Designing the Next Mission

OVERVIEW

Student groups will propose a mission to space. Each will investigate the essential question: Why and how do we explore space? Groups will research and describe one of two possible destinations: (1) Mars, to search for water as a possible sign of life; or (2) a near-Earth asteroid, to mine for materials. After analyzing evidence collected during their visit to Beyond Planet Earth, each group will present its proposal to the class and make the case that its mission is the more feasible and worthy of funding.

NYS Earth Science Core Curriculum

1.2d: Asteroids, comets, and meteors are components of our solar system.

1.2e: Earth's early atmosphere formed as a result of the outgassing of water vapor, carbon dioxide, nitrogen, and lesser amounts of other gases from its interior.

3.1c: Rocks are usually composed of one or more minerals

BACKGROUND FOR EDUCATOR

The goal is for students to research a scientific topic — the viability and value of a future space mission — by collecting evidence, making inferences, and synthesizing their findings in writing. Students will supplement what they learn at the Museum exhibition *Beyond Planet Earth* with Regents Earth Science content and the *Physical Setting/Earth Science Reference Tables*. Student groups will investigate either a mission to Mars or to a near-Earth asteroid, and ultimately the class will compare their relative feasibility and scientific payoff .

For instance, at the exhibition students investigating the mission to Mars will use the Mars Explorer interactive to travel virtually to Gale Crater. They will learn that past missions discovered evidence of water along with layers of sedimentary rock deposit. Using their *Physical Setting/Earth Science Reference Tables*, students will need to infer how sedimentary rock deposits suggest the presence of water, noting that the organization of the sediments can be evidence of water. For example, as a river enters a lake, it slows down and deposits larger sediments first (pebbles, then sand, then silt, etc.). Therefore, if a cross section of soil were found, with smaller sediments on top and larger on the bottom (top to bottom: clay, silt, sand, pebbles), this would suggest the sediments had been suspended in water and then settled, with heavier sediments settling first followed by the lighter sediments.

Students investigating the mission to a near-Earth asteroid will visit the Asteroid section of the exhibition to learn about minerals discovered in past missions. Using their *Physical Setting/Earth Science Reference Tables*, they will need to infer how to identify those minerals on an asteroid, and how the minerals might be useful back on Earth.

Both groups will need to base their proposals on the accompanying Proposal Outline, list the pros and cons of their missions, and make the case that their mission is the more feasible and worthwhile. They should take into account distance to travel, potential risks, importance of scientific discoveries, value to humanity, and any other factors that would affect this decision.

BEFORE YOUR VISIT

Activity: Preparing to Write a Proposal for Space Exploration
Divide the class into two groups. Tell students that each group will prepare a written proposal for a space mission:

- Group 1: Mission to Mars to search for water or other signs of life
- Group 2: Mission to a near-Earth asteroids to mine for materials

Have student view and discuss the following short videos and interactive galleries to find out what scientists know and want to learn more about:

Group 1: Mission to Mars
- Geologists on Mars: sciencebulletins.amnh.org/?sid=a.f.mars.20040401
- Martian Rocks Make Geological Clocks: sciencebulletins.amnh.org/?sid=a.s.mars_rocks.20081215
- Phoenix Lander Reaches Mars: sciencebulletins.amnh.org/?sid=a.s.phoenix_lander.20080609
- Mars, Close Up: sciencebulletins.amnh.org/?sid=a.s.mars_close.20080317

Group 2: Near-Earth Asteroids
- Impact! Tracking Near-Earth Asteroids: amnh.org/sciencebulletins/index.php?sid=a.f.nea.20050504
- Asteroid Provides Pre-Planet Clues: sciencebulletins.amnh.org/?sid=a.s.pre_planet.20110412
- In Hot Pursuit of Asteroids: sciencebulletins.amnh.org/?sid=a.s.asteroids.20100726
- Scientists Track Asteroid Crash: sciencebulletins.amnh.org/?sid=a.s.asteroid_crash.20090406

Distribute the Proposal Outline and Student Worksheets. Review the tasks to be completed during and after the visit to the *Beyond Planet Earth* exhibition Explain that they will use worksheets to gather evidence in the Museum, and that back in the classroom they will analyze the *Reference Tables for Physical Setting/Earth Science* and do additional research online. Distribute copies of the exhibition map so students can plan their visit.

DURING YOUR VISIT

Beyond Planet Earth: The Future of Space Exploration
3rd floor (60 minutes)
Have students explore the exhibition individually or in pairs to collect evidence for their proposals on the Student Worksheets.

Arthur Ross Hall of Meteorites
1st floor (30 minutes)
Have the Mars student group explore this hall and read the panel "Mars: Rocks from Another World" to gather additional evidence for water on Mars, and explore how Martian meteorites illustrate the effects of a watery climate.

Guggenheim Hall of Minerals
1st floor (30 minutes)
Have the Asteroid student group find examples of minerals in the pyroxene and olivine groups (these minerals were found on the Itokawa asteroid). Look for minerals in the pyroxene group by visiting the "Inosilicates Panel"; look for minerals in the olivine group by visiting the "Neosilicates Panel." Have students describe and record the commonalities within each group (e.g. color, texture, crystalline structure) and how they would identify them on a near-Earth asteroid.

BACK IN THE CLASSROOM

Activity: Write a Proposal for Space Exploration
Using the proposal outline as a guide, have student groups make the case for a potential future mission to Mars or a near-Earth asteroid by writing a proposal. Tell them that they will need to use three pieces of information:

1. Evidence collected from the Beyond Planet Earth exhibition (Student Worksheet)
2. Additional information gathered from the Reference Tables for Physical/Earth Science (Back in the Classroom Worksheet)
3. Additional online research from websites such as: NASA: Missions (nasa.gov/missions)
   In the "Missions Finder" box, click on the "Find a Mission" tab. Then select "Solar System", and check "asteroids" and "Mars."

Have each group present its proposal to the class. Then as a class, students make a case for which mission most deserves to be funded based on the impact it would have for life on Earth.

PROPOSAL OUTLINE: Designing the Next Mission

Grades 9–12

I. Define Your Mission

A. Where are you going?

B. What are your goals?

C. Will humans go on this mission? Why or why not?

D. What specific materials are you looking for, and why?

E. What earlier missions will inform yours?

F. Why is your mission important and worth funding?

II. Materials and Methods

A. What type of spacecraft will you need?

B. What tools will you require at your destination? For what purposes?

III. Impact on Science and Humanity (Back in the Classroom)

A. How would a successful mission benefit humans?

SAMPLE ANSWERS

PROPOSAL OUTLINE: Designing the Next Mission

Grades 9–12

I. Define Your Mission

A. Where are you going?

(Asteroid: Itokawa asteroid)
(Mars: Gale Crater, Mars)

B. What are your goals?

(Asteroid: to mine for minerals that are valuable on Earth)
(Mars: to search for evidence of water as a possible sign of life)

C. Will humans go on this mission? Why or why not?

(Answers will vary.)

D. What specific materials are you looking for, and why?

(Asteroid: rare-Earth minerals such as pyroxene, olivine, iridium; for mining)
(Mars: sedimentary rock deposits as evidence of water)

E. What earlier missions will inform yours?

(Asteroid: Apollo 11)
(Mars: Explorer)

F. Why is your mission important and worth funding?

(Answers will vary.)

II. Materials and Methods

A. What type of spacecraft will you need?

(Answers may include: Nautilus-X)

B. What tools will you require at your destination? For what purposes?

(Asteroid: nets, bolts, small rockets, ropes; to keep from flying off surface of asteroid)
(Mars: X-ray spectrometer, hand-held radar, metal detector; for analyzing sedimentary rock layers)

III. Impact on Science and Humanity (Back in the Classroom)

A. How would a successful mission benefit humans?

(Asteroid: asteroids could be a source of rare-Earth metals, which have many commercial uses, from precious jewelry to flat-panel screens and other electronics.)
(Mars: it might contribute to our understanding of life on other planets and whether humans might be able to live on Mars someday.)

STUDENT WORKSHEET: Mission to Near-Earth Asteroid Grades 9–12

Welcome to *Beyond Planet Earth*! Today you will be investigating near-Earth asteroids (NEAs). The evidence you collect will help you develop a proposal for a future space mission. Begin by going to the Asteroid section of the exhibition.

1. Record data about the asteroid named Itokawa:

Size: ______________________________

Gravity compared with Earth's: ______________________________

Average surface temperature: ______________________________

2. Observe the Itokawa model. What do you notice about its size and shape?

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3. What would it be like for astronauts to study an asteroid like this up close? What challenges would they face, and how might they solve them?

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4. What two minerals did Japanese researchers find when analyzing the microscopic rocky grains collected by the Hayabusa spacecraft?

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5. Explore the Knowles meteorite. What is it made of? What are some of the uses of those metals?

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6. Why would we want to mine an asteroid?

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BEYOND PLANET EARTH the future of space exploration

ANSWER KEY

STUDENT WORKSHEET: Mission to Near-Earth Asteroid

Grades 9–12

Welcome to *Beyond Planet Earth*! Today you will be investigating near-Earth asteroids (NEAs). The evidence you collect will help you develop a proposal for a future space mission. Begin by going to the Asteroid section of the exhibition.

1. Record data about the asteroid named Itokawa:

Size: *(Answer: 1,770 feet (540 meters) long by about 960 feet wide (294 meters)*

Gravity compared with Earth's: *(Answer: less than 1/100,000th)*

Average surface temperature: *(Answer: –89°F / –67°C)*

2. Observe the Itokawa model. What do you notice about its size and shape?

(Answers may include: irregular shape, large, rocky)

3. What would it be like for astronauts to study an asteroid like this up close? What challenges would they face, and how might they solve them?

(Answers may include: An asteroid has no atmosphere and so little gravity that astronauts could not walk on its surface. They might use a net to tether themselves to the asteroid, or use small rockets to pull a rope around it.)

4. What two minerals did Japanese researchers find when analyzing the microscopic rocky grains collected by the Hayabusa spacecraft?

(Answer: pyroxene, olivine)

5. Explore the Knowles meteorite. What is it made of? What are some of the uses of those metals?

(Answers will include: nickel is used in coins, cobalt is used in ceramics, germanium is used in camera lenses, iridium is used in electronics)

6. Why would we want to mine an asteroid?

(Answers may include: Even small amounts of rare-Earth metals are valuable. Platinum-groups metals such as iridium are scarce on Earth but have many commercial uses, from precious jewelry to flat-panel screens and other electronics.)

STUDENT WORKSHEET: Mission to Mars

Grades 9–12

Welcome to *Beyond Planet Earth*! Today you will be investigating Mars. The evidence you collect will help you develop a proposal for a future space mission. Begin by going to the Mars section of the exhibition.

1. Record data about Mars:

Size: ______________________________

Gravity compared with Earth's: ______________________________

Average surface temperature: ______________________________

2. How long would it take to travel to Mars? ______________________________

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3. Find the "Getting There" panel and examine the Nautilus-X spacecraft and models of life onboard. What challenges and solutions do you find interesting?

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4. Play the "Mars Explorer" interactive and locate the Gale Crater within the game. What findings may indicate that water existed on Mars?

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5. Observe the Mars landscape. Describe its terrain.

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6. Go to the Curiosity rover diorama. What is this rover's primary mission and how will it accomplish it?

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7. Turn around and explore the diorama of an astronaut studying Martian geology. What tools is she using?

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8. Many scientists think that the best way to study Mars is to send astronauts. Do you agree or disagree? Support your answer.

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STUDENT WORKSHEET: Mission to Mars

ANSWER KEY

Grades 9–12

Welcome to *Beyond Planet Earth*! Today you will be investigating Mars. The evidence you collect will help you develop a proposal for a future space mission. Begin by going to the Mars section of the exhibition.

1. Record data about Mars:

Size: *(Answer: 4,221 miles (6,792 km) in diameter)*

Gravity compared with Earth's: *(Answer: about a third (38%) of Earth's gravity)*

Average surface temperature: *(Answer: –81°F / –63°C)*

2. How long would it take to travel to Mars? *(Answers may include: six to nine months each way by current spacecrafts; about 100 years by car; about 250 days by Apollo 11 spacecraft)*

3. Find the "Getting There" panel and examine the Nautilus-X spacecraft and models of life onboard. What challenges and solutions do you find interesting?

(Answers will vary.)

4. Play the "Mars Explorer" interactive and locate the Gale Crater within the game. What findings may indicate that water existed on Mars?

(Answers may include: Sedimentary rock deposits were found in Gale Crater, which may suggest evidence of water because sedimentary rocks are carried by water.)

5. Observe the Mars landscape. Describe its terrain.

(Answers may include: The land is bright reddish-orange. It looks very dry and barren. There are rocks of various sizes.)

6. Go to the Curiosity rover diorama. What is this rover's primary mission and how will it accomplish it?

(Answers may include: Its mission is to look for signs of life. It will explore Gale Crater to analyze different layers of sediment, each one giving a glimpse of a different era in Mars' past.)

7. Turn around and explore the diorama of an astronaut studying Martian geology. What tools is she using?

(Answer: X-ray spectrometer, hand-held radar, metal detector)

8. Many scientists think that the best way to study Mars is to send astronauts. Do you agree or disagree? Support your answer.

(Answers may include: Yes. A human could do in days what it would take a rover years to do. No. A manned mission would be more expensive and far more risky.)

BACK IN THE CLASSROOM WORKSHEET

Mission to a Near-Earth Asteroid

What two minerals did Japanese researchers find when analyzing the grains collected by the Hayabusa spacecraft? (See exhibition worksheet, question 4.)

In the Physical Setting/Earth Science Reference Tables, find the "Properties of Common Minerals" chart. How would you identify pyroxene and olivine by sight? What are they used for on Earth?

List the top 5 pros (benefits) and cons (dangers/challenges) of asteroid mining.

Research online to gather additional information about your mission, such as:

- Where are these minerals found on Earth?
- How rare are they, or difficult to mine?
- Do they have other properties?
- Could materials on Earth be substituted?
- How much money will this mission cost?

ANSWER KEY

Grades 9–12

Mission to a Near-Earth Asteroid

What two minerals did Japanese researchers find when analyzing the grains collected by the Hayabusa spacecraft? (See exhibition worksheet, question 4.)

(Answer: pyroxene, olivine)

In the Physical Setting/Earth Science Reference Tables, find the "Properties of Common Minerals" chart. How would you identify pyroxene and olivine by sight? What are they used for on Earth?

(Answer: pyroxene is black to dark green, and used in jewelry and mineral collections;
olivine is green to gray or brown, used in furnace bricks and jewelry)

List the top 5 pros (benefits) and cons (dangers/challenges) of asteroid mining.

(Answers may include: Pros: these minerals are valuable on Earth so the mission will pay for itself;
we could learn how asteroids are formed, etc. Cons: dangerous mission; expensive; we shouldn't
have to go to outer space to get materials for jewelry and electronics)

Research online to gather additional information about your mission, such as:

- Where are these minerals found on Earth?
- How rare are they, or difficult to mine?
- Do they have other properties?
- Could materials on Earth be substituted?
- How much money will this mission cost?

Mission to Mars

Scientists found sedimentary rock deposits in Gale Crater. (See exhibition worksheet, question 4.) Using your *Physical Setting/Earth Science Reference Tables*, how do you think the rocks were identified as sedimentary?

Scientist also found evidence of water in Gale Crater. How might the sedimentary rock deposits provide evidence of water? (HINT: Use your Physical Setting/Earth Science Reference Tables to infer how texture and grain size of sedimentary rock might provide clues.)

List the top give pros (benefits) and cons (dangers/challenges) of exploring Mars in search of water.

Research online to gather additional information about your mission, such as:
- Other than water, what other evidence should we look for on Mars?
- How much money will this mission cost?

ANSWER KEY

Grades 9–12

Mission to Mars

Scientists found sedimentary rock deposits in Gale Crater. (See exhibition worksheet, question 4.) Using your *Physical Setting/Earth Science Reference Tables*, how do you think the rocks were identified as sedimentary?

(Answers may include: their texture, grain size, and composition)

Scientist also found evidence of water in Gale Crater. How might the sedimentary rock deposits provide evidence of water? (HINT: Use your Physical Setting/Earth Science Reference Tables to infer how texture and grain size of sedimentary rock might provide clues.)

(Answers may include: Sedimentary rock deposits were found in Gale Crater, which may suggest evidence of water if the organization of the sediments showed smaller sediments on top and larger on the bottom (top to bottom: clay, silt, sand, pebbles). This would suggest the sediments had been suspended in water and then settled, with heavier sediments settling first followed by the lighter sediments. Also, some sedimentary rocks with crystalline texture may have been formed from precipitates and evaporates — water or other minerals.)

List the top give pros (benefits) and cons (dangers/challenges) of exploring Mars in search of water.

(Answers may include: Pros: The presence of water could mean there was once life on Mars; if water exists on Mars, maybe humans could live there someday; if there's water or any life on Mars, maybe there is life on other planets as well. Cons: Expensive, long journey dangerous for humans; surface of the planet is an extremely hostile environment; possibility of colonizing Mars too remote and costly; etc.)

Research online to gather additional information about your mission, such as:
• Other than water, what other evidence should we look for on Mars?
• How much money will this mission cost?

