and print these questions (Blackline Master 3) to check for comprehension and analysis before or after discussion:

1. **What is the main topic of the article?** *(New Horizons, a robotic spacecraft, flew by Pluto for the first time ever in July. The spacecraft's findings are deepening and challenging what researchers know about the dwarf planet.)*
2. **What are some of the landforms visible on Pluto?** *(Mountains of water ice, glaciers with channels, ice flows and ice volcanoes.)*
3. **How do images from Hubble and New Horizons differ?** *(New Horizons images provide far more details than those from Hubble. New Horizons can see features the size of New York's Central Park.)*

4. **Is the New Horizons mission over, why or why not?** *(No, New Horizons will head next to 2014 MU69, about 1.6 billion kilometers past Pluto. Also, only a portion of the data from New Horizons are in, so new data will continue to be analyzed and new findings announced.)*
5. **What other robotic spacecraft are currently in the works and where are they headed?** *(Juno is headed to Jupiter; plans are under way for a mission to Europa and possibly Uranus or Neptune.)*

After reading: Analyze

1. **How are the features of Pluto similar to and different from those of Earth?** Have students use the Venn diagram in Blackline Master 4 to chart their thinking. *(Answers will vary. Some features, like the presence of volcanoes, are the same, but the volcanoes are made from different substances. Students may note the blue skies as a similarity between the two.)* Encourage students to think about how each type of landform develops on Earth, based on their knowledge of plate tectonics, and to think about whether this understanding is useful in studying other planetary and astronomical bodies.
2. **Why is Pluto called a celebrity?** *(Answers will vary but might include: Many, many people around the globe were watching and waiting for news from New Horizons. Journalists and scientists celebrated the event with a big party on encounter day. When Pluto was renamed a dwarf planet, rather than a planet, many people took a keen interest in its reclassification, writing letters and making T-shirts, for example.)*
3. **Why do scientists study other planetary bodies?** *(Answers will vary but might include: To find out what a world far from Earth is like. To understand geological features. To better understand solar system formation and evolution. Because they find interesting and unexpected things that transform their understanding.)*

Discuss and Assess

After students read the article independently, return as a group to the concepts outlined prior to reading. Invite students to share their answers and observations from the article and lead a class discussion that further underscores your current curriculum. The discussion can serve as an informal assessment. Ideas for further reading discussion or writing prompts include:

- What makes something a planet? Discuss with students what the word "planet" means to them and to others, including the International Astronomical Union. Why might scientists emphasize different criteria for planethood? Based on these conversations, discuss why Pluto was demoted from "planet" to "dwarf planet" in 2006. *(The IAU emphasized that a "planet" needs to orbit the sun, needs to have enough gravity to pull itself into a spherical shape and needs to clear the neighborhood of its orbit.)* Do students think Pluto's classification makes any difference in how it is studied, or how much attention it receives from researchers? Does the classification matter to the general public? If the debate over Pluto's planethood happened today, what position would the students take? Why? How would they share their opinions to try to influence the decision? *(Students might consider social media, public forums and letter-writing campaigns.)*
- Ask students how planets become spherical. Introduce the idea of gravity originating from the center of an object and pulling molten planetary material inward. As planets cool, they remain spherical, but their spins affect their shape, giving planets a bulge at the equator. Different planets have different bulges depending on how fast they spin; Jupiter's is visible with a backyard telescope. One way to demonstrate the spherical nature of planets is to fill a clear container halfway with water (add food coloring so it's easier to see). Carefully layer alcohol on top of the water (use the back of a spoon or a pipette) to create a clear layer. Inject a droplet of oil between the layers and observe the shape the oil takes as it suspends between the layers (photo at left). Notice that it takes the same general shape as a planet, though the mechanism is different. To add mathematical thinking, challenge students to find a way to determine the circumference of the oil droplet.

Photo of demonstration
(by Stacy Sinclair)

- What would it take to travel to Pluto? What would you take with you? What would you need when you arrived? How would you get home? Could you form a community there? Encourage students to consider the time it would take to get a large vessel to Pluto and the amount of fuel required to escape Earth's pull. Encourage them to think about what difficulties they might encounter on the journey, how they might land on the dwarf planet and how they might survive the environmental conditions there. What kind of food and water sources might the students need? Survival gear? Entertainment? Medical personnel and other professionals?
- Humans have long journeyed away from their immediate surroundings to explore what is beyond the horizon — from reaching new continents to reaching space. With each exploration, newly gained knowledge changes our understanding of the world and the universe. Ask students to research today's most interesting explorers. Where are they going? How are they getting there? What vistas are still left to explore? *(Students can research modern explorers and their areas of focus individually or in groups. People to consider include Robert Ballard, Gerlinde Kaltenbrunner, Edith Widder, along with Alan Stern. Or, have students come up with their own explorer. You can ask them to report their findings in the form of a brief essay or oral presentation.)*

Extend

Offer students other ways to explore the content of the article as it relates to your curriculum, such as:

BRAVE NEW WORLDS

- **Purpose:** Students will explore how astronomers learn about planets using remote-sensing techniques and more direct observations. In the first part of this activity, students will create their own model planet. In the second part of the activity, students will use a planetary viewer to observe their planets in various ways that simulate different types of space missions — telescope missions from Earth, a flyby mission or a landing, for example. Students will collect information and ask new questions with each new mission. This activity will demonstrate how knowledge accumulates, how space exploration progresses and what types of information can be gained from what types of missions.

- **Potential misconceptions:** Students might think that missions that get closer to the planet are always more revealing. They might not understand that each type of mission has its benefits and limitations.

- **Notes to teacher:** This activity works well over two days, one for planet creation and one for observation. The planet creation could also be done at home or as a connection to visual arts curriculum. You might ask students to make their planets individually or as a group, or you might have multiple classrooms make the planets and then swap planets between the classrooms.

- **Materials for building and positioning the planets:**

  For each team
  - large foam shapes or modeling clay
  - an assortment of craft materials including plastic balls, foam balls, sequins, perfume, essential oils, candy, small stickers, marbles, cotton balls, toothpicks, construction paper, glitter, marshmallows, beads, pushpins, paint, markers
  - an assortment of construction tools including masking tape, glue, scissors, paint brushes, metal wire, wooden dowels

  For the class
  - lightweight sheets, towels or other cloths big enough to cover each of the planets placed on a table
  - measuring tape
  - masking tape to mark distances from planets

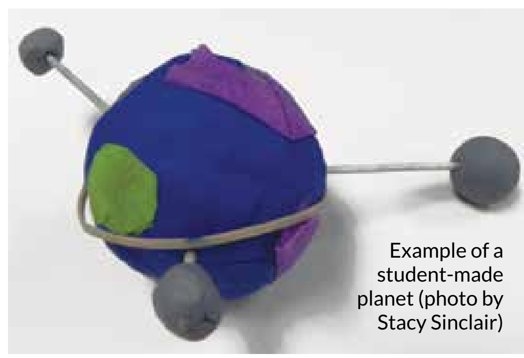
- **Materials for the planetary viewer:**

  For each student
  - white paper
  - 3-inch piece of blue cellophane
  - tape
  - rubber band

- **Materials for the missions:**

  For the teacher
  - a timer

  For each team
  - planetary viewer
  - pushpin, sticker or piece of tape
  - multiple copies of Blackline Master 5 for recording observations and questions



Example of a student-made planet (photo by Stacy Sinclair)

- **Directions:**

  Part 1: Build the planets

  1. Assign students into teams as necessary.
  2. Give students large foam shapes or modeling clay to form the basic shape for their planet. They can mix colors and decorate it with stickers, glitter, scents and so on. (See an example planet in the image, above right.)
  3. Encourage students to make their planet a place that would be interesting for observers. They might want to place some objects or decorations where they are not obvious upon brief or distant observations. Some suggestions: Create clouds over the surface, carve channels, attach high-elevation objects (use a toothpick), create craters, consider including small stickers to signify life, embed small objects, apply scent or texture to just a small area.
  4. Once the planets are complete, position the planets on small tables along one end of the room with space to walk completely around them. (If you are going to swap planets with another classroom, this is the time to do it.)
  5. Cover the planets with a sheet or towel. Mark the floor to create a near and a far observation point (2 feet and 7 feet) for each planet.

  Part 2: Observe the planets

  1. Give students a brief introduction to the mission. Tell them that they are scientists who are discovering a strange new planet. Their job is to learn as much as they can about the planet.

     It can be useful to remember history, and how scientists learn from it. Often initial observations and interpretations can turn out to be wrong. Consider Italian astronomer Giovanni Schiaparelli, who described the lines he saw on Mars as channels. Later called canals, they prompted people to think that Martians had constructed infrastructure on the planet. Percival

Lowell used observations of the same structures as evidence of water on Mars, imagining fertile green areas amid desert. However, when the first close-up photographs of Mars were captured by Mariner 4, they showed no lush and green but only barren and desert-like landscape. This information helped NASA plan later missions, including orbiters, landers and rovers. Each expedition brings new information, which leads to new questions. New questions lead to new discoveries.

2. Before beginning their missions, students will need to build their observing instrument — a planetary viewer. Have them roll their piece of paper to make a tube shape, about the diameter of an empty paper towel roll. Secure the roll with tape. Place a piece of blue cellophane over one end and secure it with a rubber band. To operate, look through the tube with the cellophane at the far end.

3. Students will now embark on the missions, listed below. You can choose to include all of them or select two or three for comparison.

4. During every mission, ask students to record their observations using Blackline Master 5. Students can use words and sketches. They should form questions based on their observations. In each round after the first, students will see if they can answer questions previously asked; this will create a running record of their thinking. Encourage students to share their way of thinking with other teammates and other teams.

5. After students have completed the task, discuss what they have learned about the planet. What missions were most revealing? Why? Are there still questions left to answer?

Mission 1: The view from Earth

1. Arrange teams against one side of the room, opposite the planets. Call this side of the room "mission control." The planetary viewer students built represents a telescope located on the surface of Earth. The blue cellophane represents Earth's atmosphere.

2. Have each team select a student who will lift the sheet or towel off the planet. That student has to keep his or her eyes closed while the sheet is lifted so as not to give away any secrets.

3. Tell students they will have their first look at the strange new planets, using their telescopes, but they cannot move from where they are standing. Have helpers lift the planetary covering for 30 seconds and replace it. The covering simulates the limited time the planet is in view either due to daylight or other obstacles, such as its orbit.

Mission 2: A view from space

1. Arrange teams against one side of the room, opposite the planets, in "mission control."

2. Ask students to take one step forward and remove the blue cellophane from their viewers. Tell them that their viewers are now a space telescope (like Hubble), so the atmosphere no longer obscures their view.

3. Space telescopes are expensive and many scientists want time to use them. Students, therefore, have a very short period of time to use their viewers. Have the sheets or towels lifted again for 15 seconds, then replaced.

Mission 3: Flyby

1. Instruct students to turn their backs to the planets until it's time for their mission. (It's dark traveling across space.)

2. Uncover the front of each planet (the rest is still masked by the sheet or towel).

3. A partner can guide a student from each team to the far observation point.

4. All at once, or sequentially depending on the space in your classroom, have the students raise their viewers to their eyes and sweep them across the planet.

5. Replace the sheet or towel.

Mission 4: Orbiting the planet

1. Instruct students to turn their backs to the planet until it's time for their mission.

2. Uncover the full planet this time.

3. Give students one minute to circle the planet at a distance of no more than two feet, looking through the viewer.

Mission 5: Landing expedition

1. Tell students they will develop a mission plan for their landing expedition. Discuss what they think they can learn from landing on the planet versus a flyby. How are these missions inherently different? *(A flyby is primarily about observation and some features can be obscured. A landing allows for testing of surface materials.)* Discuss some disadvantages of a landing. *(You can only see a small part of the planet. Lander missions are often more expensive and trickier to carry out.)*

2. Mission plans should include selecting a landing spot and deciding which features will be examined based on the interests and questions from previous missions. Encourage students to make notes about what they hope to learn from their expedition.

3. Teams use a pushpin, tape or sticker to mark the landing site (have a team member approach the selected landing site and mark it without damaging the planet).

4. Tell each team they have one minute to look at the landing site through their viewers, from as close as they'd like to get. They must leave the pushpin in the center of their field of view. To illustrate this, draw a simple circle on the board and mark the position of the pushpin inside the circle. Depending on the nature of the planets, you might also allow students to touch and smell the planet in the region of the pushpin.

- **Extension: Mission types**

  After the activity above, students can use Blackline Master 6 to reflect on the kinds of information that can be gathered from each type of mission. They can connect their experience with actual NASA missions to the planet Mars by visiting NASA's site for Mars exploration. Have the students research the following types of missions:

  - Telescope missions: The first observations of Mars by telescope were recorded in the 1600s. Who did these observations and what did they find? The first images of Mars from Hubble were in the 1990s, just after Hubble became functional.
  - Flyby missions: Mariner 4, 6 and 7
  - Orbiters: Mariner 9, Viking 1 and 2, Mars Global Surveyor, Mars Odyssey Orbiter, Mars Reconnaissance Orbiter
  - Landers/rovers: Viking 1 and 2, Mars Pathfinder and the Sojourner Rover, Mars Exploration Rovers (*Spirit* and *Opportunity*), Phoenix Lander, Mars Science Laboratory and the *Curiosity* rover

This exercise was inspired by NASA's Mars Exploration Project Lessons: *Solar System Scale and Size* and *Strange New Planet*, as well as lessons by Los Angeles USD educator Alex Ballian.

SN
IN HIGH SCHOOLS

A world like no other COMES INTO VIEW

Thinking in astronomical units

Materials:
- 5-meter strips of cash register tape
- metric ruler

Directions:
Often we think about planets revolving around the sun, but how often do we think about how far each one is from the sun? Astronomers use the distance between the sun and Earth as a unit of measurement, called an "astronomical unit," or AU. 1 AU is about 150 million kilometers (approximately 93 million miles).

Take a look at the following table. Convert AU to cm (in this case, the scale is 1AU = 10cm). You might want to start with the object that's farthest from the sun (the dwarf planet Pluto).

Solar system objects	AU (average distance)	Scale value (cm)
Sun	0.0	0.0
Mercury	0.4	
Venus	0.7	
Earth	1.0	
Mars	1.5	
Asteroid belt	2.2 to 3.2	
Jupiter	5.2	
Saturn	9.5	
Uranus	19.2	
Neptune	30.1	
Pluto	39.5	

Use your ruler and mark the location of the sun at one end of the cash register tape. Mark the relative location of each object in the solar system. Reflect on the distances between Earth and its closest (and farthest) neighbors.

A world like no other COMES INTO VIEW

SN
IN HIGH SCHOOLS

A world like no other COMES INTO VIEW

Comprehend

After reading the article, "A world like no other comes into view," answer these questions:

1. **What is the main topic of the article?**

2. **What are some of the landforms visible on Pluto?**

3. **How do images from Hubble and New Horizons differ?**

4. **Is the New Horizons mission over, why or why not?**

5. **What other robotic spacecraft are currently in the works and where are they headed?**

Analyze

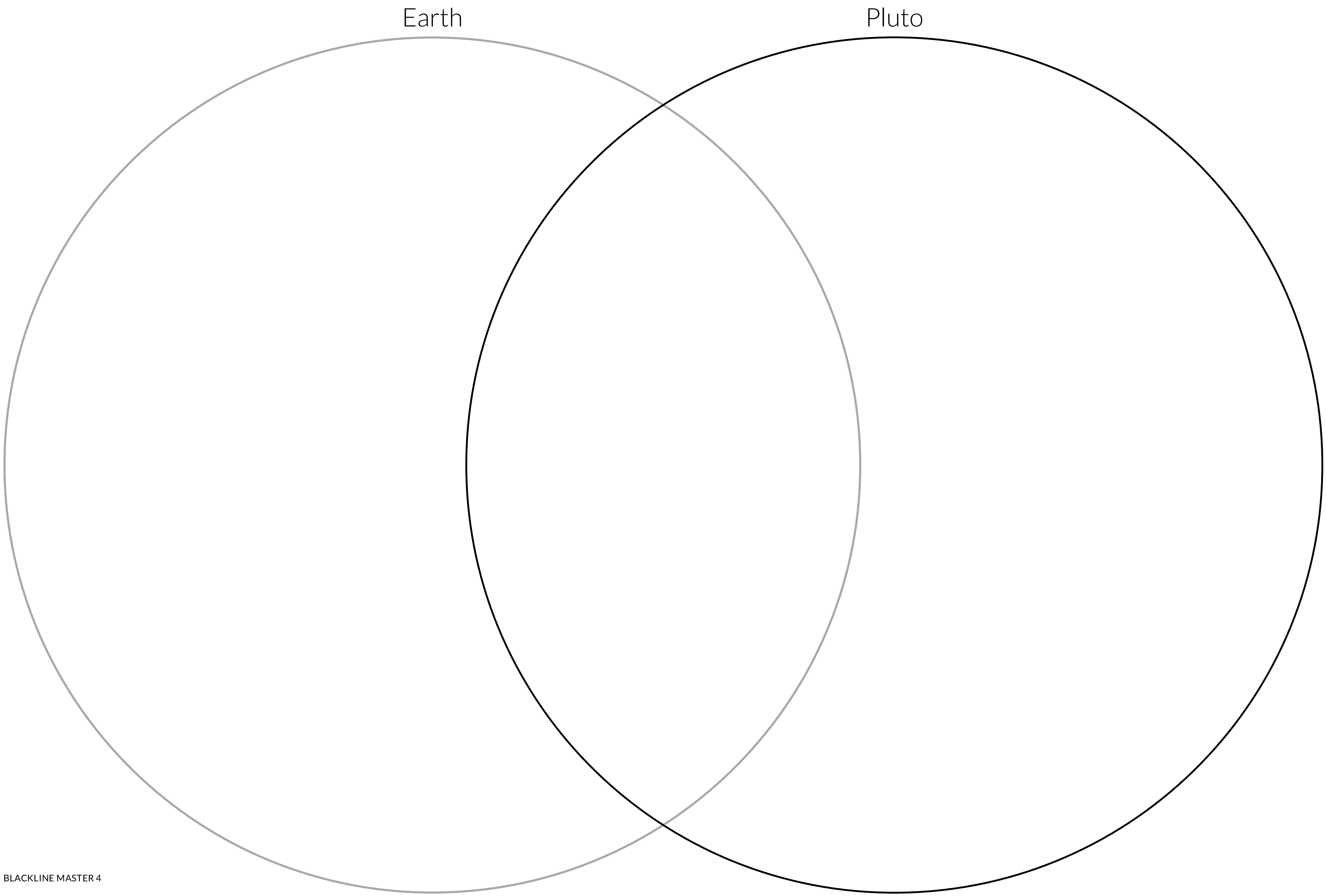
1. **How are the features of Pluto similar to and different from those of Earth?**

2. **Why is Pluto called a celebrity?**

3. **Why do scientists study other planetary bodies?**

Compare the features of Earth and Pluto

Directions: How are the appearances of Earth and Pluto similar and different? Use this Venn diagram to record your ideas.



SN
IN HIGH SCHOOLS

A world like no other COMES INTO VIEW

Observing the planets

Directions: Use the following chart to record your mission type and any observations and questions you have about the planet you are viewing.

Mission: ____

Observations	Questions

SN
IN HIGH SCHOOLS

A world like no other COMES INTO VIEW

Mission types

Directions: Use what you learned from the planetary observation activity and/or your research on NASA's Mars missions to determine what can and cannot be learned from each mission type. Consider why NASA conducts different types of missions to study solar system objects.

Mission type	Information learned	Advantages	Disadvantages
Telescope missions			
Flyby missions			
Orbiter missions			
Lander/ rover missions			