WORLDS APART

REMOTE SENSING OF MARS

PLANETS

Science Pathway

Planetary Science Activities for Out-of-School Time • Grades 6–8

Contents

Welcome to Worlds Apart!

In This Unit

In this unit, learners think and work like scientists and engineers. They investigate and use real NASA data about Mars to select a scientifically interesting landing site and design remote sensing devices.

The unit is composed of a Science Pathway and an Engineering Pathway. In both pathways, learners have the opportunity to build their problem solving, teamwork, communication, and creative thinking skills. Specifically,the PLANETS units are designed to ensure that learners will

- engage in real-world activities that provide inclusive ways for all learners to connect to science and engineering.
- choose their path through open-ended challenges that have multiple solutions.
- engage in the habits of mind of engineers and inquiry practices of scientists.
- communicate and collaborate in innovative, active problem solving.

Getting to Know PLANETS

Planetary Learning that Advances the Nexus of Engineering, Technology, and Science (PLANETS) is an interdisciplinary and cross-institutional partnership that integrates planetary science, education, technology, and engineering.

The Center for Science Teaching and Learning at Northern Arizona University (NAU), the U.S. Geological Survey (USGS) Astrogeology Science Center, the Museum of Science, Boston, and WestEd have partnered to develop, pilot, and research the impact of three curriculum units and related professional development resources **(http://planets-stem.org)** for grades 3–8.

The purpose of PLANETS is to increase public awareness and use of NASA resources by highlighting the relationship between science, technology, engineering, and mathematics in the context of planetary science in out-of-school time settings.

Note

Much of the information at the start of this guide is the same for the Science and Engineering Pathways. If you have already read the Engineering Pathway, you can read just **Learners Working and Thinking Like Scientists**, pg. vi, and the **Science Pathway Storyline**, pgs. xxiii–xxvi, then skip to the **Science Pathway Vocabulary**, pg. 1, and read from there.

Worlds Apart *Unit Overview*

This guide contains the **Science Pathway**.

Remote sensing engineering is an interdisciplinary field that deals with the collection of data remotely, or from a distance.Remote sensing engineers use techniques from many fields, such as cartography, optics, civil engineering, software engineering, and computer science. It has a wide variety of applications, from creating models of cities or natural landscapes to helping scientists predict the effects of climate change to precisely tracking orbiting satellites. In this unit, learners engineer remote sensing devices and analyze remote sensing data from Mars to choose a landing site for a rover. The unit contains an Engineering Pathway and a Science Pathway.

DID YOU KNOW?

The latest NASA Mars rover, Perseverance, landed on Mars in February of 2021. However, there have been three prior Mars rovers –– Sojourner, Spirit, Opportunity, and Curiosity — starting as early as 1997. These rovers have differed in weight, speed they can travel, and type of instruments they contain based on the type of information they are designed to collect. For more information about these rovers see: spaceplace.nasa.gov/mars-rovers/

DID YOU KNOW?

Mars has familiar landforms similar to Earth such as river valleys, deltas, and alluvial fans. However, some additional familiar surface features, like volcanoes and canyons, are extremely large on Mars. Mars is home to the largest volcano in the solar system, Olympus Mons. It's three times taller than Earth's Mt. Everest. Also, a large canyon system on Mars, called Valles Marineris, is long enough to stretch from California to New York and is about 10 times the size of Earth's Grand Canyon! These features are examples of the importance of selecting viable landing sites for remote sensing rovers from NASA.

Science Pathway Overview: *Remote Sensing of Mars*

Planetary scientists often use the technologies developed by remote sensing engineers to further their understanding of the planets, satellites, and smaller bodies in the solar system. Engaging in the study of other planets provides scientific insight into the origins of features on Earth.

Learners in the Science Pathway participate in a fictional NASA mission to choose a landing site for a Mars rover. Learners engage with and interpret Mars data captured during actual NASA missions. In these activities, learners explore how scientists use remote sensing techniques to explore the surface of Mars in search of ideal landing sites for rovers. They learn about topography and mineral identification using light, and combine multiple data sets to choose a safe and scientifically interesting landing site for a Mars rover. Ensuring a viable landing site allows scientists to understand habitable environments on Mars and how the planet has changed over geologic time.

The Science Pathway Storyline that more fully articulates the progression of activities can be found on pgs. xxiii–xxvi.

Engineering Pathway Overview: *Engineering Remote Sensing Devices*

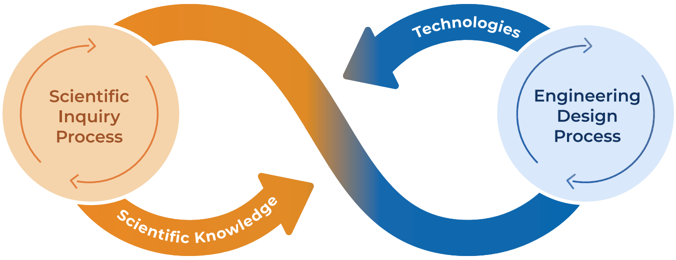
Remote sensing engineers at NASA design instruments to remotely observe Earth and other planetary bodies by recording characteristics of objects at a distance, sometimes forming an image by gathering, focusing, and recording light. A camera, also called an imager, is a classic example of a remote-sensing instrument.

Learners in the Engineering Pathway (this guide) are part of a team on a fictional NASA mission. They engineer remote sensing devices to gather and visualize information about the surface of Mars. The data they collect will help the scientists meet their scientific goals, such as choosing a landing site that is best suited for gathering data on the geological features of the landscape and looking for evidence of water.

The Engineering Pathway Storyline that more fully articulates the progression of activities can be found on pgs. xxiii–xxvi of the Engineering Educator Guide.

Connecting Across Science & Engineering

Science and engineering depend on one another. Engineers leverage their scientific knowledge to effectively and efficiently develop new technologies. Scientists rely on a wealth of technologies that have been developed by engineers to advance understanding of the natural world—and their understanding, in turn, helps engineers develop additional technologies.



Scientific inquiry and engineering design require similar skills and practices, such as utilizing critical thinking skills, bringing a lens of curiosity, taking a systems approach, and tapping into creativity to answer questions and solve problems. Neither process follows a set path but both typically rely on similar tools, such as developing models, using mathematics and statistics, and computers. However, scientists primarily focus on understanding natural phenomena through an inquiry-based process, while engineers apply their knowledge, including scientific knowledge, to design and build practical solutions to help solve real-world problems.

The PLANETS curriculum provides equitable opportunities to engage learners in the habits of mind of engineers and the thinking practices of scientists can increase engagement and catalyze STEM identity and confidence for *all* learners. Learning activities that engage learners in the habits of mind and thinking practices of engineers and scientists also fuel development in the 21st Century learning skills of critical thinking, creativity, collaboration, and communication. For more insight into how these skills develop as learners engage in an engineering design process, see the educator resource on **Developing 21st Century Skills**.

Learners Working & Thinking Like Scientists

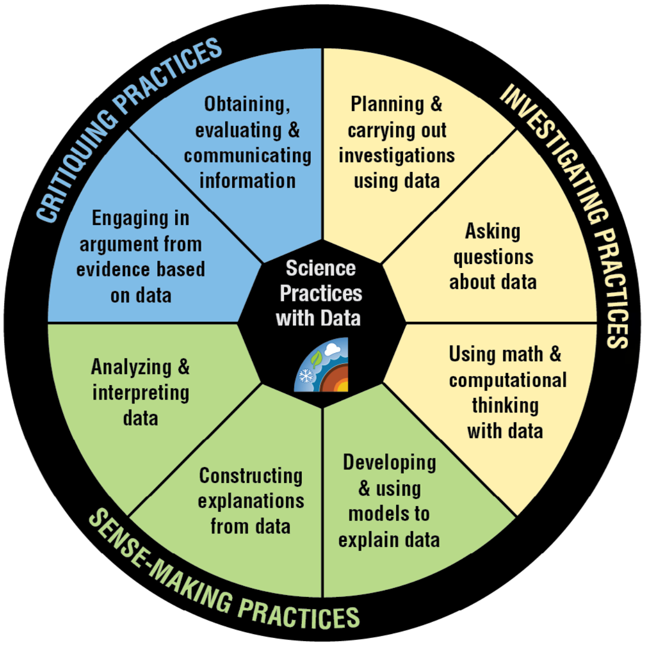
A Process of Scientific Inquiry

Like an engineering design process, scientific inquiry is a non-linear and iterative process of investigating, reasoning, evaluating data and models, and critiquing and communicating explanations based on evidence. During this process, scientists rely on mathematics, computers, and technologies that have been developed by engineers.

Science Practices

As scientists engage in the process of inquiry about and with natural phenomena, a few practices emerge from their work. These are known as practices instead of "skills" because they require a coordination between both knowledge and skill. The core practices that learners should engage in as they move iteratively through scientific investigations, reasoning, and critiquing are provided below. You'll notice that many science practices are similar to the habits of mind that engineers use—such as asking questions, using mathematics, and developing models. These practices include

- Asking questions
- Planning and conducting investigations
- Using mathematics and technology
- Developing and using models
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Finding, critiquing, and communicating scientific information



Adapted from My NASA Data, "Resources for Science and Engineering Practices (with Data)"

For additional resources, please see the [Worlds Apart Unit Website]

Navigating the Unit

Considerations for Using the Worlds Apart Unit

- The following pathways present suggested orders in which to teach the activities. However, you can adapt the order of activities as appropriate for your learners and setting. (For example, you can alternate between pathways.)
- If you have time, it is beneficial for learners to engage in both the Engineering Pathway and then the Science Pathway. Learners do not need to repeat the context-setting.
- It is not necessary for learners to complete the Engineering Pathway activities to participate in the Science Pathway.

CONTEXT-SETTING ACTIVITY: ***Ready, S.E.T., Go!***
Learners investigate remote sensing. As scientists, they decide what they want to learn about a planetary body. As engineers, they choose which instruments to put on a spacecraft for that investigation.

ACTIVITY 1: ***Sharing Experiences***
Learners share experiences with and stories about technology.

Science Pathway

ACTIVITY 2: ***Introducing Landforms***
Learners explore how different landforms are formed by wind and water.

ACTIVITY 3: ***Exploring Landforms on Mars***
Learners examine images of landforms on Mars and Earth to find evidence of past water.

ACTIVITY 4: ***Introducing Topography***
Learners build three dimensional models of topographic maps and then turn them into two-dimensional maps.

ACTIVITY 5: ***Exploring Topography on Mars***
Learners interpret topographic maps of Mars to identify safe and interesting landing sites.

ACTIVITY 6: ***Introducing Spectroscopy***
Learners learn to interpret the spectra of reflected light from various objects.

ACTIVITY 7: ***Using Spectroscopy to Understand Mars***
Learners interpret spectra to identify water-based minerals at potential Mars landing sites.

ACTIVITY 8: ***Choosing a Landing Site and Preparing for Science Share-Out***
Learners combine multiple data sets to choose a safe and scientifically interesting landing site for a Mars rover. They then prepare to share their findings with the whole group and invited guests.

ACTIVITY 9: ***Using Spectroscopy to Understand Mars***
Learners share their recommendations for the safest and most scientifically interesting Mars rover landing site.

Engineering Pathway

ACTIVTY 2: ***Investigating Light***
Learners investigate how light travels and how mirrors can redirect it to gather data from a dist

ACTIVTY 3: ***Portable Light Redirection***
Learners design light redirection systems to gather data from a distance.

ACTIVTY 4: ***Finding Minerals***
Learners work to distinguish between minerals using sight and/or sound.

ACTIVTY 5: ***Finding the Shape of Land***
Learners engineer a model of a LiDAR technology to capture the shape and height of a landscape (topography).

ACTIVTY 6: ***Creating a Remote Sensing Device***
Learners work in groups to plan, create, and test remote sensing technologies that use the different technologies from the previous activities to gather data from a distance.

ACTIVTY 7: ***Improving a Remote Sensing Device***
Learners improve their remote sensing devices by making them easier to use, more compact, or better able to gather high-quality data.

ACTIVITY 8: ***Preparing for the Engineering Share-Out***
Learners plan to share their designs at an Engineering Share-Out.

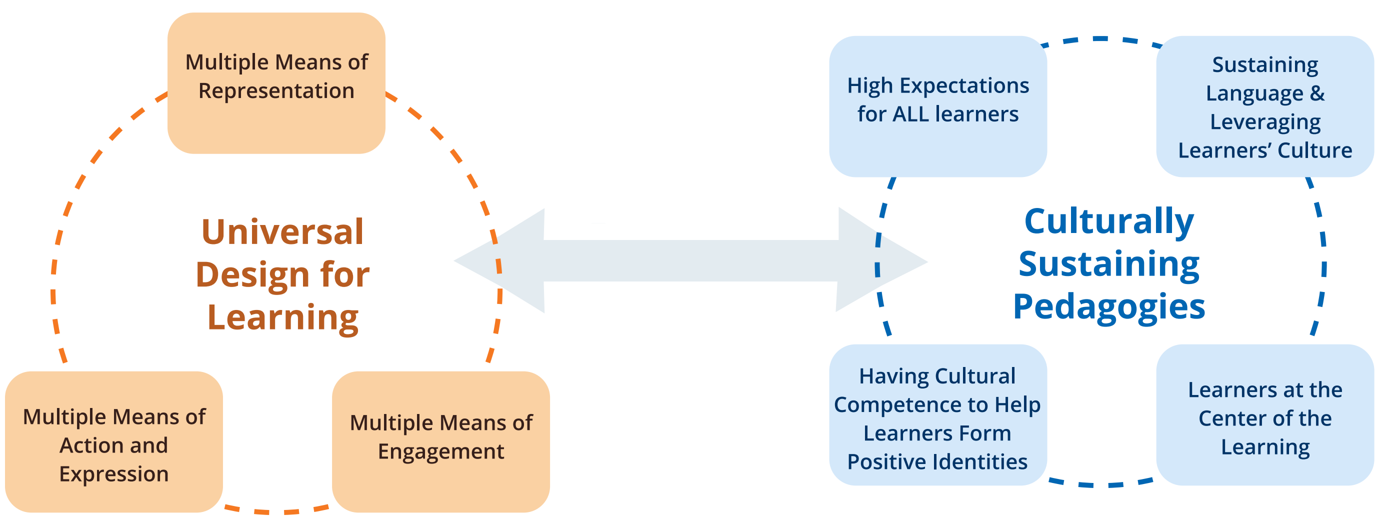
ACTIVITY 9: ***Engineering Share-Out***
Learners recommend a remote sensing technology to be sent on a spacecraft.

Educator Resources to Support Learning

An Inclusive and Equitable Approach for STEM Learning

The Worlds Apart unit has been designed with an explicit focus on promoting STEM learning for all, and particularly Indigenous learners, emergent multilingual learners, and learners experiencing differing physical and/or sensory abilities. The Universal Design for Learning (UDL) and culturally sustaining pedagogies (CSP) conceptual frameworks informed the instructional design of this unit. This purposeful design supports all learners by reducing as many barriers as possible and incorporating planning for variability in learner strengths, needs, and interests.

These principles include the following:



Creating Inclusive & Collaborative Learning Environments

To create an inclusive learning environment, educators need to approach their learners with an asset-based mindset. Each learner possesses assets that contribute to the development and maintenance of that person's identity. Assets can be intellectual, physical, or social skills and personal strengths or qualities. A few ideas for cultivating inclusive and cooperative learning environments include the following:

Practices and Strategies for Inclusive Learning Environments

- Facilitate inclusive and cooperative learning environments.
- Build relationships with learners and their communities for learning partnerships.
- Build rapport to establish an emotional connection.
- Affirm the personhood of each learner by appreciating all aspects that they bring into a learning space and creating accessible and inclusive learning spaces.
- Design learning experiences that are authentic and relevant to the contexts of learners.
- Incorporate multisensory instruction.
- Provide options for multiple forms of expression to demonstrate understanding.
- Model and support self-advocacy.

Designing Instruction to Reach Diverse Learners

The strategies outlined below appear in this unit to support three groups of learners:

Multilingual learners: Youth who speak languages other than English at home and are in the process of becoming fluent speakers of English.

Indigenous learners: Youth who descend from the original, culturally distinct ethnic peoples of a land.

Learners with diverse abilities: Youth who experience differing physical abilities: (a) physical traits that affect mobility and/or dexterity; (b) sensory abilities that affect sight; and (c) sensory abilities that affect hearing.

DID YOU KNOW?

Some of these strategies, initially designed and highlighted below for specific learners, have shown potential benefits for all learners.

These strategies have been adapted from the *PLANETS Practical Guide for Inclusive and Engaging STEM Learning: Promoting Inclusion and Engagement in STEM Learning: A Practical Guide for Out-of-School-Time Professionals.*

The icons shown on the following pages appear throughout this guide in tips that are especially relevant for each group of learners.

Strategies for Multilingual Learners

Want to learn more about how PLANETS activities support Multilingual Learners? Please watch this educator support video.

Encourage translanguaging: learners using all the languages they know and making connections between those languages.

Why is this important?

Translanguaging signals to multilingual learners that their languages, culture, and experiences are valued and enrich learning.

It empowers learners to participate and can increase their comprehension and engagement.

Note that not all words have exact counterparts in English.

Strategy in Action

Encourage learners to share key vocabulary in their home or preferred languages. You can capture terms visually.

Note that some learners, including many Indigenous ones, communicate through gestures instead of speech.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 3: "Encourage Translanguaging and Storytelling" on pg. 20 of the **Practical Guide**.

Provide multiple means of accessing language.

Why is this important?

Providing learners enough support and tools (e.g., images, videos, diagrams with headings) to understand texts on their own empowers them to independently make sense of content without compromising the complexity of language.

Instead of simplifying language, amplify speech and text with supports and offer assistance to help learners grasp concepts effectively.

Strategy in Action

Actively listen and capture learners' ideas and use of vocabulary and language during partner, small-group, or whole-group discussions using written words, diagrams and pictures.
In PLANETS, this strategy is called the *Our Ideas Poster.*

Use icons and images to anchor language.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Welcoming Learning Environments" on pg. 13 of the **Practical Guide**.

Teach vocabulary in context.

Why is this important?

Exposing learners to vocabulary and concepts together and not separately helps learners make sense of key concepts and ideas.

Strategy in Action

Learners engage in activities and then use their experiences to make sense of vocabulary.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the **Practical Guide.**

Provide multiple means of expressing ideas.

Why is this important?

Multiple forms of expression, such as spoken, visual, and written, help learners share their understanding of science and engineering, make sense of concepts, and clarify their ideas.

Offering space to use different levels of formality (e.g., casual language from home vs. academic language from school) helps learners make sense of ideas.

Strategy in Action

Share-outs during group activities encourage multiple means of expression. Learners can share in diverse ways (e.g., posters, graphs, writing, drawings, audio, gestures, or videos).

Rather than "correcting" learners' speech, help them connect less-formal and more-formal words with similar meanings.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 3, "Provide options for multiple forms of expression to demonstrate understanding" on pg. 28 of the **Practical Guide**.

Use strategic grouping.

Why is this important?

Conversations among peers who share languages (e.g., pairs, small groups, or whole-group share-out) provide a safe environment for learners to participate and gain comfort and confidence while testing out ideas. Educators can then build on the ideas expressed in whole-group discussions.

Strategy in Action

Activities engage learners in peer-to-peer conversations and sense-making discussions, including in pairs, small groups, and the whole group, depending on the needs of the learners.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 1, "Facilitate inclusive and cooperative learning environments" on pg. 16 of the **Practical Guide**.

Prioritize precise name pronunciation and understanding.

Why is this important?

Names are important in culture and personal identity. Pronouncing names correctly shows respect for individuals and their culture. (Because different languages use different sounds, it can take practice to pronounce names correctly.)

This approach is particularly beneficial for multilingual learners but creates an inclusive environment for all learners.

Strategy in Action

When meeting new learners, educators are encouraged to ask about, practice, and model pronouncing learners' names correctly.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the **Practical Guide**.

Strategies for Indigenous Learners

Want to learn more about how PLANETS activities support Indigenous Learners? Please watch this educator support video.

Encourage narratives.

Why is this important?

Indigenous communities have strong narrative traditions. These traditions serve as vital conduits of cultural heritage, transmitting knowledge, values, and history across generations. Through oral narratives, these communities forge a profound connection to their ancestral roots, fostering a sense of identity.

Relating narratives lets learners receive stories and tell their own. Narratives can be spoken, written, in song, or in pictures.

Strategy in Action

Make time for learner narratives that connect their learning to existing knowledge, stories, and culture. The "Building Community and Family Connections" section on p. xvi offers extension activities to engage community and family.

Take time to understand how stories are told in a particular community. Rhetorical style and the expected parts of a narrative vary between groups.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 3: "Encourage Translanguaging and Storytelling" on pg. 20 of the **Practical Guide**.

Use strategic grouping.

Why is this important?

Collaborative decision-making is more effective than individual spotlights in some Indigenous cultures. Small-group rather than large-group work enhances communication for Indigenous learners.

Thoughtful talk is often valued over spontaneous contributions, and delayed engagement may signify politeness rather than disinterest or shyness.

Strategy in Action

Group work is built into each activity. Grouping suggestions provide a comfortable group setting for Indigenous learners and others, such as grouping learners in even numbers to avoid a single designated leader.

Connections to the PLANETS Practical Guide

See Promising Instructional Practices, section 1, "Facilitate inclusive and cooperative learning environments" on pg. 16 of the **Practical Guide**.

Prioritize precise name pronunciation and understanding.

Why is this important?

Names are important in culture and personal identity. Pronouncing names correctly shows respect for individuals and their culture. (Because different languages use different sounds, it can take practice to pronounce names correctly.)

Note that Indigenous learners may want to share other information, such as their connections to tribes and locations.

Strategy in Action

When meeting new learners, educators are encouraged to ask about, practice, and model pronouncing learners' names correctly.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Features of Culturally and Linguistically Accessible and Welcoming Learning Environments" on pg. 13 of the **Practical Guide**.

Design authentic and relevant learning experiences.

Why is this important?

Learners are most engaged when what they are learning is connected to their lives and communities. Providing a relevant cultural context helps to drive this engagement.

Strategy in Action

Spend time in learners' community and make connections with local knowledge keepers.

Learn about the cultural approaches of the community regarding competition and collaboration, communication styles, and systems of observation.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 1, "Design learning experiences that are authentic and relevant to the contexts of learners" on pg. 23 of the **Practical Guide**.

Strategies for Learners with Diverse Abilities

Want to learn more about how PLANETS activities support Learners with Diverse Abilities? Please watch this educator support video.

Ask learners what they need.

Why is this important?

The needs of learners with diverse sensory and physical abilities vary. Learners and caregivers, being the most knowledgeable about their capabilities, provide valuable insights. Educators should emphasize learners' strengths and rely on them to guide facilitation of activities.

Strategy in Action

Ask learners directly about their needs prior to beginning an activity. This guide gives some ideas to consider when offering learners options.

Learn about etiquette for working with **blind learners**, etiquette for working with **D/deaf learners**, or etiquette for working with **wheelchair users**.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Create safe, accessible, and welcoming learning environments" on pg. 11 of the **Practical Guide**.

Incorporate multisensory activities.

Why is this important?

Visual representations can be particularly beneficial for learners who are deaf or hard-of-hearing. Visual science and engineering models are powerful tools to illustrate observations, processes, and connections.

Auditory modalities of instruction can facilitate access to learners who are blind or have low vision.

Tactile models and physical objects are beneficial for all learners but are particularly important for blind and low vision learners.

Strategy in Action

Learners are given diverse means to participate in activities. For instance, spectrographic information is presented both visually and aurally so that all learners can access it.

Allow blind and low-vision learners to explore pre-made models ahead of time and to join the educator during demonstrations to follow the educator's movements.

Connections to the PLANETS Practical Guide

See Promising Curriculum Design Elements, section 2, "Incorporate multisensory instruction" on pg. 26 of the **Practical Guide**.

Use strategic grouping.

Why is this important?

For blind and low vision learners, although a note-taking role may be a preferred option, provide learners with the flexibility and opportunity to choose from a variety of roles, fostering exploration and skill development.

For deaf and hard-of-hearing learners, group work can be challenging due to elevated noise levels. Engage learners in smaller groups, move groups to quieter spaces, and encourage learners to speak clearly so everyone can follow the conversation.

Strategy in Action

Educators are provided with guidance on **surfacing learners' diverse abilities** through activities.

It's essential to ask individual learners about their preferences and needs, as learners with diverse abilities have widely varying preferences.

Connections to the PLANETS Practical Guide

See Promising Practices for Program Design, section 1, "Create safe, accessible, and welcoming learning environments" on pg. 11 of the **Practical Guide**.

Building Community and Family Connections

Strong relationships are key to learner success. Building community and family connections with learners encompasses having ongoing and meaningful two-way interactions between educators and families and/or other communities of supportive adults. It also involves creating a learning environment within OST (Out-of-School Time) programs that is familial, supportive, and empowering. OST programs with strong learning environments and communities recognize the assets that learners bring and allow learners to express themselves, making them feel comfortable engaging in STEM content. Family connections set the stage for social-emotional learning in the unit via:

- **Relevance—**Family connections allow learners to draw connections between NASA science and engineering and the science and engineering in their daily lives and communities. This type of connection allows learners to bring their own funds of knowledge to the activities.
- **Belonging—**When learners see how their cultures and families use science and engineering principles, they feel that they belong in STEM.
- **Cultural responsiveness—**Family connections allow for relevant aspects of learners' cultures to enter or ground the learning in ways that the educator may not have been aware of. Learners' cultural knowledge can play an important scaffolding role in learning science and engineering while simultaneously sustaining that cultural knowledge for the next generation.

What does building community and connections look like in action?

A few examples of how to purposefully develop these relationships with learners and their families include the following:

- **Use a variety of communication methods.**
- **Acknowledge challenges to family and community engagement.**
- **Invite families to engage in and design STEM learning activities.**

Consider using some of the following ways to build family connections during this unit based on your capacity and/or your learners' ability to include family members:

- Add an activity in which you invite families to be guest speakers. (Families can also work with you to find guest speakers from the community.)
- A Level Up! tip at the end of each activity invites learners to discuss a particular question with their families. (You can also suggest family activities to spark conversation around a particular topic.) Learners can share what they discussed at the start of the next activity.
- Invite families to the Engineering and Science Share-Outs at the end of each pathway to not only share in celebration of their learners' accomplishments but also to provide their knowledge (cultural or otherwise) about the engineering or science discussed and used in the pathway.

Instructional Support Tips for Learning

Within each activity across the Worlds Apart unit, several strategic tips are provided as opportunities for additional instructional support. These tips are guided by the following PLANETS core design principles:

- Support Thinking
- Teaching Tips
- Connecting Across Activities
- Support Learner Differences
- Level Up

The table below provides guidance on the purpose and use of each of the tips found within the activities.

Instructional Support Tip: **Support Thinking** 	**Purpose:** Provides ideas for educators to productively support learners' thinking, such as • suggestions of targeted language to use with learners to increase social emotional supports. • things to emphasize during student collaboration. • language that explicitly helps students to realize they are working, thinking, and looking like engineers or scientists (metacognitive and representation/identity/ confidence in STEM). • additional resources that may enhance student engagement/thinking about the current instructions of the activity (e.g., videos, audio).
Instructional Support Tip: **Teaching Tip** 	**Purpose:** Provides additional recommendations for educators with regards to the mechanics of the activity, such as • modifying materials. • grouping and/or roles of learners during parts of the activity based on materials, timing, and engagement. • additional procedural tips to increase effectiveness of investigations and designs. • modifying timing of activities with different procedures.

Instructional Support Tip: Connecting Across Activities	**Purpose:** Highlights ways that the activities connect within the pathways and across the disciplines of engineering and science.
Instructional Support Tip: Support Learner Differences	**Purpose:** Provides just-in-time supports during the activity that help educators ensure they are meeting the needs of all STEM learners—especially Indigenous learners, emergent multilingual learners, and learners experiencing differing physical and/or sensory abilities—such as • ways to support multiple pathways for ensuring all learners can equitably engage in the activity. • strategic peer grouping(s) to enhance engagement equity. • additional challenges or ways to increase the learning rigor for learners who are ready. • additional resources that increase equity to ensure that all learners can engage effectively in the activity (e.g., videos, audio). Unique icons are used in PLANETS activities to help educators quickly identify specific tips that may apply to their learners: **Multilingual learners** **Indigenous learners** **Learners with diverse abilities** **Engaging all learners**
Instructional Support Tip: Level Up	**Purpose:** Provides supplemental guidance to educators facilitating activities, such as • ways to make the activities more inclusive to all STEM learners. • extensions to broaden both content and options provided within each activity. Note that time estimates for Level Up activities are provided separately from the main activity timing.

References

Elsayed, R., Clark, J. G., Daehler, K. R., & Bloom, N. E. (2022). *A practical guide for out-of-school-time professionals to promote inclusion and engagement in STEM learning*. PLANETS, Northern Arizona University and WestEd.

Inclusion Activities

At the beginning of each activity, you can lead an inclusion activity that is appropriate for your group. Below are some possible activities:

Story of Your Name

In pairs or small groups, have learners share their names and stories behind them. For example, what do they mean? Why were they given? Have learners share other important information about their identities, such as locations they are from and tribes or other groups they belong to.

Handshakes and High Fives

Play three rounds of this inclusion activity. Each round, have learners pair up and introduce themselves in some way (e.g., handshake, high five, elbow bump, dance, nod, codeword). Then ask a question and have them discuss it for one minute. Once learners have completed all three rounds, have them re-find their three partners in order and repeat the introduction for each.

Paper Toss

Give each learner a piece of paper and a writing utensil. Ask a question and have them write an answer on the paper (for example, What is your name? What do you do for fun?) Have learners crumple the papers and throw them around. Then have them uncrumple the papers and share the answers with the group.

Choose an Object

Lay out a set of objects, such as small figurines, playing cards, or craft supplies. Ask a question (for example, How is your day going? What is a strength you bring to the group?) and have each learner choose an object that represents their answer (for example, *I chose the owl because I am good at watching what is happening*). Have learners share their objects and answers in pairs or small groups.

Interviews

Have learners pair up and spend three minutes each interviewing each other, then have them share about their partners in a large group. Possible interview questions include the following:

- What is your favorite place to hang out that is not school or home?
- What are some things you are good at?
- What tools or machines do you know how to use?
- What languages do you speak at home?
- What is something you did this week with someone else?
- How do you like to express yourself?

Accessibility Check

Have learners go around a circle and share their names and access needs. Access needs are things they might need to fully participate and feel comfortable in an activity or space. They can be anything that helps people learn, communicate, move around, or feel safe and included. As needed, share first yourself and give some examples, such as "I need short breaks during long activities to stay focused," "I need to refill my cup of water," "I feel more comfortable lying on the floor," or "I need pictures to help me understand what we are learning." Learners can also say "I'm still thinking about my access needs" or "All my access needs are met, check." Note that learners may not be comfortable sharing their needs until after several days of participation.

Design a NASA Mission Patch

NASA mission patches are special symbols that tell the story of each space mission. They use pictures, colors, and symbols to show the mission's goals, who the astronauts are, and important parts of the crew's lives. Have learners form groups of three, choose a mission name, choose a patch shape, and draw or write three things to include on their patch. Patches can include meaningful images, symbols, and colors. As needed, show examples from **NASA's Human Spaceflight Mission Patches.**

Transition

Say:

Let's talk about why we did this. Inclusion isn't just a nice idea–it's crucial for success, both here and in the real world. At NASA, every astronaut needs to know their team well. Why? Because in space, your crew is your lifeline. Similarly, in our group, everyone matters. We learn better when we understand each other. Knowing our teammates helps us work together and solve problems. By sharing parts of ourselves, we build trust and respect. This makes our "mission"—learning together—more fun and more effective. Remember, great teams are built on understanding and appreciating each person's unique strengths.

Conclude by connecting the inclusion activity to what learners are doing next. For example, say:

You just made different partners. Now you are going to work with one of those partners to...

Intentional Grouping Strategies

Intentional Grouping can support learners in a variety of ways.

Group roles can play to learners' **diverse abilities and strengths**. For instance, a blind or low vision learner might be much more skilled at tactile or auditory tasks, and having a role that plays to this strength will elevate that learner and strengthen the group. Never assume which tasks learners will prefer, because they can feel othered and misunderstood. Give them the first choice of group roles.

Grouping learners with **similar spoken or signed languages** can help multilingual learners bounce ideas off each other in their native language before translating them for the whole group. This will also help learners decide what words to share in their native languages.

Grouping learners by **culture** can allow them to work through things in ways that are familiar and valued at home before sharing with the larger group. For instance, Indigenous learners might benefit from being grouped together and working by consensus rather than by having a leader. Or they may decide to communicate their final challenge on posters during a gallery walk, rather than by presenting publicly.

Similarly, if learners are grouped by **shared interests or hobbies**, they may start to interpret the learning in the context of what they know, which is fantastic! For example, "We mitigate hazards when biking all the time by slowing down, wearing helmets, and not biking when it's dark outside."

The number of learners in a group

Groups of 2: If students are sharing personal information or stories, working in pairs first gives learners an opportunity to hear other ideas and rehearse their own ideas before sharing with the whole group. Pairing up is especially helpful for multilingual learners.

Groups of 4: Use groups of four when learners would benefit from lots of perspectives or ideas.

Please note, *these activities are not designed for groups of five or more. A group of five would likely have an outlier with not enough to contribute.*

Science Pathway Storyline

Science Activities 2–7

Learners gain knowledge about data collected from remote sensing technologies designed by engineers so they are successful in making their recommendations for a Mars landing site in the final activity.

Science Activities 8–9

Learners combine the data across the prior activities to select a safe and scientifically interesting landing site for a Mars rover. They then share their recommendations.

CONTEXT

CONTEXT SETTING ACTIVITY – *Ready, S.E.T., Go!*

ACTIVITY OVERVIEW

Learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send on the mission.

Prep Snapshot

Prep Time: 60min

- Read unit
- Print Notebooks
- Cut out instruments.
- Make *Our Ideas* Poster

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Habits of Mind

- Use a structured problem-solving process

Science Practices

- Planning and conducting investigations

Connecting Across Activities

Today, learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send on the mission.

Next time, learners share experiences with, and stories about, technology.

1

SCIENCE ACTIVITY 1 – *Technology Stories: Sharing Experiences*

ACTIVITY OVERVIEW

Learners share experiences with, and stories about, technology.

Prep Snapshot

Prep Time: 30 min

- Set up Materials Table

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Communication

Science Practices

- Communicate effectively

Connecting Across Activities

Last time, learners designed spacecraft to gather data about Mars. As scientists, they chose a mission. As engineers, they figured out which instruments to send on the mission.

Today, learners share experiences with, and stories about, technology.

Next time, learners generate questions about Mars before they explore how wind and water can make landforms on a planet's surface using models.

2

SCIENCE ACTIVITY 2 – *The Lay of the Land: Introducing Landforms*

ACTIVITY OVERVIEW

Learners explore how different landforms are formed by wind and water.

Prep Snapshot

Prep Time: 60 min

- Dry sand the day before
- Set up Water and Wind Stations

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Developing & Using Models
- Analyzing & Interpreting Data

Connecting Across Activities

Last time, learners shared experiences with, and stories about, technology.

Today, learners generate questions about Mars before they explore how wind and water can make landforms on a planet's surface using models.

Next time, they will examine images of Mars to identify landforms which may have been formed by liquid water. These images are the first set of data they will use to choose a landing site.

3

SCIENCE ACTIVITY 3 – *Red Planet Places: Exploring Landforms on Mars*

ACTIVITY OVERVIEW

Learners examine images of landforms on Mars to find evidence of past water.

Prep Snapshot

Prep Time: 60 min

- Print resources for the Activity

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data

Connecting Across Activities

Last time, learners generated questions about Mars and explored how wind and water can make landforms on a planet's surface using models.

Today, learners act as scientists to examine images of landforms on Mars. These images are the first set of data they will use to choose a landing site.

Next time, they will deepen their understanding of landforms by considering topography.

4

SCIENCE ACTIVITY 4 – *Shape Up: Introducing Topography*

ACTIVITY OVERVIEW

Learners build three-dimensional models of topographic maps and then turn them into two-dimensional maps.

Prep Snapshot

Prep Time: 30 min

- Print resources for the Activity

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data
- Planning Investigations

Connecting Across Activities

Last time, learners acted as scientists to examine images of landforms on Mars. These images are the first set of data they will use to choose a landing site.

Today, learners deepen their understanding of landforms by considering topography.

Next time, they will interpret Mars topographic maps. These maps are the second set of data they will use to choose a landing site.

5

SCIENCE ACTIVITY 5 – *Cliffs and Craters: Exploring Topography on Mars*

ACTIVITY OVERVIEW

Learners interpret topographic maps of Mars to identify safe and interesting landing sites.

Prep Snapshot

Prep Time: 30 min

- Print resources for the Activity.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data
- Planning Investigations

Connecting Across Activities

Last time, learners deepened their understanding of landforms by considering topography.

Today, learners interpret topographic maps of Mars to locate interesting landforms and to determine the safest place for a rover to land. These maps are the second set of data they will use to choose a landing site.

Next time, they will learn how to interpret spectra of light reflected from various objects, which will later help them identify minerals from a distance.

6

SCIENCE ACTIVITY 6 – *Beyond the Rainbow: Introducing Spectroscopy*

ACTIVITY OVERVIEW

Learners interpret the spectra of reflected light from various objects.

Prep Snapshot

Prep time: 50 min

- At least two days ahead, create tactile spectra graphs and allow them to dry
- Determine how learners will access audio files

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data

Connecting Across Activities

Last time, learners interpreted topographic maps of Mars to locate interesting landforms and to determine the safest place for a rover to land. These maps are the second set of data they will use to choose a landing site.

Today, learners learn how to interpret spectra of light from various objects, which will later help them identify minerals from a distance.

Next time, they will interpret spectra to identify minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.

7

SCIENCE ACTIVITY 7 – *Hidden Minerals: Using Spectroscopy to Understand Mars*

ACTIVITY OVERVIEW

Learners interpret spectra to identify water-based minerals at potential Mars landing sites.

Prep Snapshot

Prep time: 50 min

- At least two days ahead, create tactile spec tra graphs and allow them to dry
- Determine how learners will access audio files

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data

Connecting Across Activities

Last time, learners learned how to interpret spectra of light reflected from various objects, which will later help them identify minerals from a distance.

Today, learners interpret spectra to identify the types of minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.

Next time, they will use the various kinds of data they have collected–landform images, topographic maps, and spectra –to choose a landing site.

8

SCIENCE ACTIVITY 8 – *Destination Mars: Choosing a Landing Site and Preparing for the Science Share-Out*

ACTIVITY OVERVIEW

Learners combine multiple data sets made possible by technologies that engineers designed to choose a safe and scientifically interesting landing site for a Mars rover. They then prepare to share their findings with the whole group and with invited guests.

Prep Snapshot

Prep Time: 40 min

- Send Science Share-Out Invitations to people from the community

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Communication

Science Practices

- Interpreting Data
- Constructing Explanations
- Communicating Information

Connecting Across Activities

Last time, learners interpreted spectra to identify the types of minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.

Today, learners use the various kinds of data they have collected–landform images, topographic maps, and spectra–to choose a landing site.

Next time, they will share their findings.

9

SCIENCE ACTIVITY 9 – *Sum It Up: Science Share-Out*

ACTIVITY OVERVIEW

Learners share their recommendations for the safest and most scientifically interesting Mars rover landing site.

Prep Snapshot

Prep Time: 40 min

- Send Science Share-Out Invitations to people from the community.

* See *Materials & Preparation* for more information

Skills, Habits, Practices

21st Century Skills Connection

- Communication

Science Practices

- Interpreting Data
- Constructing Explanations
- Communicating Information

Connecting Across Activities

Last time, learners used the various kinds of data they collected –landform images, topographic maps, and spectra–to choose a landing site.

Today, learners share their findings.

Next time, learners experience engineering related to this topic in the PLANETS Worlds Apart Engineering Pathway (optional)

Science Pathway Vocabulary

This list is included to provide an overview of the content of this pathway. Note that you should not pre-teach it to learners before the activities–terms are introduced after learners have direct experience with the materials and processes to which those terms are connected.

Ready, S.E.T., Go!

- **Composition**: What a surface is made of
- **Constraints**: limits on a design
- **Criteria**: things a successful design needs to do or have
- **Fairing**: the part that sits on top of the rocket and protects a spacecraft during launch
- **Physical properties**: the shape and texture of a surface
- **Resolution**: The amount of detail in an image
- **Technology**: an object, system, or process designed by people to solve a problem

Science Activity 2

- **CTX**: Context Camera, a camera on the Mars Reconnaissance Orbiter
- **HiRISE**: High Resolution Imaging Science Experiment, a camera on the Mars Reconnaissance Orbiter
- **Landform**: a shape on the surface of a planetary body

Science Activity 4

- **Topography**: the shape of land in an area
- **Topographic map**: a representation of the shape of land in an area

Science Activity 6

- **Spectrometer**: a technology that measures the amount of light reflected from an object at many different colors (wavelengths).
- **Spectroscopy**: the study of how light of different colors behaves when it touches something
- **Spectrum**: a range of colors

Teaching Tip

No new vocabulary terms are introduced in Activities 1, 3, 5, or 7–9.

Science Materials List

The quantities below are for one group of 24 learners. Download this spreadsheet to calculate the amount of materials you'll need for your number of learners.

Non-Consumable Items

Quantity	Material
3	baking (cookie) sheets with raised rims
3 cups	gravel or pebbles
3	jugs, bottles, or watering cans, for refilling
3	pans or boxes, 9" × 13" (approx. 23 cm × 33 cm), such as dish pans, aluminum baking pans, or copy-paper box lids lined with plastic
3–6	rocks, large, dry
6	audio player(s) with headphones (or learners' personal devices)
6	drop cloths, tarps, or large trash bags (if working inside)
6	paper clips or small resealable bags (optional)
6 pairs	scissors
12 pairs	safety goggles
	rocks and minerals, assorted, small, such as gravel mixture
1	computer with internet access (optional)

Consumable Items

Quantity	Material
1 pad	chart paper
3	bags, trash (clear if possible)
3	cups, paper, 8 oz
3	pieces of cardboard wrapped with aluminum foil with small notch cut (alluvial fan barrier; see Activity 2)
6 sheets	craft foam
6 sheets	felt, 9" × 12"
6 rolls	tape, masking
6	glue sticks (optional)
6 sets	writing utensils (pencils or crayons), colored, in gradually darker shades of yellow, green, and blue if possible
10.5 cups	sand, completely dry
24	straws, regular
48	cleaning wipes (2 per learner, to clean safety goggles and headphones between users)
24	face masks
24	Science Notebooks
	water
6	markers, dry-erase, fine point (optional, if using page protectors)
6	page protectors (optional)
24 pairs	gloves, plastic (optional)
	play-doh or clay (optional)
	school glue or puff paint (optional)
	sand or glitter (optional)

Science Advance Preparation

You can complete much of the preparation for the Science Activities ahead of time. Follow the steps below.

Educator Background

1. Read through the entire PLANETS Science Pathway Educator Guide Introduction, pgs. iii-xxvi, to learn more about this unit.
2. Read the Educator Science Background (weblink) for context about the science and engineering in the unit.
3. View the following video playlists:
   - How to prepare and teach with the materials
   - Background science and engineering content
   - How to support learner differences
4. Print and laminate any pages you want available for easy reference. (The Inclusion Activities, pgs. xx-xxi, Intentional Grouping Strategies, pg. xxii, and Pathway Storyline, pgs. xxiii-xvi, are especially useful.)
5. Consider printing all handouts at once from our All Downloads (weblink).
6. Print your own copy of the Science Notebook (PDF) for reference.
7. Reflect on the learners who will engage in the pathway and identify ways to create an inclusive and collaborative learning environment, pgs. iii-xxvi.

Level Up!

Consider whether you want to use the basic version of this pathway, which examines two sites on Mars (Gale Crater and Jezero Crater) or the advanced version, which adds two additional sites (Nili Fossae and Iani Chaos). The advanced pathway is more interesting and enriching with four choices, but it requires more time.

If you choose to use the advanced version, use the advanced versions of the following files:

- Science Activity 3 Landforms on Mars Data Packet with Level Up (PDF)
- Science Activity 5 Mars Landing Site Topography Data Packet with Level Up (PDF)
- Science Activity 7 Mars Minerals Spectroscopy Data Packet with Level Up (PDF)
- Science Activity 7 Mineral Station Signs with Level Up (PDF)
- Science Activity 7 Level Up Audio Files (weblink)

For the Whole Group

8. Invite staff, family, and community members to attend the Science Share-Out in Activity 9. Make copies of the Science Activity 7 Share-Out Invitation Handout, pg. 92, to distribute to family and friends.
9. Prepare an *Our Ideas* poster by following the Prep & Setup Guide: components and examples for Ready, S.E.T. Go! Examples | Templates and for the rest of the Units Examples | Templates. You can build your own poster with blank paper and markers if you don't have access to a printer.
10. Print the following handouts for stations:
    - 6 copies of Science Activity 2 Landforms Handout (PDF), in color, if possible
    - 3 copies of Science Activity 2 Wind Station Directions Handout, pgs. 39-40
    - 3 copies of Science Activity 2 Water Station Directions Handout, pgs. 41-42
    - 3 copies of each image in Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)
    - 6 copies of Science Activity 7 Mineral Fingerprints Handout (PDF)
    - 1 copy of Science Activity 7 Mineral Station Signs, pgs. 89-91 (3 signs per station)

11. Obtain or download topographic maps of your local area if you are using this option (examples on pgs. 61-62).
12. Make a sample topography model using the directions on Science Activity 4 Topography Template Handout, pg. 60.
13. Optional: Create a clay model of each of the landing sites in Science Activity 5 Mars Landing Site Topography Data Packet (PDF) to provide a tactile version of the data (see pgs. 3 and 5). The models can be estimations; they do not need to be exact.
14. Determine how you will share the Science Activity 6 Audio Files on the day of the activity with the whole group. You have the option to download the audio files (weblink) or access audio files online (weblink). If you have devices and connectivity, QR codes are provided in the guide, Data Packets, and Notebook.
15. To further support learners' understanding, it may be important to offer additional visual and audio support. Review the resources from the Activity Resources page (weblink) and decide which you would like to have available.

For Each Group of Learners

16. Print 1 copy of each of the following handouts for each group of 4 learners:
    - Science Ready, S.E.T., Go! Visual Instructions Handout, pg. 20
    - Science Activity 2 Image of Mars Handout, pg. 38, in color, if possible
    - Science Activity 2 Image of Mars in Context of the Solar System Handout, pg. 38
    - Science Activity 2 Landforms Handout (PDF), in color, if possible
    - Science Activity 3 Landforms on Mars Data Packet (PDF), in color, if possible

Support Learner Differences

Data Packets for Activity 3, 5 and 7 are available in swell paper/Braille printable files (weblink).

If you do not have access to a swell paper or a swell form machine, making tactile graphs will create accessibility for blind and low vision learners and enhance engagement for all learners. If using this option, print extra copies and prepare a tactile model by adding a line of glue or puff paint to the data line, to each of the axes, and on either side of the visible spectrum of each of the following graphs:

- 3 copies of Electromagnetic Spectrum, pg. 8 in the Science Notebook
- 3 copies of Green Paint, pg. 9 in the Science Notebook
- 3 copies of Red Paint, pg. 10 in the Science Notebook
- 3 copies of Olivine, pg. 11 in the Science Notebook
- 3 copies of each graph in Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)
- 6 copies of each graph in Science Activity 7 Mineral Fingerprints Handout (PDF)

Ensure you have a space to let the graphs dry. Consider sprinkling the glue with a bit of fine sand or glitter to add additional texture.

All videos in this unit include captions. As needed, these captions can be translated by online video platforms.

Teaching Tip

If internet access may be a problem, consider downloading videos ahead of time. If it would benefit your learners, you can adjust the video playback speed. Note that video links may change over time; if a link does not work, try searching the title of the video.

- Science Activity 3 Landing Site Ovals Handout (PDF) on transparency or regular paper. Cut along the dotted lines to separate the ovals so there is one oval for each group of 2–4 learners. Cut around the oval to make individual ovals.
- Science Activity 4 Topography Template Handout pg. 60
- Science Activity 4 Grand Canyon Topographic Map Handout or local map. See pg. 61
- Science Activity 4 Grand Canyon Aerial Photo Handout or local photo. See pg. 62
- Science Activity 5 Mars Landing Site Topography Data Packet (PDF)
- Consider laminating the pages or placing them into plastic page protectors to prevent them from getting damaged.

For Each Learner

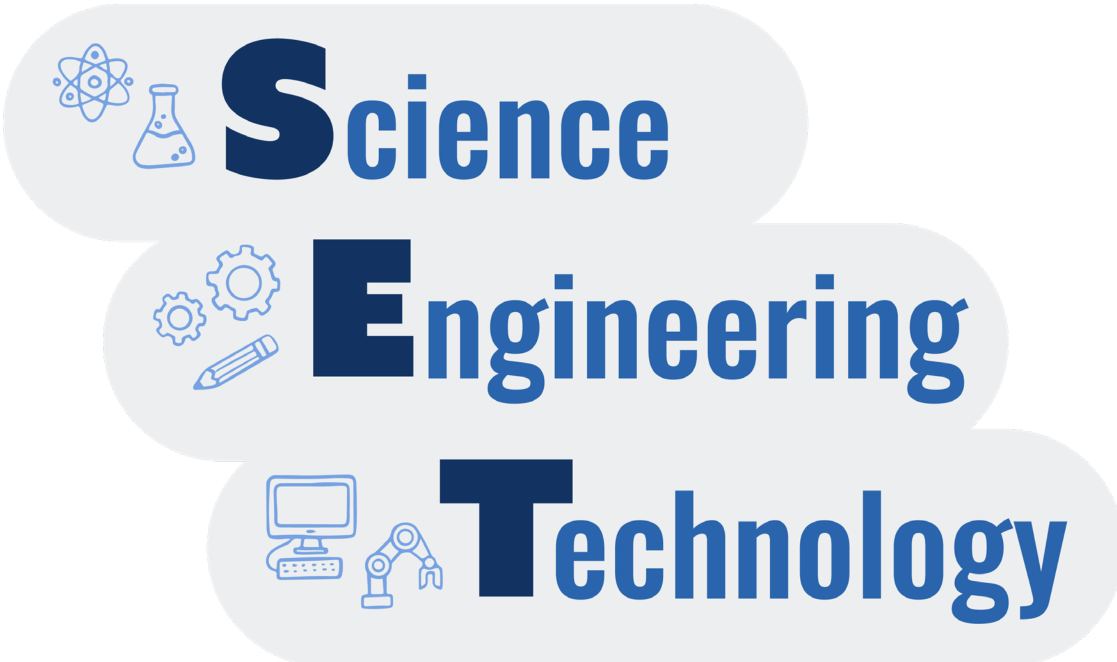
17. Print and staple one Science Notebook (PDF) for each learner, in color if possible.

Teaching Tip

If you think learners will benefit from having more space in the *Science Notebook (PDF)*, print one-sided or add sheets of blank paper as you copy.

Educator Guide

Ready, S.E.T. (Science, Engineering, Technology), Go!



Educator Preview

Activity Snapshot

Learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send on the mission.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Plan & Create (S.E.T.)	25 min.
Reflect (Go!)	10 min
Total	**45 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time 60 min.

- Read front matter and activity.
- Print Notebooks.
- Cut out instruments.
- Make *Our Ideas* poster.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Habits of Mind

- Use a structured problem-solving process.

Science Practices

- Planning and Conducting Investigations

Guiding Questions

Which survey mission should we send to Mars?
What instruments does a spacecraft need for it?

Learners Will Do

As scientists, choose a type of mission. As engineers, choose and arrange instruments for that mission.

Learners Will Know

Scientists and engineers can work together to solve problems.

Connecting Across Activities

Ready, S.E.T., Go!	Activity 1: Sharing Experiences
Today, learners design spacecraft to gather data about Mars. As scientists, they choose a mission. As engineers, they figure out which instruments to send on the mission.	**Next time**, learners share experiences with, and stories about, technology.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/e7a7641c

Materials and Preparation

Materials

For the educator

- *Our Ideas* poster (on paper or a shared digital document). See Prep & Setup Guide (PDF) Examples | Templates
  - index cards
  - markers
  - scissors
  - tape

For each group of 4–6

- Cutouts from Science Ready, S.E.T., Go! Fairing and Instruments Sheets Handout, pgs. 16-18
- Science Ready, S.E.T., Go! Visual Instructions Handout, pg. 20

Teaching Tip

If you think learners will benefit from having more space in the Notebook, print one-sided or add sheets of blank paper as you make the Notebooks.

For each learner

- Science Notebook (PDF)

Ready, S.E.T., Go! Materials Preparation (60 min.)

Ahead of Time

1. Read through the entire PLANETS Science Pathway Educator Guide Introduction, pgs. iii-xxvi, to learn more about this unit.
2. Read the Educator Science Background (weblink) for context about the science and engineering in the unit.
3. Print and staple one *Science Notebook* for each learner, in color if possible. As needed, prepare to share the Notebook digitally.
4. Print a copy of the Science Notebook *(PDF)* for your own reference throughout the pathway.

Teaching Tip

This activity is the same in both the Science and Engineering Pathways. If you have already taught it in one pathway, you do not need to teach it again.

This activity can stand alone as a brief single-session program.

Support Learner Differences

The Science Notebook can be printed in large font and you can share a digital version that will work with screen readers. The Science Notebook is written in English, but you can translate the instructions into other languages; see translation guidance in our editable Translatable Glossary (DOCX).

5. Prepare an *Our Ideas* poster by following the online [Prep & Setup Guide (PDF)](). Add the Guiding Question "Which survey mission should we send to Mars? What instruments does a spacecraft need for it?" so learners can refer to it throughout the activity.

6. Cut out one set of instruments from the *Science Ready, S.E.T., Go! Fairing and Instruments Sheets Handout, pgs. 16-18* for each group of 4–6 learners, or prepare for learners to cut their own. (Cut around the edges of the instruments themselves, not around the edge of the rectangles.)

7. Print one [Science Ready, S.E.T., Go! Instruments Key Handout, pg. 19]() for each group of 4–6 learners.

8. Print one [Science Ready, S.E.T., Go! Visual Instructions Handout, pg. 20]() for each group of 4–6 learners.

In Your Space

9. Place the *Our Ideas* poster in a location all learners can access. Make a plan to store it between activities.

Teaching Tip

You can begin the *Our Ideas* poster with several standard 23" × 32" pieces of chart paper. You may fill them up before the end of the pathway, in which case you can add additional pieces as needed. See the [Our Ideas poster example (PDF)]().

The *Our Ideas* posters capture students' authentic language and ideas as they emerge in real-time discussions. The posters are not meant to simply display and front-load vocabulary. The posters develop over time as the educator listens for and adds the language that learners use in the moment, thus validating their ideas, providing feedback and supporting sensemaking and language development.

Support Learner Differences

Different learners have different needs. Choose from the following tips to best support your learners:

- View the [Translanguaging Video]() to support learners who speak multiple languages.
- For those with low vision: add tactile elements, such as three-dimensional representations and Braille. Prepare a shared digital document all learners can access, ensuring that it supports text-to-speech for your learners.
- Add learner questions to the *Our Ideas* poster to foster an interest-led approach.

If it will support your learners, consider making the following modifications to each instrument:

- Punch out the white circle to indicate the top center.
- Attach dots to indicate the relevant levels of communication, weight, and power: one dot if the feature does not appear, two dots if it is a low value (e.g., low power, low weight), and three dots if it is a high value (e.g., high power, heavy).
- Attach a Braille sticker over the instrument number to indicate that number (e.g., "S4").
- Print an extra *Science Ready, S.E.T., Go! Instruments Key Handout, pg.19*, cut out the information for that item, and tape it to the back of that instrument.

Consider also placing all the instruments for each group in a tub or other container.

Activity Guide

Get Ready & Team Up (10 min.)

1. Organize learners into groups of 4–6.

2. Say: **NASA wants to learn about Mars; one way they do that is by sending spacecraft to orbit the planet. Today, you are going to choose a mission to learn about Mars and design a spacecraft to complete it.** Share the Guiding Question with learners aloud and in writing (using multiple languages as needed): **Which survey mission should we send to Mars? What instruments does a spacecraft need for it?**

Plan & Create (S.E.T.) (25 min.)

Science: Choose a Mission

3. Ask: **What kinds of things do you think we should learn about Mars?** *(What it is made of, what mountains and other features it has, how big it is, where there is water, where a rover could land.)* Give groups five minutes to discuss and record their ideas on the *Our Ideas* poster. Say: **We will keep recording ideas on this poster.**

4. Say: **You've listed many possible things to study on Mars. It is not possible to study them all at once, so you will have to choose one mission to design for.**

5. Give each learner a Science Notebook. Say: **This Notebook is a place to record your observations and ideas.**

Support Learner Differences

If learners are new to you or each other, have them share their names, name pronunciations, and other important parts of their identities. These introductions are important for all learners and can be especially relevant for Indigenous learners, multilingual learners, and learners with different physical abilities. You can also distribute index cards and have learners write anything they want you to know but do not want to share with the whole group, such as resources that will help them learn. If everyone knows each other's names, ask if anyone has a middle name or nickname you could learn to pronounce. Invite them to share about it.

For more strategies to engage learners, refer to Designing Instruction to Reach Diverse Learners, pg. xv.

Check out the Intentional Grouping Strategies, pg. xxii.

Recording learners' ideas using words, diagrams, and pictures on the *Our Ideas* poster or shared digital document throughout the activities allows them to refer to the poster to remember words and build on past ideas. You can refer to an "In-Use Example" in the online Prep & Setup Guide - Examples (PDF).

If you have learners who speak multiple languages, encourage them to share in their preferred languages.

Teaching Tip

Throughout this guide, information for you to say to students appears in **bold**. You can say the bold sentences exactly as they are written or paraphrase them.

6. Have learners turn to Missions to Mars, Science Notebook (PDF). Say: **NASA designs different missions for different purposes. This page describes two different kinds of missions to Mars. Decide as a group which one you want to complete.**
   - **A *global survey* is a long-term mission to explore and map a new planet or moon.**
   - **A *landing site selection survey* is a short-term mission to choose the best place to land a robot or human on the surface.**

Support Thinking

To help learners understand what they will be doing during this activity, play the translatable video Remote Sensing Instructional Read Aloud.

7. Allow each group to discuss, choose one mission, and mark it on the Science Notebook page.
8. Say: **Now that you've chosen a mission, you need to figure out what the mission needs to succeed.**
9. Say: **Survey missions need to make images. Which mission do you think needs more detailed images? Which mission needs less detailed images?** *(A global survey needs less detail because it is observing the entire planet. A landing site selection survey needs more detail because it is observing specific smaller locations.)*
10. Say: **The amount of detail in an image is called its *resolution*. A global survey can have lower-resolution images; a landing site selection survey needs higher-resolution images.** Write the word *resolution* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well. Have learners record the level of resolution their chosen mission needs in their Notebook.
11. Say: **Some missions need to know what the surface of a planet is made of, and some just need to know the planet's general shape and texture. Which do you think is needed for each mission?** *(A global survey needs to know about shape and texture, but not necessarily what the surface is made of, because nothing is landing on the surface. A landing site selection survey needs to know shape and texture as well as what the surface is made of, because that information is important when landing.)*
12. Say: **The shape and texture of a surface are called its *physical properties*. Knowing about these is required for all missions. What a surface is made of is called its *composition*. Knowing about this is required for a landing site selection survey and optional for a global survey.** Write the terms *physical properties* and *composition* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well. Have learners record information their chosen mission needs in their Notebook.
13. Explain that things a successful design needs to do are its ***criteria***. Learners have just listed criteria for each mission. Have learners write this word after its definition in the Notebook, and add it to the *Our Ideas* poster.
14. Say: **Throughout history, people have figured out how to learn more about the world, from local plants and animals, to Earth, to other planets. Like these people, you have been using some practices of scientists. Scientists do many other things that we did not have time to do today, such as analyzing data.** Write the word *scientist* on the *Our Ideas* poster. Have learners work together to come up with a description of scientists and record it on the poster. *(For example:*

Scientists often ask questions, test things out, make observations and measurements, and gather evidence to answer the questions.) You can have learners add translations, drawings, or related images to the poster as well.

Engineering: Design a Spacecraft

15. Ask: **Now that you have chosen a mission and figured out its criteria, what do you think you should do next?** *(Figure out how to complete the mission, design a spacecraft to do it.)*

Level Up!

Have learners sort the instruments by weight. Ask: **What do you notice about the weight of the instruments?** *(They have different weights. Some are light, some are moderate, and some are heavy.)* Set a limit for the maximum amount of weight on the spacecraft. (5 min.)

16. Have learners discuss in their groups:

    What kinds of things does a spacecraft need to work? What kinds of things does it need to study the surface of Mars? *(A spacecraft needs a source of power and a way to communicate with Earth. It needs technologies like cameras and sensors to study the surface of Mars.)*

17. Hand out one set of *Science Ready, S.E.T., Go! Fairing and Instruments Sheets Handout* cutouts, one *Science Ready, S.E.T., Go! Instruments Key Handout*, and one *Science Ready, S.E.T., Go! Visual Instructions Handout* to each group. Say: **You will design a spacecraft using these pieces of paper, which represent different instruments and parts of the spacecraft. This key explains what each instrument is.** Demonstrate how to use the key: for example, find the S1 instrument and look it up to determine it is the High Resolution Camera.

18. Ask: **What symbols are on these instruments? What do you think they mean?** *(The bars mean communication or signal. The weight means how much it weighs. The battery means power.)*

19. Have learners sort the instruments by how big they are. Ask: **What do you notice about the size of the instruments?** *(They are different sizes. Some are small, some are medium, and some are large.)* Say: **When NASA designs a spacecraft, they build it so it can fit on top of a rocket. The part that sits on top of the rocket and protects a spacecraft during launch is called the *fairing*. All the instruments need to fit into the cargo hold inside the fairing and not overlap.** Have learners find the piece of paper that represents the fairing.

20. Have learners sort the instruments by how much power they need or how much power they give. Ask: **What is needed to power these instruments?** *(Different instruments need different amounts of power. Some power sources give more power than others.)* Say: **Your spacecraft must have as much power as whichever instrument needs the most power. For example, if you have an instrument that needs a full battery, you need a source that provides a full battery of power.**

21. Have learners sort the instruments by how much data volume they need or how much data volume they can communicate. Ask: **How much data volume do these instruments need to communicate?** *(Different instruments need to send different amounts of data. Some communications relays can send more data than others.)* Say: **Your spacecraft must have as much communications relay as whichever instrument has the highest data signal needs. For example, if you have an instrument that needs more than two bars of signal, you need a relay that can transmit large data volumes.**

22. Explain that limits on a design are ***constraints***. Learners have just listed constraints for their spacecraft. Have learners write this word after its definition in the Notebook, and add it to the *Our Ideas* poster.

23. Say: **Now it is time to choose instruments for your spacecraft. You will need to choose two types: instruments to help you learn about the planet for your mission (your criteria) and instruments to provide as much power and data volume as you need (your constraints).** Give groups 5 minutes to choose instruments.

24. Say: **Now it is time to arrange the instruments inside your fairing. They must fit without overlapping and without going past the edge of the fairing.** Give groups 5 minutes to arrange the instruments.

25. Say: **Humans often need to learn about things that are far away. Throughout history, people have done this in many ways, from telescopes to spacecraft. Like these people, you have been using the practices of engineers.** Write the word *engineer* on the *Our Ideas* poster. Have learners come up with a description of engineers together and record it on the poster. (For example: Engineers design things to solve problems.) You can have learners add translations, drawings, or related images to the poster as well.

26. Say: **Scientists start with a question and work to answer it. Engineers start with a problem and work to solve it. The objects, systems, and processes engineers design to solve problems are *technology*; for example, the spacecraft you designed are technologies. Engineers often design technologies that help scientists answer their questions. They depend on each other.** Write the word *technology* on the *Our Ideas* poster. You can have learners add translations, drawings, or related images to the poster as well.

Support Thinking

Help learners understand that this challenge does not have a single correct answer. Learners need to make tradeoffs in what they include on their spacecraft.

Level Up!

- Learners may believe that *technology* refers only to devices powered by electricity. Explain that anything designed by people to solve a problem is technology. Have learners identify as many non-electrical technologies around them as they can. (10 min.)
- Have learners create portrayals–through drawing, acting, or some other method of their choice–of scientists and engineers working together to plan missions and design spacecraft. (30 min.)

Reflect (Go!) (10 min.)

27. Have learners discuss the following questions in their small groups: **Where on Mars do you think it might be interesting to land your spacecraft? What would be useful to know about the place before it landed there?** Consider returning to learners' ideas at the start of the next activity.

28. Say: **You will be acting as scientists to think more about Mars. You will gather information about possible landing sites in order to choose one to land at.**

29. Say: **Next time, we will think about what we already know about technology and why it is important.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 1.
   - Collect all paper cutouts. If possible, save them for reuse.
2. Plan ahead for Activity 1. See Activity 1 Preparation on pg. 22.
3. Take time to reflect on the following educator prompt. **How did you create continuity between the science and engineering portions of the activity?**

Level Up!

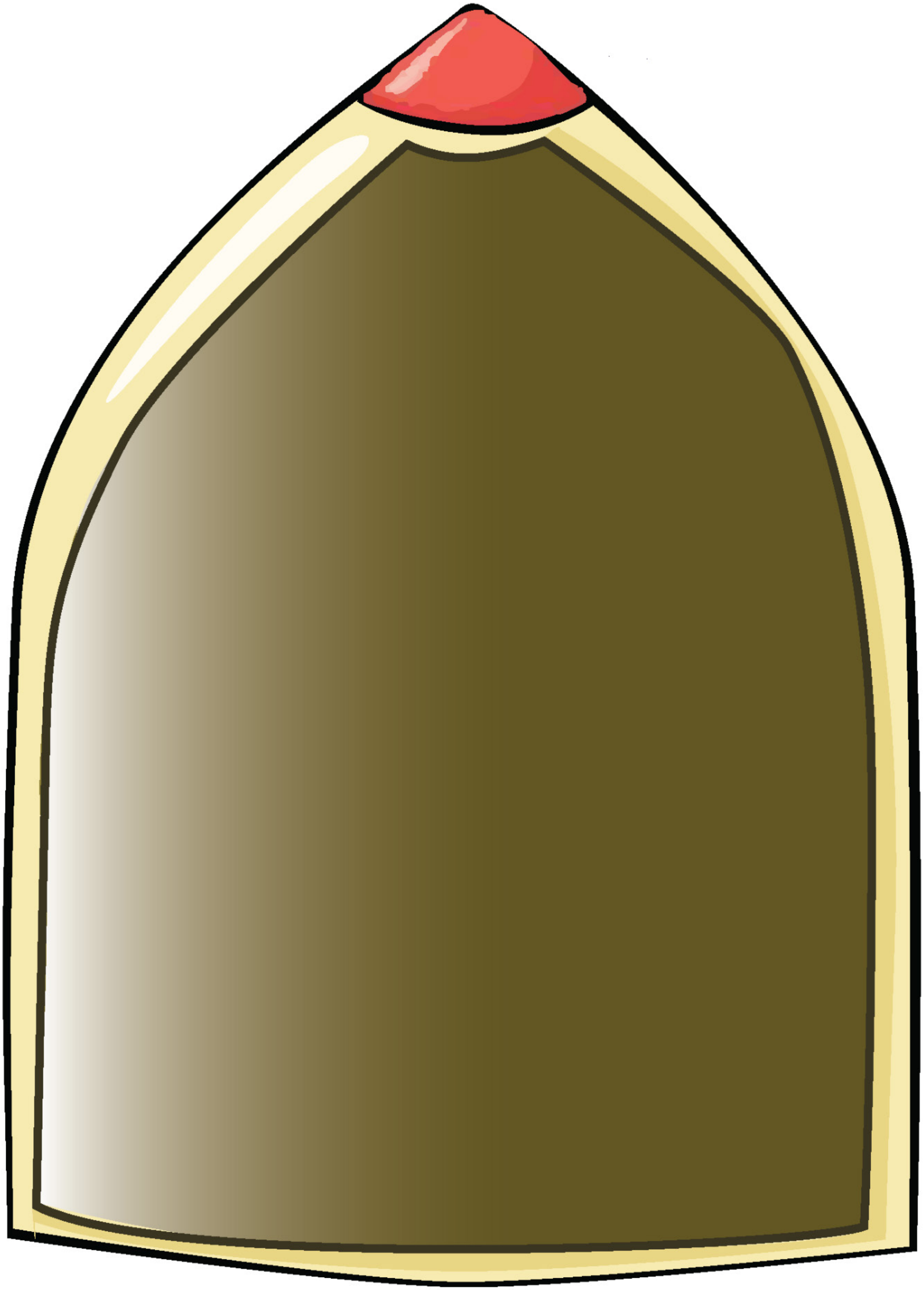
Watch this video about plans for sending humans to the Moon during the Artemis missions - How We Are Going to the Moon - 4K. Discuss how spacecraft must be designed differently if they are carrying robots versus if they are carrying humans. (15 min.)

Remote Sensing Additional Resources

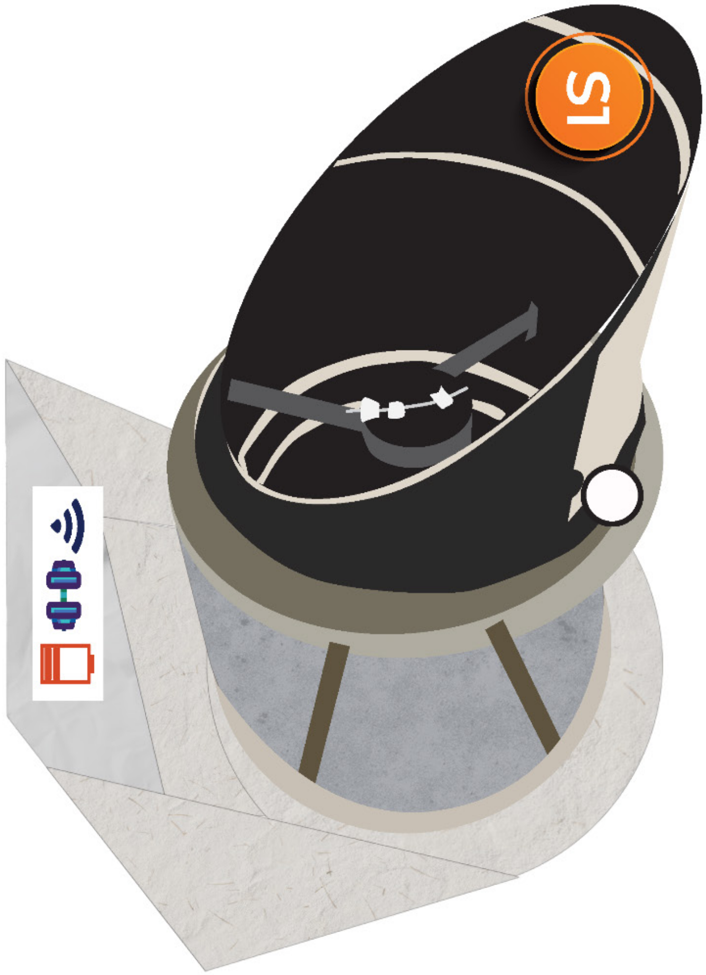
QR code leads to resources available for this unit.

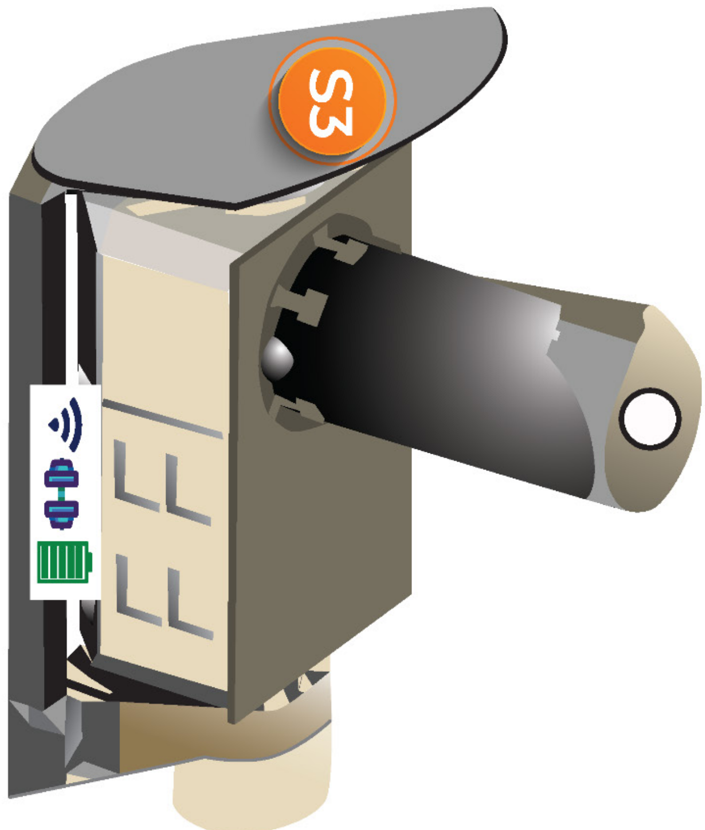
weblink: https://hov.to/248cf0d9

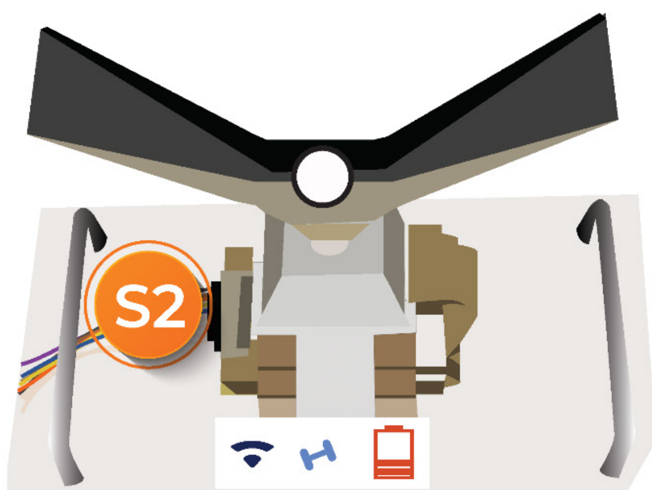
Fairing Handout

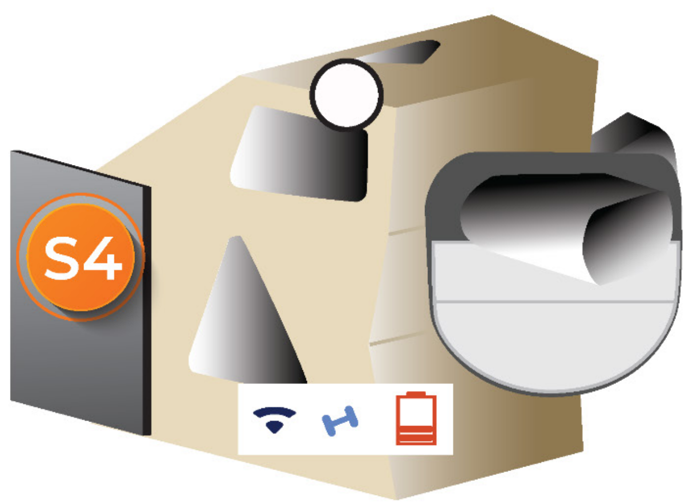


Instruments Sheet Handout – 1

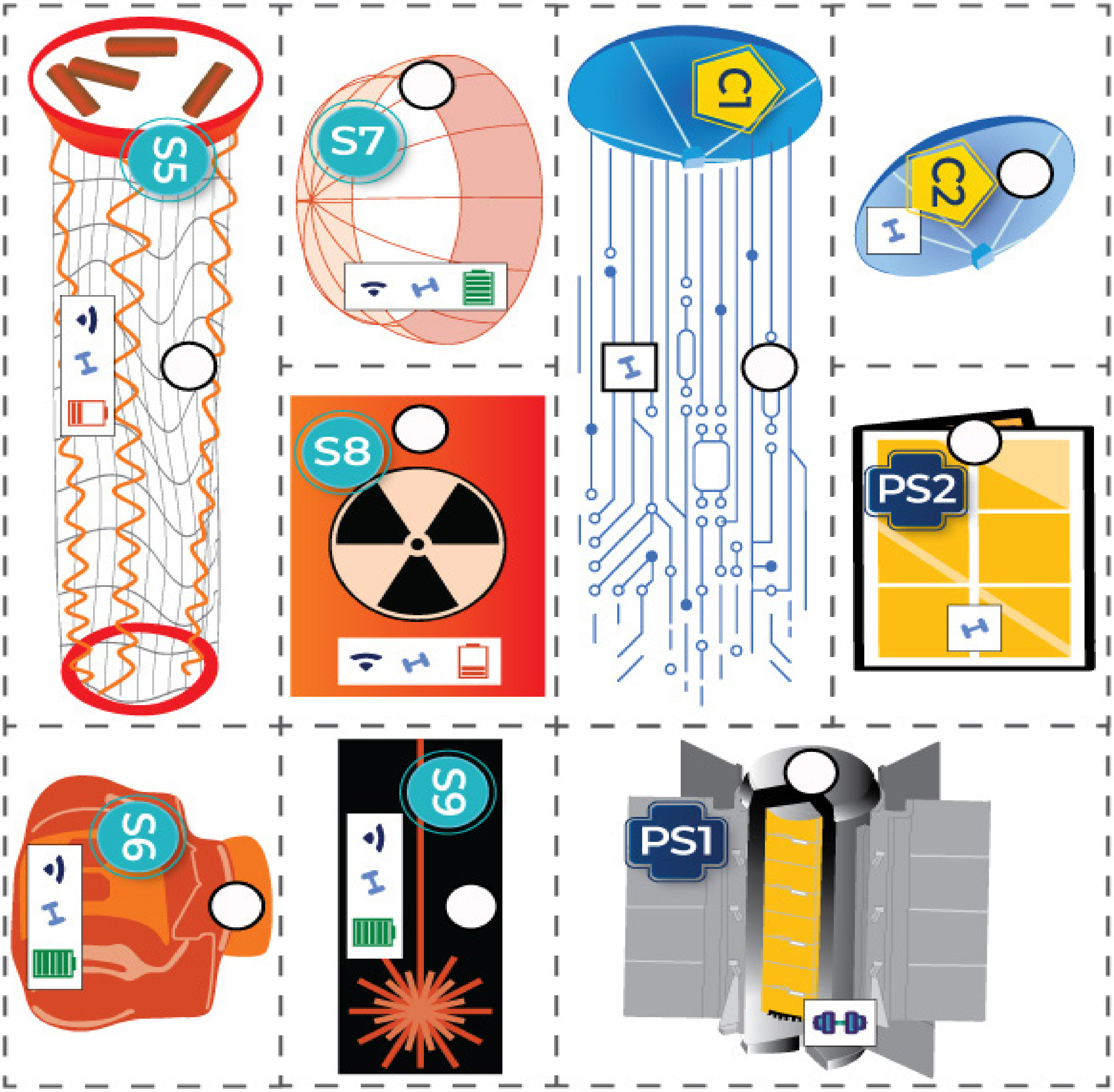








Instruments Sheet Handout – 2



Instruments Key Handout

Science Instrument 1:
High Resolution Camera
Can take 3D images of the surface and can take scientific measurements, which makes it great for making different kinds of maps.
high signal, heavy weight, low energy

Science Instrument 2:
Low Resolution Camera
Can take good images of the surface, but has more limited scientific measurements.
low signal, light weight, low energy

Science Instrument 3:
High Resolution Spectral Imager
Can take images of the surface and can take high resolution scientific measurements.
high signal, heavy weight, high energy

Science Instrument 4:
Medium Resolution Spectral Imager
Takes good scientific measurements, but with reduced detail.
low signal, light weight, low energy

Comms Instrument 1:
High-Volume Communications Relay
Can transmit large data volumes.
light weight

Comms Instrument 2:
Low-Volume Communications Relay
Can transmit small data volumes.
light weight

Power Source 1:
High Power Source
Can last for a long-duration mission.
heavy weight

Power Source 2:
Low Power Source
Can last for a short mission.
light weight

Science Instrument 5:
Magnetometer
Measures the magnetic field of the planetary body.
low signal, light weight, low energy

Science Instrument 6:
Thermal
Measures the temperatures of the surface, which can be used to figure out the grain size and where rocks are.
low signal, light weight, high energy

Science Instrument 7:
Radar Instrument
Detects below the surface, showing us buried rocks, ice, and caverns.
low signal, light weight, high energy

Science Instrument 8:
Gamma Ray Spectrometer
Detects gamma rays on the surface, showing where different elements may be located.
low signal, light weight, low energy

Science Instrument 9: LiDAR
"Light Detection and Ranging" instruments can measure distances using light, which helps to understand the shape of the surface.
low signal, light weight, high energy

Last Updated
033125 tmsr

Science Ready, S.E.T., Go! Visual Instructions Handout

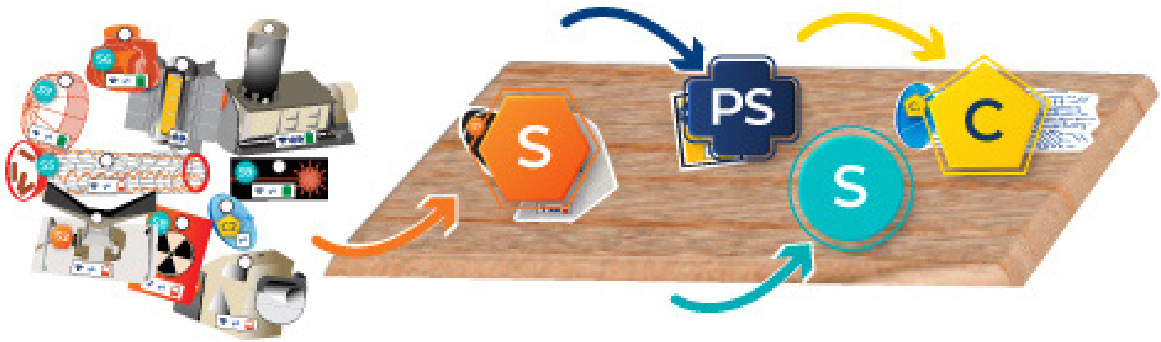
Prep for your Mission to Mars

1

Cut out all pieces

2

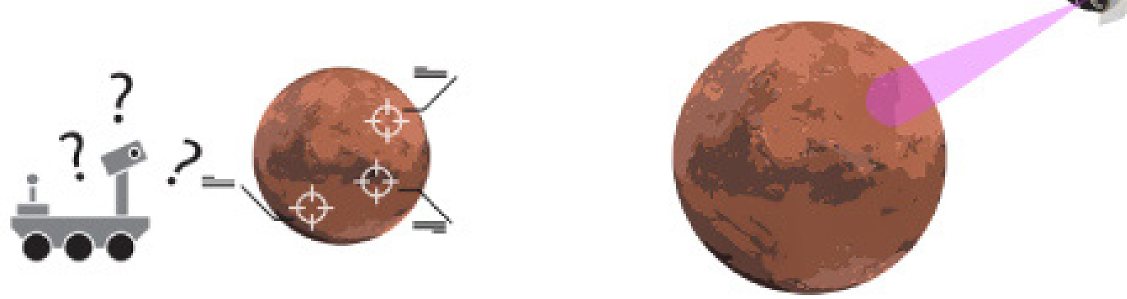
Sort the instruments



3

Choose your mission!

The Landing Site Mission –or– The Global Mission



Once you decide, you are on your way!

4

Guidelines

Science Activity 1: Technology Stories: Sharing Experiences

Educator Preview

Activity Snapshot

Learners share experiences with, and stories about, technology.

Timing | 45 minutes

Get Ready & Team Up	10 min.
Storytelling	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–60 min. each

Prep Snapshot*

Prep Time 30 min.

Set up a Materials Table.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Communication

Science Practice

- Obtaining, Evaluating, and Communicating Information

Guiding Question

Why is technology important?

Learners Will Do

Share a story or experience about technology.

Learners Will Know

Humans design technologies to solve problems they have identified

Connecting Across Activities

Ready, S.E.T., Go!	Activity 1: Sharing Experiences	Activity 2: Introducing Landforms
Last time, learners designed spacecraft to gather data about Mars. As scientists, they chose a mission. As engineers, they figured out which instruments to send on the mission.	**Today**, learners share experiences with, and stories about, technology.	**Next time**, learners generate questions about Mars before they explore how wind and water can make landforms on a planet's surface using models.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/699f13d4

Materials and Preparation

Materials

For the educator

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
  - index cards
  - markers
  - scissors
  - tape

For the Materials Table

- drawing supplies (such as pencils, crayons, markers)
- building supplies your site has access to (such as clay, Lego bricks, beads, natural materials).

For each learner

- Science Notebook

Activity 1 Materials Preparation (30 min.)

Ahead of Time

1. Prepare an *Our Ideas* poster by following the Prep & Setup Guide (PDF). Add the Guiding Question "Why is technology important?" so learners can refer to it throughout the activity.

Teaching Tip

This activity is the same in both the Science and Engineering Pathways. If you have already taught it in one pathway, you do not need to teach it again.

2. Learn about local industries and traditions, reasons why they are important in local communities and cultures, and their history in your area. This information will help you understand learners' stories, and you can use it to provide examples and prompt learners' thinking.
3. Learn about or reflect on the storytelling styles of learners' communities. Think about the kinds of stories learners might tell and how you can structure the activity to support them.

In Your Space

4. Place the *Our Ideas* poster in a location all learners can access. Make a plan to store it between activities.
5. Set up a Materials Table with the materials listed in the Materials section.
6. Optional: Set the mood for the activity by playing music.

Get Ready & Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*As scientists, we chose a kind of mission to send to Mars. As engineers, we designed a spacecraft to complete that mission.)*
2. Say: **Our ultimate goal is to choose a site on Mars to land a rover. We will use various technologies to learn about Mars. To start our exploration, we're going to share what we know about why technology is important. Remember that a technology is anything designed by people to solve a problem.** Share the Guiding Question with learners aloud and in writing (using multiple languages as needed): **Why is technology important?**
3. Organize learners into groups of four.

Support Learner Differences

If learners are new to you or each other, have them share their names, name pronunciations, and other important parts of their identities. These introductions are important for all learners and can be especially relevant for Indigenous learners, multilingual learners, and learners with different physical abilities. You can also distribute index cards and have learners write anything they want you to know but do not want to share with the whole group, such as resources that will help them learn. Lead an inclusion activity that is appropriate for your group (a list of possible activities is available on pgs. xx-xxi). This tip is repeated because you may have new learners joining you in this and future sessions. Whenever you have new learners, repeat this strategy.

For more strategies to engage learners, refer to Designing Instruction to Reach Diverse Learners, pg. xv.

If you have learners who speak multiple languages, consider pairing learners with the same preferred language so they can share with each other in that language. Check out Intentional Grouping Strategies, pg. xxii.

If you have learners who speak multiple languages, have them discuss words for "technology" in their preferred languages and notice similarities between languages. If you can, provide an example from a language you know. Take time to learn learners' words and use them throughout the activities.

Storytelling (25 min.)

4. Say: **We all have stories. They can be stories we've heard from other people, stories we've watched or read about, or stories about things we have experienced ourselves. We experience stories every day in conversations, art, traditional craft, and online videos. Today, we're going to share stories about technologies or tools that made a big difference in our lives. These stories could be about technologies you use at home, technologies in history, what it means to use technology responsibly, and how technology affects different people in different ways.**
5. Have learners turn to *My Technology Story*, pg. 4 in the Science Notebook (PDF). Say: **To start, everyone will have 15 minutes to think about a story to tell that shows how a technology or tool has made a big difference in your life. Create some art that tells your story. You can write it down or write a poem that tells it, draw it, record it on a device, create a performance about it, or build something to demonstrate it.** Note that there are drawing and building materials on the Materials Table. During this time, check in with each group. If learners are struggling, consider sharing your own short story about technology to spark ideas.
6. After 15 minutes, say: **Now, everyone in your group will take a few minutes to share their stories. If your story is long, you can choose one or two minutes of it to share so there is time for everyone.**
7. Allow learners to share their stories for 10 minutes. Remind them to switch so that everyone has time to share. Visit each group and listen to learners' perspectives on technology.

Reflect (10 min.)

8. Say: **Thank you for sharing your stories. They gave us great reasons why technology is important.** Point out common themes you noticed among stories. Emphasize how technologies allow people to do things they could not do otherwise. Ask: **Is there anything else you want to share to answer the Guiding Question?** Revisit the Guiding Question: **Why is technology important?**

Support Thinking

Learners may want to make up their own stories. Bear in mind that the goal of the activity is to identify why technology is important to learners and communities they belong to, which made-up stories may or may not do.

Support Learner Differences

It is possible that stories about the use and effects of technology may bring up trauma. If you notice this, ask the learner privately what they might need at that moment. If they do not know, you can offer some ideas from the Arizona Adverse Childhood Experiences Consortium Resource Library.

In this activity, you will need to strike a balance between allowing learners to share complete stories and ensuring there is enough time for everyone to share. Different cultures have different conventions for storytelling, which may involve very long stories with many parts, the significance of which is not immediately apparent. Consider the best way to approach time management, which may involve dedicating multiple sessions to this activity.

You can use storytelling as an opportunity for learners to practice social skills such as taking turns and showing respect for other people's experiences.

9. Have learners record answers to the Guiding Question near it on the *Our Ideas* poster. You can
   - have each group designate a member to record responses on the *Our Ideas* poster.
   - have each learner write or draw something on a (physical or digital) index card and add it to the *Our Ideas* poster.

10. Say: **Next time, we will think about the ways land is shaped on the surface of Earth and Mars.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 2.
   - If learners created objects related to their stories, save those objects for reference in future activities.
2. Have learners invite people from the community, including their families and friends, to save the date for the Science Share-Out in Activity 9.
3. Plan for Science Activity 2. See the Activity 2 Preparation on pg. 28.
4. Take time to reflect on the following educator prompt. **What strategies helped learners feel comfortable sharing stories?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Support Learner Differences

As needed, allow learners to choose other methods of sharing their ideas, such as audio recordings. Have them write the filename of each record on an index card and put the index cards on the *Our Ideas* poster. They will serve as placeholders. When necessary, you can ask, **"Who has the idea named X?"** and have the learner in question share the record.

Support Thinking

Learners may bring up ideas that will be relevant in future activities, such as technology that can gather information from far away. As appropriate, note that the group will return to these ideas.

Level Up!

- Check out some great examples of the more than 2,000 NASA spin-off technologies that enrich our lives thanks to space exploration. (5 min.)
- Get families or a community member involved to share relevant stories of engineering. Download customizable flyers and get ideas on the Remote Sensing Family and Community Connections (weblink). (45 min.)
- Tell learners, if anyone asks them what they did today, they can tell them "We shared stories about why technology is important." (5 min.)

Science Activity 2: The Lay of the Land: Introducing Landforms

Educator Preview

Activity Snapshot

Learners explore how different landforms are formed by wind and water.

Timing | 45 minutes

Get Ready and Team Up	15 min.
Explore Landforms	20 min.
Reflect	10 min.
Total	**45 min.**

Level Up: Crater Activity 30 min.

Prep Snapshot*

Prep Time 60 min.

As needed, dry sand the day before.

Set up Water and Wind Stations.

Print resources.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practices

- Developing & Using Models
- Analyzing & Interpreting Data

Guiding Question

What are landforms and how are they formed?

Learners Will Do

Explore how wind and water can create the same landforms on Earth and Mars.

Learners Will Know

Landforms are the result of the history and climate of a location.

Connecting Across Activities

Activity 1: Sharing Experiences	Activity 2: Introducing Landforms	Activity 3: Exploring Landforms on Mars
Last time, learners share experiences with, and stories about, technology.	**Today**, learners generate questions about Mars before they explore how wind and water can make landforms on a planet's surface using models.	**Next time**, they will examine images of Mars to identify landforms which may have been formed by liquid water. These images are the first set of data they will use to choose a landing site.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/63187371

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
  - index cards
  - markers
  - scissors
  - tape
- 6 copies of Science Activity 2 Landforms Handout (PDF)
- 3 copies of Science Activity 2 Wind Station Directions Handout, pgs. 39-40.
- 3 copies of Science Activity 2 Water Station Directions Handout, pgs. 41-42.
- 3 bags, trash, (clear, if possible)
- 3 baking (cookie) sheets with raised rims
- 3 pieces cardboard wrapped with aluminum foil with small notch cut (alluvial fan barrier)
- 24 cleaning wipes (1 per learner, to clean safety goggles between users)
- 3 cups
- 6 drop cloths, tarps, or large trash bags (if working inside)
- 12 pairs safety goggles
- 3 jugs, bottles, or watering cans, for refilling
- 24 face masks (1 per learner)
- 3 pans or boxes, 9" × 13" (approx. 23 cm × 33 cm), such as dish pans, aluminum baking pans, or copy-paper box lids lined with plastic
- 3 cups gravel or pebbles
- 3–6 rocks, large, dry
- 10.5 cups of completely dry sand
- 24 straws (1 per learner)
- water
- 6 page protectors (optional)
- gloves, plastic (optional)

Teaching Tip

To let learners shape larger landforms, consider providing longer pans or stream tables.

For each group of four

- items marked ***1 per learner*** in Landforms Stations, above

Activity 2 Materials Preparation (60 min.)

Ahead of Time

1. Print one copy of the *Science Activity 2 Landforms Handout (PDF)* in color, if possible, for each group of 2–4 learners, in addition to the six copies needed for the stations.
2. Print three copies of *Science Activity 2 Wind Station Directions Handout, pgs. 39-40,* and three copies of *Science Activity 2 Water Station Directions Handout, pgs. 41-42,* for learners to reference when they are at the stations.

In Your Space

3. If you did not do so before Activity 1, prepare an *Our Ideas* poster by following the Prep & Setup Guide (PDF).
4. See *Station Assembly Instructions* (Wind, pg. 35, Water, pg. 36) for instructions on using the materials to set up the stations. Ensure all learners can access the stations.

Teaching Tips

Quantities listed are for three setups per landform station (6 stations total). Three setups per landform station accommodate 24 learners total (6 groups of 4). If you have fewer learners, reduce the materials quantities and create fewer stations as appropriate.

Laminate or place the *Science Activity 2 Landforms Handouts* in page protectors or large plastic zip-top bags to keep them from getting wet at the Water Station. Learners can write on them with dry erase markers, and they can be reused. You can reuse the *Science Activity 2 Landforms Handouts* from the stations instead of making new ones for each group.

To reduce mess, work outdoors. Use a hose for the Water Stations and create the dunes for the Wind Stations directly on concrete.

Play sand or aquarium sand work well. If you are able to find only wet sand, be sure to build in time to spread it out and let it dry.

Do one station at a time on different days to reuse the sand, saving the Water Stations for the end to keep the sand dry.

For safety at the Wind Station, have learners wear safety goggles and masks to prevent the sand from blowing into their eyes and noses.

Level Up!

Craters are visible in the images of Mars. If you have time, add a Crater Station by following online directions such as those on https://www.jpl.nasa.gov/edu/resources/project/make-a-moon-crater/. Craters are fun and interesting to model but usually are not directly related to finding water on Mars. (>30 min.)

Activity Guide

Get Ready and Team Up (15 min.)

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

1. Ask: **If you did the last activity, what did you do and why?** *(We told stories about why technology is important, which helped us understand why it's important to think carefully about designing technology.)* Draw learners' attention to their work on the *Our Ideas* poster about how technology makes a difference in their lives.

2. Say: **NASA has sent several missions to Mars. As scientists, our ultimate goal is to analyze the data collected by these missions and answer the big question <u>"What is the best landing site for a Mars rover?"</u>** Write the question in a prominent spot on the top of the *Our Ideas* poster. (Leave room at the end of this question to add the words "to look for past liquid water.")

3. Distribute one *Science Activity 2 Image of Mars / Image of Mars and Its Context in the Solar System Handout, pg. 38* per group. Say: **Look at these images. What questions do you have about Mars? What questions might scientists have about Mars?**

4. Say: **Those are all great questions.** If it hasn't come up, say, **Liquid water is needed for life. If liquid water was once present somewhere, it could have once supported some form of life. Scientists say the place could once have been habitable. The search for liquid water is the driving force behind several NASA missions. Turn to a neighbor and discuss: What do you already know about the importance of water?** After a few minutes, invite learners to share with the group. *(Answers may be similar or vary by culture. Encourage learners to draw from their experiences, stories from Elders, families, teachers, etc. Accept all answers as equally valid.)*

5. Say: **As scientists, your task is to examine data collected by remote sensing technologies. You will use these data to choose the best site to send a rover to look for past liquid water. Then, you will compare your choice to NASA's.** At the top of the *Our Ideas* poster, write "to look for past liquid water" after "What is the best landing site for a Mars rover" so that it says: "What is the best landing site for a Mars rover to search for past liquid water?"

Teaching Tip

Each activity in this pathway has a suggested Guiding Question. As much as possible, replace these questions with similar ones from the list of questions learners have thought of. Using learners' questions will increase their engagement. There will likely be questions you do not answer in the pathway. When you can, mention these questions and have learners think about ways to answer them in the future.

Learners may not ask these questions directly, but they may ask related questions. For example, "Was there life on Mars?" can be investigated by looking for evidence of past water. Landforms and minerals can provide evidence of past water.

6. Ask: **What do you need to know to choose the best landing site to find liquid water?** Allow learners to think of questions in pairs, then share them with the whole group. Record their questions on the *Our Ideas* poster in related categories. Possible sets of questions include the following:
   - **Evidence of Life**: What evidence of life is there? Where is there water? What are the most interesting areas? What is the weather/atmosphere like?
   - S**afe Landing Sites**: What is the landscape like? Where is the safest place to land a rover? Can rovers go everywhere or are they limited? How much space does a rover need?
   - **Minerals:** What is the land made of? Which minerals are evidence of liquid water?
7. Say: **Those are all great questions. Today, we will start to answer questions about finding liquid water on the surface of the land.**
8. Organize learners into groups of four.

Explore Landforms (20 min.)

9. Say: **Turn to your neighbor and discuss: What are some natural land features in our community or that you know about?** After a few minutes say: **These natural shapes on the surface of a planet are called *landforms*.** Have learners record landforms on the *Our Ideas* poster.
10. Say: **Scientists often examine landforms to learn about the past history and climate of a location. Today, we will think about how landforms might hold evidence of past liquid water.** Write the Guiding Question and share it or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **What are landforms and how are they formed?**

Support Thinking

Asking learners to discuss a few broad questions at the beginning of an activity surfaces helpful prior knowledge and acknowledges and values their experiences. This provides a more inclusive entry-point to developing new understandings.

Level Up!

The Engineering Pathway, Worlds Apart: Engineering Remote Sensing Devices (PDF), challenges learners to design many different remote sensing technologies to gather data from a distance.

Support Learner Differences

- Group learners with different abilities and strengths in a way they can all contribute. Check out Intentional Grouping Strategies, pg. xxii.
- Introduce the idea of a "sense of place": the meanings of and attachment to a place built from a person or community's experience. Have students discuss places that are meaningful to them and their connections to those places.
- As learners engage with important but perhaps unfamiliar concepts and vocabulary terms, provide visuals and examples to amplify their understanding. Invite them to share translations, both orally and in writing, of the terms in their preferred language. If time permits, ask learners to think of additional examples of the concept/term that they know from previous experiences. You can allow time for them to add ideas to the *Translatable Glossary (docx)*.

11. Say: **Before scientists study landforms and other things on Mars, they make sure they understand how they work on Earth. Here on Earth, what are some ways you can tell that water used to be somewhere, even though it is gone now?** *(Dried mud with cracks, ripples in sand, dry riverbeds, rounded rocks, lines, such as on the side of a teacup or bathtub, and patterns, such as the collapse of land at the edge of a riverbed.)* Prompt learners to think about communities they belong to and what they see after a rainstorm or windstorm.

12. Say: **Today, we will explore these ideas with models of Earth. In small groups, you will come to two stations. You will use sand, water, and air, representing wind, to model different landforms. You will rotate through both the stations, spending about 10 minutes at each.**
    - Demonstrate as you say: **Each station has a Landforms Handout that shows types of landforms. Try to make the landforms by acting out the natural processes involved, like water and wind.**
    - At the Wind Station, demonstrate how to have a partner hold the bag open as learners use a straw to blow across the sand to form dunes. Encourage learners to explore placing large rocks as obstacles. As needed, give learners time to feel the materials at the station.
    - At the Water Station, demonstrate how to create a river valley by tilting a container of sand and slowly pouring water into it at the higher end in one location. Encourage learners to explore tilting at different angles and to try to make different landforms. Caution learners to tilt the container gently, so they do not spill the sand. Demonstrate how to pour water slowly in one spot on one side of a barrier and explore what happens to the sand. As needed, give learners time to feel the materials at the station.

Supporting Learner Differences

Make connections to local phenomena with which learners are familiar, such as nearby hills, washes, and sources of water. If possible, share satellite images or photos of the community and point out some of these locations.

Support Thinking

To help learners understand what they will be doing, show the translatable video RS Science How To (0:16–1:08).

Precisely replicating the landforms is not the goal. In fact, they likely cannot be the same because the scale is so different. The goal is for learners to explore and get a sense of what water and wind can do before looking at the images of Mars. Encourage learners to think about and discuss their experience with wind- and water-related landforms in nature.

Teaching Tips

- Remind learners that they are creating models of how landforms naturally develop. So, learners should not sculpt the landforms with their hands. The idea is to allow the “natural” processes (wind, water) to create the landforms. Emphasize safety as you demonstrate.
- Consider running this activity as a whole group, guiding learners to create specific landforms, or as a demonstration rather than allowing groups to freely explore.

13. While groups are working, ask: **Do you have any of these landforms in your community? What do you notice about the shapes of different landforms when you observe them from above?** *(They look like snakes, rope, fans, etc.)*

14. As a group gains experience with each landform, have learners in that group look at the examples and read the landform's name and description from the *Landforms Handout*.

Reflect (10 min.)

15. Gather the whole group. Ask: **Which landforms were you able to make? Which were you not able to make? Why?** *(Sand dunes were difficult to make because of the scale of the images, etc.).* **What similarities or differences did you notice between landforms on Earth and Mars? What do these observations tell you?** *(Landforms are similar on Earth and Mars, suggesting that Mars has things like wind and water on it.)* **Why might scientists be interested in these landforms?** *(Landforms formed by water on Earth may provide evidence of past liquid water on Mars.)*

16. Revisit the Guiding Question: **What are landforms and how are they formed?** *(Wind, water, and volcanic activity on other planets create the same landforms that they do on Earth. Alluvial fans, deltas, and river valleys form in water. Sand dunes are formed by wind, and lava flows are formed by volcanic activity.)* Have learners record their ideas on the *Our Ideas* poster. As needed, remind learners of the term *habitable* and *landforms*.

17. Ask: **What are the different ways that land is shaped by water near our community?** *(Hills, mesas, mountains, plateaus; canyons, valleys, lakes, ponds, deltas etc.)* Encourage learners to name or describe their experiences with specific landmarks. Consider returning to learners' ideas at the start of the next activity.

18. Say: **Good job working as scientists today! Now you are prepared for next time, when you will examine images of Mars showing landforms at potential landing sites. The process you are following is like the process NASA uses to choose landing sites.**

Support Thinking

When introducing questions that require learners to extend their thinking and formulate new ideas, invite them to share ideas with a partner or small group before sharing with the whole group.

Consider adding these landforms and images to the *Our Ideas* poster to reinforce new vocabulary.

After the Activity

1. Clean up:
    - Keep the *Our Ideas* poster for Activity 3.
    - Throw away the straws, face masks, cleaning wipes, and gloves (if used). Clean the safety goggles. Allow the sand to dry. Store all Wind and Water Station materials for reuse.
2. Plan ahead for Science Activity 3. See Activity 3 Materials Preparation on pg. 44.
3. Take time to reflect on the following educator prompts: **How did you support learners' needs in acquiring the vocabulary used in this activity? How could you use similar strategies during future activities?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Wind Station Assembly Instructions

Use these materials to set up the Wind Station. Three setups are needed for a group of 24 learners. The Materials list at the start of this activity has additional details about the materials.

Materials for each setup:

- Science Activity 2 Landforms Handout (PDF)
- 1 page protector
- 8 straws
- 1 cookie sheet
- ½ cup dry sand
- 1 drop cloth
- 1–2 rocks
- 1 trash bag
- 4 safety goggles
- 8 cleaning wipes
- 8 face masks
- Science Activity 2 Wind Station Directions Handout, pgs. 39-40

1. If learners are working inside, lay out the drop cloth underneath the work area to make sand cleanup easier.
2. Place the cookie sheet inside the trash bag.
3. Pour the sand onto the cookie sheet.
4. Fold the bag closed until learners are ready to use it. You can use a rock to hold it closed.
5. Put the *Landforms Handout* in the page protector and place it next to the bag. Put the *Wind Station Directions* nearby.
6. Place the straws, safety goggles, cleaning wipes, and face masks next to the bag.

In the Wind Station setup, the pan is placed inside a trash bag for protection. Plastic sheet protectors keep the handouts from getting sandy.

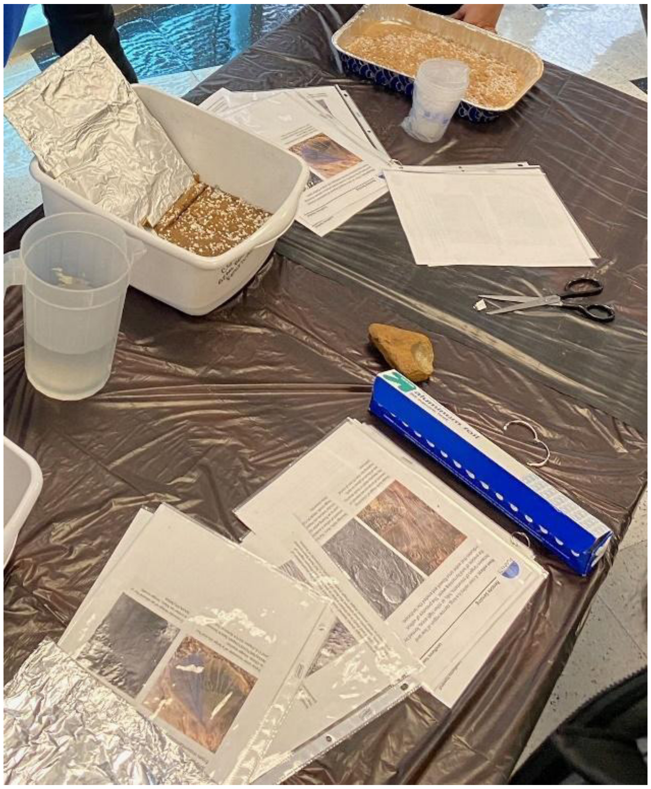
Water Station Assembly Instructions

Use these materials to set up the Water Station. Three setups are needed for a group of 24 learners. The Materials list at the start of this Activity has additional details.

Materials for each setup:

- Science Activity 2 Landforms Handout (PDF)
- 1 page protector
- pan or box
- 1 cup
- Mixture of 3 cups dry sand and 1 cup pebbles or gravel
- 1 drop cloth
- 1 jug
- 1 alluvial fan barrier
- water
- Science Activity 2 Water Station Directions Handout, pgs. 41-42

1. If learners are working inside, lay out the drop cloth underneath the work area to make water cleanup easier.
2. Place the pan or box on the drop cloth.
3. Fill the pan or box with the sand and pebble mixture.
4. Create the alluvial fan barrier. Cut a piece of cardboard the width of the pan. Cover it in aluminum foil. Add a 1" notch at the bottom to allow water to stream through the hole.
5. Put the *Landforms Handout* in the page protector and place it next to the pan of sand. Put the *Water Station Directions* nearby.
6. Set the cup and alluvial fan barrier next to the pan of sand.
7. Fill the jug with water and place it near the pan of sand.



In the Water Station setup, the table is covered with plastic to protect against spills. Two pans hold the gravel and sand mixture; an alluvial fan barrier is placed in one of them. Plastic cups are provided for pouring and a pitcher of water for refilling. Plastic sheet protectors keep the Landforms Handouts from getting wet.

A close-up view of the alluvial fan barrier. The one-inch notch allows water to flow through and create a fan-like shape in the sand. This barrier simulates what happens to water when it flows from a mountainous area where it can't spread out into a low-lying flat area where it can spread out.

Image of Mars

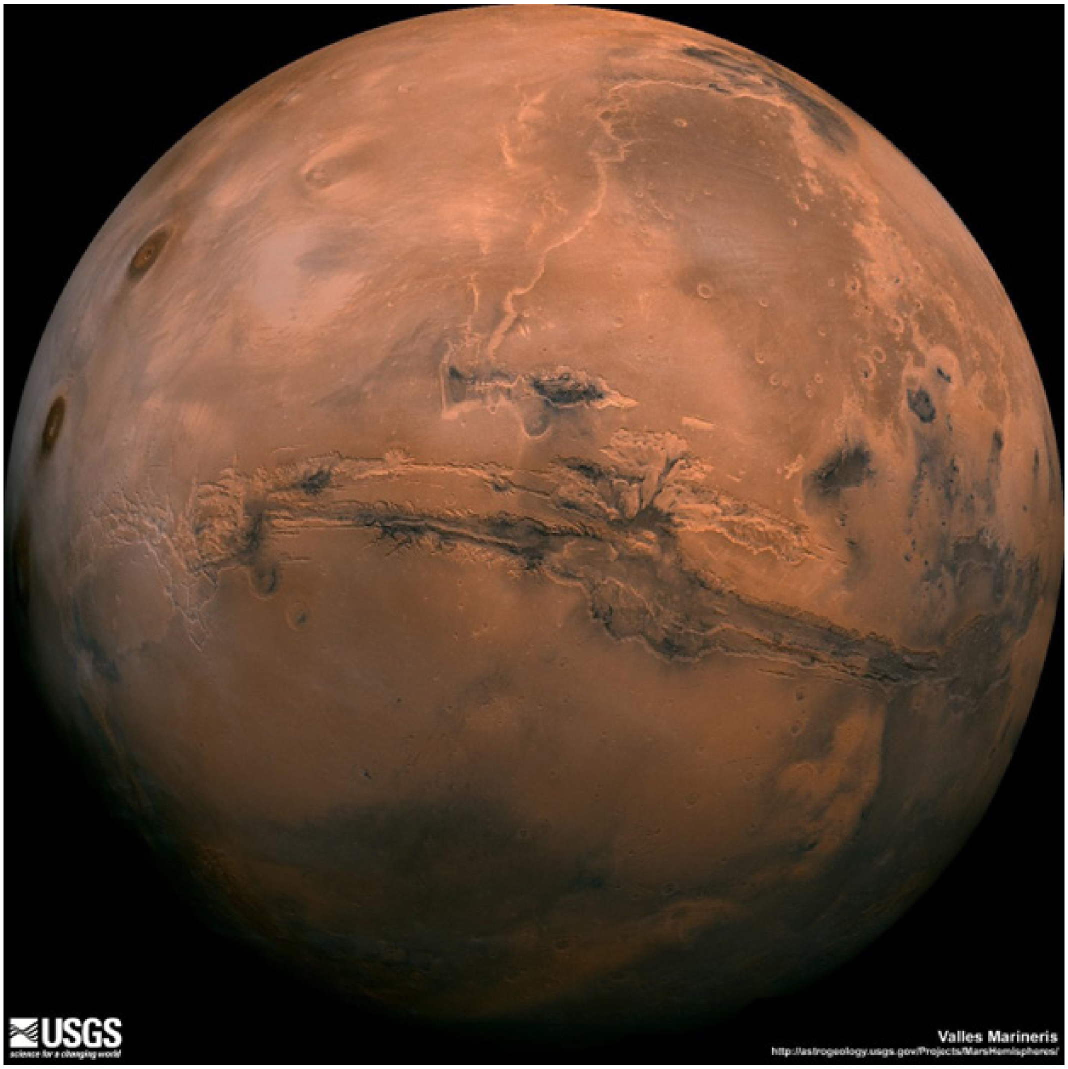


Image of Mars

Image of Mars in the Context of the Solar System

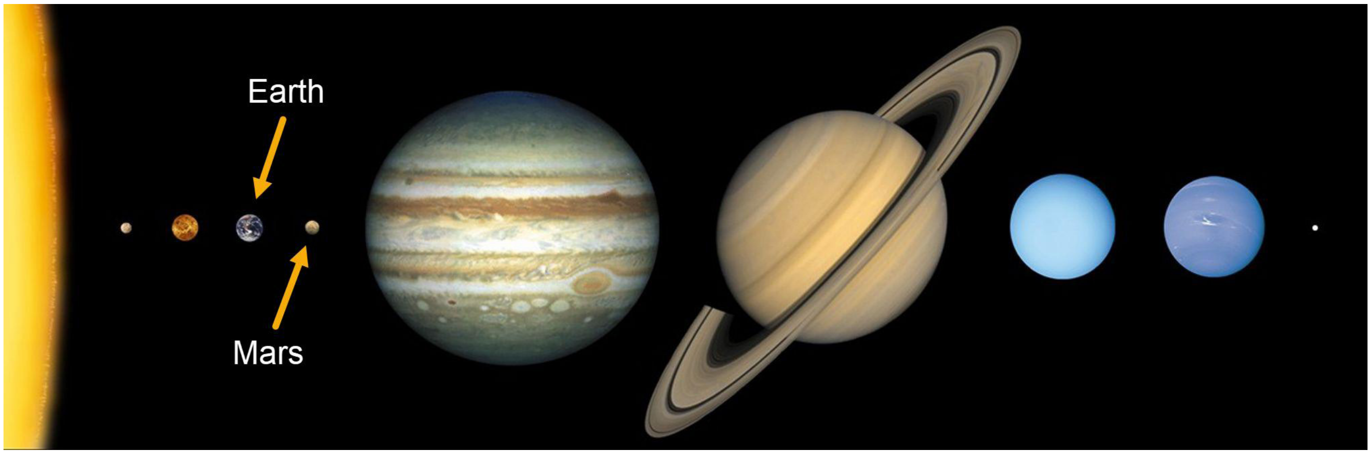
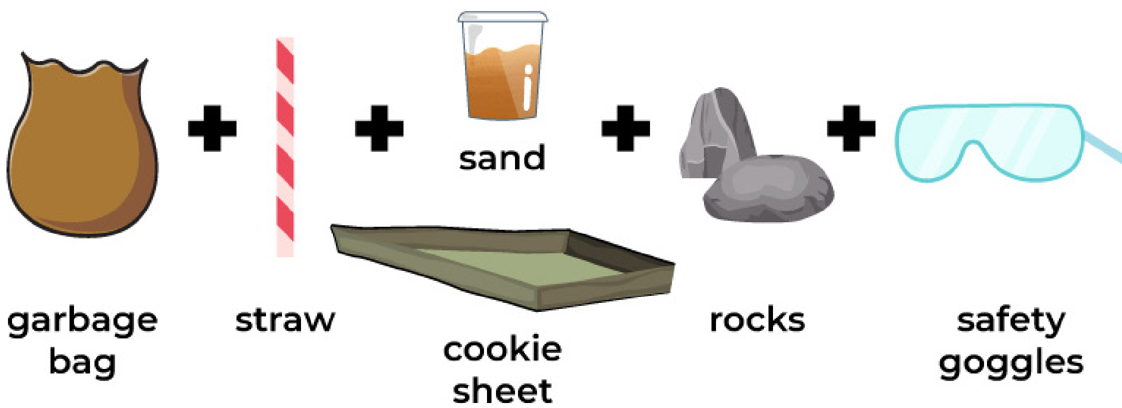


Image of Mars in the Context of the Solar System

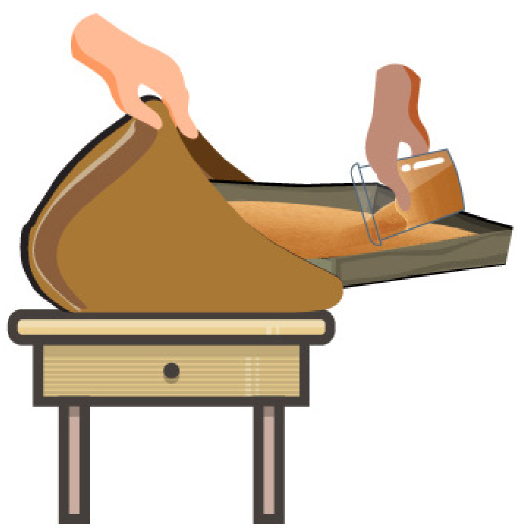
Wind Station Directions

Note: These instructions are also read aloud in a translatable online video.

1



2



3

1. Have one person hold the bag open. Have the others use straws to blow gently across the sand to form dunes, ripples, or other "landforms".

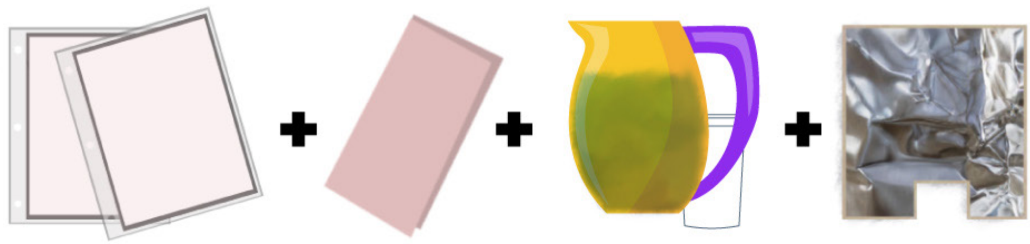
2. You can try placing large rocks as obstacles.

3. Examine the dunes you make.
   - How are your dunes like the dunes on the Landforms Handout? How are they different?
   - Where have you encountered landforms like these before?
   - What do you notice about the shapes of different landforms when you observe them from above?
   - What are the different ways that land is shaped by wind near communities you belong to?

Water Station Directions

Note: These instructions are also read aloud in a translatable online video.

1

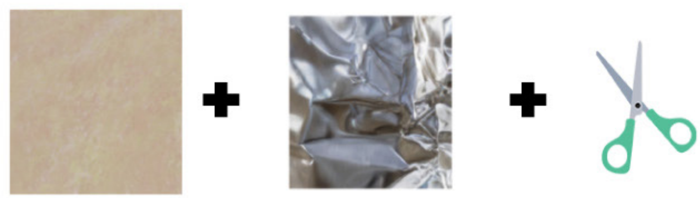


landform handout references in page protector + (1) drop cloth (if indoors) + pitcher of water & cup + (1) alluvial fan barrier*

pan or box + (3) cups dry sand & (1) cup pebbles or gravel, mixed + Water Station directions

***1**

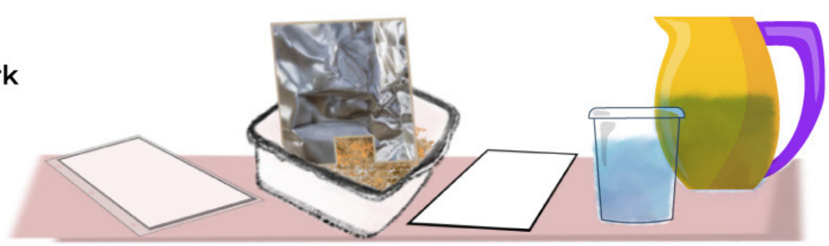
alluvial fan barrier =



cardboard + aluminum foil + scissors

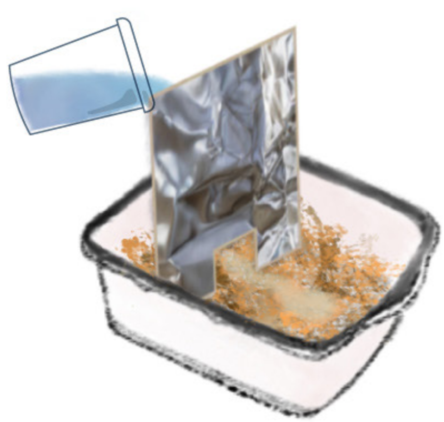
2

Set up work area



3

Try to make the same landforms as those in the Landforms handout



4. Try to make landforms from the *Landforms Handout* by pouring water into the sand. Pour from the cup and refill from the pitcher as needed.

5. To make a river valley, try tilting the container and slowly pouring water into it at the higher end in one location.

6. Explore tilting at different angles and to try to make different landforms. Make sure to tilt the container gently, so you do not spill the sand.

7. Try pouring water slowly in one spot on one side of a barrier and explore what happens to the sand.

8. Examine the landforms you make.
   - How are your landforms like the ones in the *Landforms Handout*? How are they different?
   - What do you notice about the shapes of different landforms when you observe them from above?
   - What are the different ways that landforms are shaped by water near communities you belong to?

Educator Guide

Science Activity 3: Red Planet Places: Exploring Landforms on Mars

Educator Preview

Activity Snapshot

Learners examine images of landforms on Mars to find evidence of past water.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Search for Evidence of Water	20 min.
Reflect	15 min.
Total	**45 min.**

Prep Snapshot*

Prep Time 60 min.

Print resources.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data

Guiding Question

How can landforms help us choose a landing site on Mars?

Learners Will Do

Recognize landforms on Mars that provide evidence of past water.

Learners Will Know

Scientists examine landforms to learn about the past history and climate of a location.

Connecting Across Activities

Activity 2: Introducing Landforms	Activity 3: Exploring Landforms on Mars	Activity 4: Introducing Topography
Last time, learners generated questions about Mars and explored how wind and water can make landforms on a planet's surface using models.	**Today**, learners act as scientists to examine images of landforms on Mars. These images are the first set of data they will use to choose a landing site.	**Next time**, they will deepen their understanding of landforms by considering topography.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/b0d49f31

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates

For each learner

- Science Notebook (PDF)

For each group of four

- 1 copy of Landforms Handout (PDF) from Science Activity 2
- 1 copy of Science Activity 3 Landforms on Mars Data Packet (PDF) (in color and in page protectors, if possible)
- 1 Landing Site Ovals Handout (PDF) (on transparency, if possible)
- 1 dry-erase marker, fine point (optional, if using page protectors)
- 1 piece felt or soft paper to erase marker (optional, if using page protectors)

Activity 3 Materials Preparation (60 min.)

Ahead of Time

1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Print one *Science Activity 3 Landforms on Mars Data Packet (PDF)* in color, if possible, for each group of 2–4 learners. Note: Data Packets are large 1–5MB PDF files and should be downloaded and printed ahead of time.
3. Print one copy of *Landing Site Ovals Handout (PDF)* on transparency or regular paper. Cut along the dotted lines to separate the ovals so there is one oval for each group of 2–4 learners. Cut around the oval to make individual ovals. Store in a bag or envelope for easy distribution.
4. Optional: Print the images in *Science Activity 3 Landforms on Mars Data Packet* on swell paper with these printable files (weblink).

In Your Space

5. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally. Add a section divided into two columns. Title one column “Gale Crater” and the other “Jezero Crater.”

Level Up!

Although this activity lists two possible landing sites, if you have time, the activity is more interesting and enriching with four choices that were all considered by NASA for the Perseverance Rover. If you are using the advanced version of this pathway with four possible landing sites, use the advanced version of the Science Activity 3 Landforms on Mars Data Packet with Level Up (PDF) and add columns titled “Nili Fossae” and “Iani Chaos” to the *Our Ideas* poster.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We generated questions about Mars, including what the landscape was like and if there was life and water there. We explored models of Earth to understand how landforms form from water and wind. We compared images of landforms on Earth to images of landforms on Mars.)* Draw learners' attention to the list of landforms on the *Our Ideas* poster.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**

Support Learner Differences

- If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).
- Have learners discuss their knowledge of local landforms and the ways that those landforms are connected to water.

Support Thinking

Share information about current Mars orbiters to support understanding of the process of data collection.

3. Say: **Today we will focus on answering questions about the landscape of Mars.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can landforms help us choose a landing site on Mars?**
4. Organize learners into groups of four and distribute Science Notebooks.

Search for Evidence of Water on Mars (20 min.)

5. Say: **Now that you have some experience with landforms, you are ready to explore real NASA Mars data to search for landforms that may have been created by liquid water to see if Mars was once able to support life, or *habitable*.**
6. Provide each small group with a *Science Activity 3 Landforms on Mars Data Packet.* Tell groups to write their group name on this packet, so they get the same packet back to refer to in future sessions. Say: **Scientists need pictures to study planets from a distance. Multiple NASA spacecraft are circling Mars, and they have cameras on them that take pictures, or images of the surface. These images are one type of data sent back from the spacecraft that you can now explore.**
7. Say: **You will study the data from two potential landing sites (Gale Crater and Jezero Crater). Then, you will choose a place on each possible site to land a rover.** Demonstrate as you point out the following:
   - The *Map of Mars* pgs. 2-3 and the explanation of each site on pgs. 4-15 in the Science Activity 3 Landforms on Mars Data Packet.
   - Each site has multiple images. Each set of images provides different information about each site.
   - Viking images are really zoomed out and have less detail.
   - Context Camera (CTX) and High-Resolution Imaging Science Experiment (HiRISE) images are of the same sites but are more zoomed in and provide more detail than the Viking images.

8. As they investigate, have learners fill out Landforms We Notice, pg. 6 in the Science Notebook (PDF).
9. Hold up a *Landing Site Oval* as you say: **Landing on Mars is difficult! Engineers can design a rover to land in an area 10 miles by 5 miles (16 km by 8 km), but they can't pinpoint the landing location any better than that. This oval represents the landing area. To stay safe on Mars, rovers drive slowly over short distances, so a scientifically interesting landing site should contain evidence of past liquid water within the oval or very nearby.**
10. Demonstrate as you say: **With your group, you will choose and trace scientifically interesting landing site ovals within the Gale Crater and Jezero Crater Context Camera (CTX) images** (point out the Context Camera (CTX) images in the packet)**. Do not trace ovals on the High Resolution Imaging Science Experiment (HiRISE) or Viking images because the size of those images isn't the same as the oval size** (point out where it says "Do not place an oval on this image")**.**
11. Pass out one *Landforms Handout* from Science Activity 2 and one *Landing Site Oval* to each small group. (If you are using page protectors, also hand out dry erase markers.). Provide time for groups to choose and trace landing site ovals within the Gale Crater and Jezero Crater Context Camera (CTX) images.

Support Thinking

Help learners think about how big the oval is by talking about local landmarks that are 5 miles (8 kilometers) and 10 miles (16 kilometers) away. It's a large area!

If learners ask why landing on Mars is difficult, you can tell them that Mars has an atmosphere that is thick enough to burn up a spacecraft without a heat shield, but not thick enough for a parachute to slow the spacecraft down enough to land safely. Mars is also far away from Earth, so the spacecraft must go through the whole landing process automatically: it takes too long for radio signals to travel between Earth and Mars for a human to land the spacecraft with a joystick.

Support Learner Differences

Allow learners to first use their preferred language to think about and describe their work before using and applying the vocabulary and definitions from this activity in English.

Teaching Tip

Suggest roles that group members can fill, such as organizing the data, searching for landforms, and tracing the oval.

Reflect (15 min.)

12. Invite groups to share the landforms at each site and note which provide evidence of past water. Record their ideas on the *Our Ideas* poster.

13. Revisit the Guiding Question on the *Our Ideas* poster. Ask: **How can landforms help us choose a landing site on Mars?** *(Alluvial fans, deltas, and river valleys all provide evidence of water. If these are present at a site, liquid water may have once been present at that site, so it might be a good landing site to find evidence of habitability.)* Ask: **What questions do you still/now have?** *(What other types of data–besides visual data–are available? What are the size and scale of the landforms?, etc.)*

14. Ask: **Which of the water-related landforms have you seen in your everyday life? Are there other water-related landforms that you can think of that were not discussed here? Why not?** *(Mud cracks and rounded stones are good indicators of water, but they are too small to be seen from orbit, etc.)* Consider returning to learners' ideas at the start of the next activity.

15. Say: **Good job working as scientists today! The visual data that was collected by the cameras engineers designed are essential, but it provides only some information. You will need other types of remotely sensed data to choose a landing site–you cannot rely on just one sense. Now you are prepared for next time, when you will explore a different type of remotely sensed data that can give you more details about the surface of Mars. The process you are following is like the process NASA uses to choose landing sites.**

Teaching Tip

Use the following key for reference, but do not share it with learners.

- Gale Crater contains a river valley, alluvial fan, layered rocks*, sand dunes, and craters.
- Jezero Crater contains a delta, river valley, lava flow, crater rim, and craters.

Alluvial fans, deltas, and river valleys are evidence of water.

*Layered rocks sometimes form in water, other times not.

Support Thinking

Encourage learners to keep an eye out for these same water-related landforms the next time they look at a natural landscape from above, such as in online maps or from an airplane.

Level Up!

Tell learners that the Viking landers had landing ellipses more than 100 km long, but improvements in science and engineering have shrunk the uncertainty of Mars landings down to within just a few kilometers. Future missions may be able to land with pinpoint accuracy.

Have learners find out more about the mission types NASA uses to gather information about a planetary body surface. For Mars, these include the remote sensing instruments Mars Reconnaissance Orbiter (MRO); High Resolution Imaging Science Experiment (HiRISE), Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), landers and rovers (Insight, Spirit, Opportunity, Curiosity), and sample return (Perseverance). On the Moon, the Apollo and Artemis missions included sample return referenced in the *NASA Career Spotlight for Aaron Yazzie*, pg. 16 in the Science Notebook (PDF). (10 min.)

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 4.
   - Collect the Science Notebooks, *Landforms Handouts* from Science Activity 2, *Science Activity 3 Landforms on Mars Data Packets*, and *Landing Site Ovals*.
2. Plan ahead for Science Activity 4. See Activity 4 Materials Preparation on pg. 52.
3. Take time to reflect on the following educator prompts: **How did you get learners engaged in data analysis? How could you use similar strategies during future activities?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Educator Guide

Science Activity 4: Shape Up: Introducing Topography

Educator Preview

Activity Snapshot

Learners build three-dimensional models of topographic maps and then turn them into two-dimensional maps.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Build Topographic Models	25 min.
Reflect	10 min.
Total	**45 min.**

Prep Snapshot*

Prep Time 30 min.

Print resources.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data
- Planning Investigations

Guiding Question

How can maps help us understand a planet's landscape?

Learners Will Do

Interpret topographic maps to identify flat areas and landforms.

Learners Will Know

A topographic map represents the three-dimensional shape of land in an area in two dimensions.

Connecting Across Activities

Activity 3: Landforms on Mars	Activity 4: Introducing Topography	Activity 5: Exploring Topography on Mars
Last time, learners acted as scientists to examine images of landforms on Mars. These images are the first set of data they will use to choose a landing site.	**Today**, they deepen their understanding of landforms by considering topography.	**Next time**, they will interpret Mars topographic maps. These maps are the second set of data they will use to choose a landing site.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/43551cda

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates

For each group of four

- Science Activity 4 Topography Template Handout, pg. 60
- 1 sheet of foam, craft (or cardboard)
- scissors
- tape, masking
- glue sticks (optional)
- writing utensils (pencils or crayons), colored, in gradually darker, but non-adjacent shades of yellow, green, and blue if possible
- Resealable bag or paper clip (optional)
- Science Activity 4 Grand Canyon Topographic Map Handout pg. 61 or local topographic map
- Science Activity 4 Grand Canyon Aerial Photo Handout pg. 62 or local aerial photo
- Optional: Print the image in *Science Activity 4 Grand Canyon Topographic Map* on swell paper (weblink).

Support Learner Differences

Consider providing the cut foam pieces instead of having learners cut them using the Science Activity 4 Topography Template Handout, pg. 60.

Some learners may have color blindness to certain color combinations. Allow them to choose colors that work best for them and suggest adding different patterns on each layer to add extra contrast.

Activity 4 Materials Preparation (10 min.)

Ahead of Time

1. Review the *Our Ideas* poster in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.

2. Make copies of the *Science Activity 4 Topography Template Handout*, pg. 60 for each group of four.

3. Make a sample topography model using the directions on the *Science Activity 4 Topography Template Handout*.

4. Obtain or download topographic maps and aerial images of your local area if you are using this option. You will need Adobe Reader or comparable PDF viewing software to use the option below.
   a. To find a topographic map of your local area, use the USGS TopoView website. Search for your location in the search field in the upper right.
   b. Once you have found your location, narrow down the list of available maps by adjusting the Date slider in the upper right to only show recent years.
   c. Select a map from the list and click the "Show" icon to show it on the main map. If this looks like it covers the correct area, download a GeoPDF file of the map.
   d. Open the GeoPDF Adobe Acrobat Reader* (not online). There is a lot of information in the PDF, but if it's too cluttered, you can turn some of it off. When you open the PDF in Adobe Acrobat, you should see a list of "layers" on the left. If you don't see this, go to View > Show/Hide > Side Panels/ Navigation Panes > Layers
   e. For the simplest possible topographic map, you can turn off all layers except for "Contour Features." However, you may find it useful to keep some other layers turned on, such as "Transportation" (to see roads) or "Geographic Names" (to see landmarks).
   f. You may also choose to zoom in on the map to see details more clearly.
   g. To see a satellite view/aerial photo of the map area, turn on the Images layer in the PDF and turn off contours.

   *To *save* the image or the map displaying only the layers you choose, you will need Adobe Acrobat. Export to an image.

5. Print one *Science Activity 4 Grand Canyon Topographic Map Handout, pg. 61* and *Science Activity 4 Grand Canyon Aerial Photo Handout, pg. 62*–or local area maps–per group of four learners.

In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Support Thinking

We suggest you start this activity by going outside and exploring the local terrain. Choose an area with some noticeable elevation changes, if possible.

A topographic map of the Grand Canyon is provided in case you live in a very flat area; however, we highly recommend you download a topographic map and aerial images of an area that is familiar to learners from TopoView. These resources are especially important if you are unable to go outside.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We examined images of Mars to identify water-based landforms. We chose which landing site would be most interesting to send a rover to.*) Invite learners who were present to share findings from the *Our Ideas* poster and their notebooks.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**

Support Learner Differences

- If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).
- If you have learners who speak multiple languages, encourage them to form answers with each other in their preferred languages first, then share answers in the language of the whole group.

3. Say: **Today we will focus on choosing a safe landing site.** On the *Our Ideas* poster, focus on the questions about how safe and easy it is to land a rover on Mars. If there are no questions in this category, ask: **What else might we need to know about the landforms or the rover?** *(The size and height of the landforms, the materials they are made from, space the rover needs, etc.)* Invite learners to add additional questions.
4. Share the Guiding Question with learners, aloud and in writing, or share a similar question from the *Our Ideas* poster. Guiding Question: **How can maps help us understand a planet's landscape?** Say: **You will get to explore real maps of Mars later, but first you will make models to understand how maps can show the height of the land. Then it will be easier for you to understand the Mars maps.**
5. Organize learners into groups of four.

Teaching Tip

Learners may not have asked about topography directly, but they may have asked related questions. For example, to answer the question "Where can a rover land?", they will need to know the topography of the landing sites.

Build Topographic Models (25 min.)

6. Hold up your sample topography model as you say: **Today we will create a model of a hill using foam pieces to represent the different heights of the hill.** As needed, allow learners to feel the sample model.

7. Hold up the *Science Activity 4 Topography Template Handout, pg. 60* and demonstrate as you say: **You will get a paper template to create your model. The largest shape on the template represents the lowest spot on the hill. It will be the bottom layer. Each of the other shapes are slightly smaller and represent a slightly higher part of the hill. First, you will decide how to color each shape so you have darkest (shape 1, blue) to lightest (shape 7, yellow). Then, you will cut out the shapes.**

8. Provide each group with one copy of the *Science Activity 4 Topography Template Handout, pg. 60*, scissors, and colored writing utensils. Allow them 5 minutes to color and cut out the shapes.

9. When groups are ready, demonstrate as you say: **Next, trace the paper shapes onto one sheet of craft foam (or cardboard) and cut out the pieces. You only get one piece, so you have to plan carefully. Save these paper pieces–we will use them later. Then tape your craft-foam (or cardboard) shapes together using tape loops on the back of each shape. Begin with the largest shape and attach the next smallest shape to it, and then the next smallest, so that each shape is fully within the boundary of the one below it.**

Support Thinking

If time and weather permit, go outside and travel with learners across areas of varying height and slope. Ask: **What do you notice about the height of the land as we travel?** *(It is going up or down; it is steep, not steep, or flat; it is difficult or easy to travel on; or it is a landform such as a valley or hill, etc.)* **Where would be the best place to have a picnic or play a game of soccer? Why? When would it be good to know ahead of time if the land is steep or not? Why?** *(Before traveling across the land so we know how difficult it will be and if we need special equipment to help us, etc.)*

If your environment allows, have learners spread out to areas of different heights. Have learners observe each other spatially and ask: **How could we record these changes in height on a map?** *(Using color, texture, measurement numbers, lines to represent different heights, etc.)*

Support Learner Differences

Encourage learners to use patterns or textures instead of colors to indicate the different layers if they find that more useful or accessible.

Teaching Tip

Groups can cut the paper template in half or thirds, leaving one to four shapes on each section so multiple learners can color at once and then cut out the detailed shapes. This can be repeated with the cutting of foam.

10. Provide one piece of craft foam or cardboard, a roll tape and/or a glue stick per group and provide 5 minutes to create the models.
11. Say: **Now you have a three-dimensional model of the shape of a hill. If we combine our models, we can make a three-dimensional model of the land.** If time, invite learners to combine their models, leaving room in between to represent flat areas. As needed, give learners time to feel the combined model. Say: **The shape of the land in an area is called that area's topography**. Write the word *topography* on the *Our Ideas* poster.

Teaching Tip

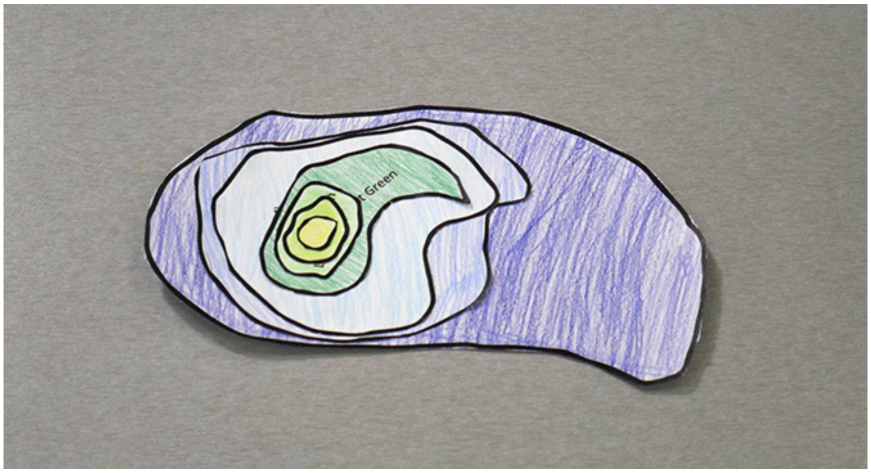
Provide each group with a bag or a paper clip to keep their cut paper template pieces together.

Using loops of tape between layers and not pressing layers down helps to increase the height of the topographic models.

Support Learner Differences

As needed, provide groups with a tub or other container to hold their materials, which is especially helpful for blind learners.

12. Say: **Because it's not easy to carry around three-dimensional models of places, we rely on flat, two-dimensional maps.** Demonstrate as you say: **Make a map from the paper pieces you saved. Tape or glue the layers of the paper templates in the same way as the foam pieces, then trace the outline of each layer so you can see the lines.** Provide 5 minutes for learners to construct their maps.

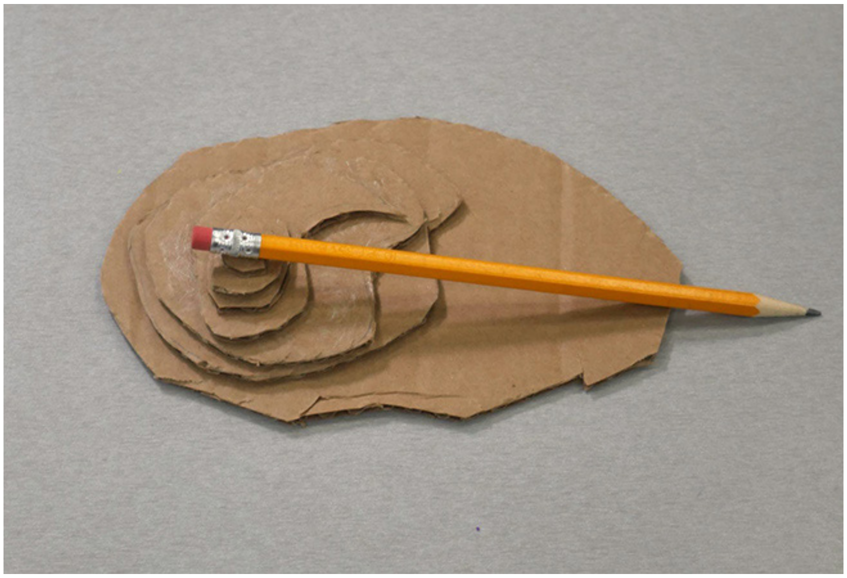


Topography template pieces combine to make a two-dimensional topographic map

13. While learners are working, help them understand their maps. Ask: **Because these layers are all flat, how can you tell which layer stands for the highest area and which stands for the lowest?** *(The lightest color layer is the highest area, and the darkest color is the lowest.)* **What does each line represent?** *(Each line represents land at the same height.)* **What does it mean when the lines are close together? When they are far apart?** *(Where there are a lot of lines close together, the slope is very steep. When the lines are far apart, it is not as steep.)* **Are there areas around here that have topography similar to what is represented by this map?** *(Local steep areas, such as hillsides and cliffs, could be represented by areas of the map where the lines are close together. Local flat areas, such as fields and plains, could be represented by areas on the map where the lines are far apart.)*

14. After learners have made their maps, say: **The lines on your map trace places that are all the same height. If you walked one of these lines on the ground, you would never go up- or downhill. The different lines on your maps show different heights. Because the maps show topography, these maps are called *topographic maps*. You just created topographic maps.** Write the term *topographic map* on the *Our Ideas* poster.

15. Provide each group with a pencil. Use hand gestures to indicate changes as you say: **Place the pencil on different parts of your foam/cardboard model. Using the information from the map, decide whether your pencil would be flat or tilted if it was really in this location.** *(It would be tilted if it is sitting across lines and level/flat if it is not sitting across any lines.)* Give them a few minutes to test their models. As they work, ask: **If you want your pencil to be stable and not tilt, where should you place it? Why?** *(You should place the oval/pencil on a single layer because it doesn't tilt there. If it is on multiple layers, it tilts.)*



The best landing site will tilt the pencil the least.

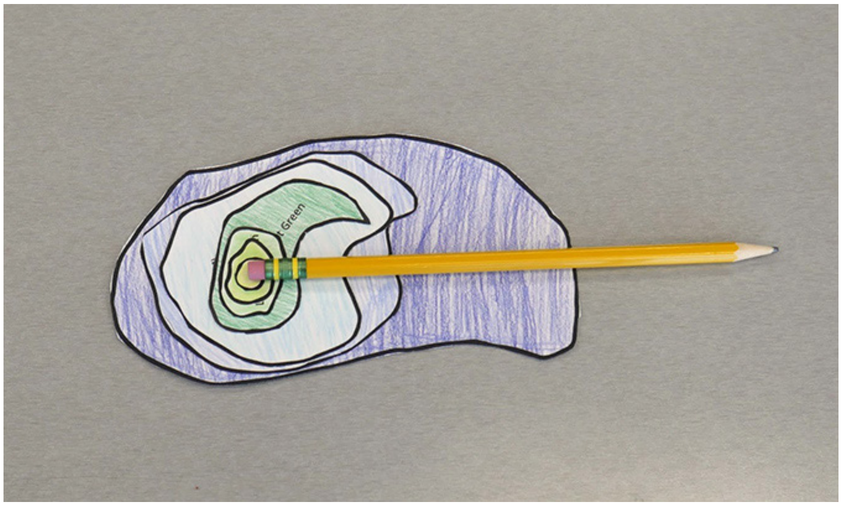
Support Thinking

To support understanding of the word *topographic*, tell learners that it comes from the roots topo, meaning "place," and graph, meaning "to write or draw." Have learners think of other words they know that come from similar roots, such as utopia (a good or nonexistent place), dystopia (a bad place), graph (a drawing of data), graphite (a soft mineral that leaves a gray streak, used to make pencil "lead"), and bolígrafo (Spanish for pen).

Allow learners to share stories about any previous experiences with topographic maps, such as when hiking or using depth finders for fishing. You can also prompt learners to consider the topography of indoor spaces, such as the height and arrangement of different items in a room.

The pencil is a way to measure the average slope across the area that it spans. Encourage learners to notice where the lines on the 3D model appear closer together. Ensure learners understand that lines that are closer together indicate steeper slopes.

16. Say: **Now place the pencil on different parts of your paper model. Using the information from the map, decide whether your pencil will be flat or tilted in different locations.** Give them a few minutes to test their models. As they work, ask: **If you want your pencil to be stable and not tilt, where should you place it? Why?** *(You should place the pencil on a single layer because it doesn't tilt there. If it is on multiple layers, it tilts.)*



The best landing site will tilt the oval or pencil the least.

17. Provide each group with a *Science Activity 4 Grand Canyon Topographic Map Handout, pg. 61,* and *Science Activity 4 Grand Canyon Aerial Photo Handout, pg. 62,* or the local topographic map and aerial photo. Provide 5 minutes for them to compare their topographic models to the topographic map and aerial photo. Ask questions such as: **Where is the steepest area?** *(Where the lines are closest together).* **Where would you want to play soccer and why?** *(The flattest area.)*

Reflect (10 min.)

1. Revisit the Guiding Question on the *Our Ideas* poster. Ask: **How can maps help us understand a planet's landscape?** *(They show the shape of land in an area. We can see how steep an area is by looking at the lines. If the lines are close together, the landscape is steep.)* Remind learners of the terms *topography* and *topographic map*.
2. Ask: **How might topographic maps help us choose a landing site?** *(They show the shape of landforms. Scientists can think about how much water might have been involved in the formation of the landforms. They also help choose a safe place to land.)*
3. Ask: **When might someone use a topographic map?** *(Prior to construction, farming, hiking, etc.)*
4. Ask: **What questions do you still/now have?** *(What other types of data–besides visual and topographic data–are available? What are the landforms made of?, etc.)*
5. Say: **Good job working as scientists today! Now you are prepared for next time, when you will explore topographic maps of each of the potential landing sites. Remember, the process you are following is like the process NASA uses to choose landing sites.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 5.
   - Collect the topographic maps. Save them for reference in future activities or display at the Share-Out.
2. Plan ahead for Science Activity 5. See Activity 5 Materials Preparation on pg. 64.
3. Take time to reflect on the following educator prompt: **How did you help learners understand the concept of a topographic map? How could you use similar strategies during future activities?**

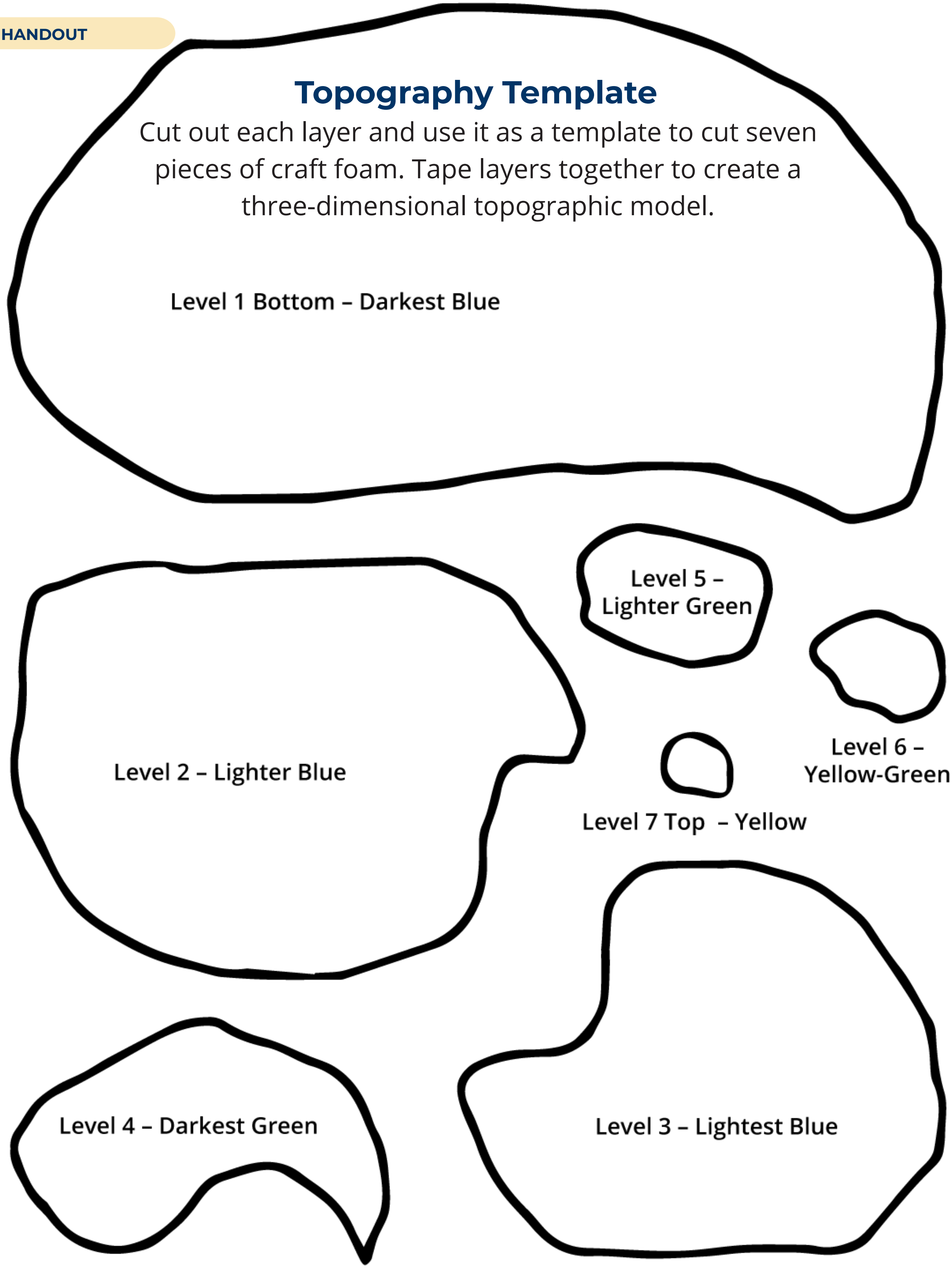
Remote Sensing Additional Resources

QR code leads to resources available for this unit.

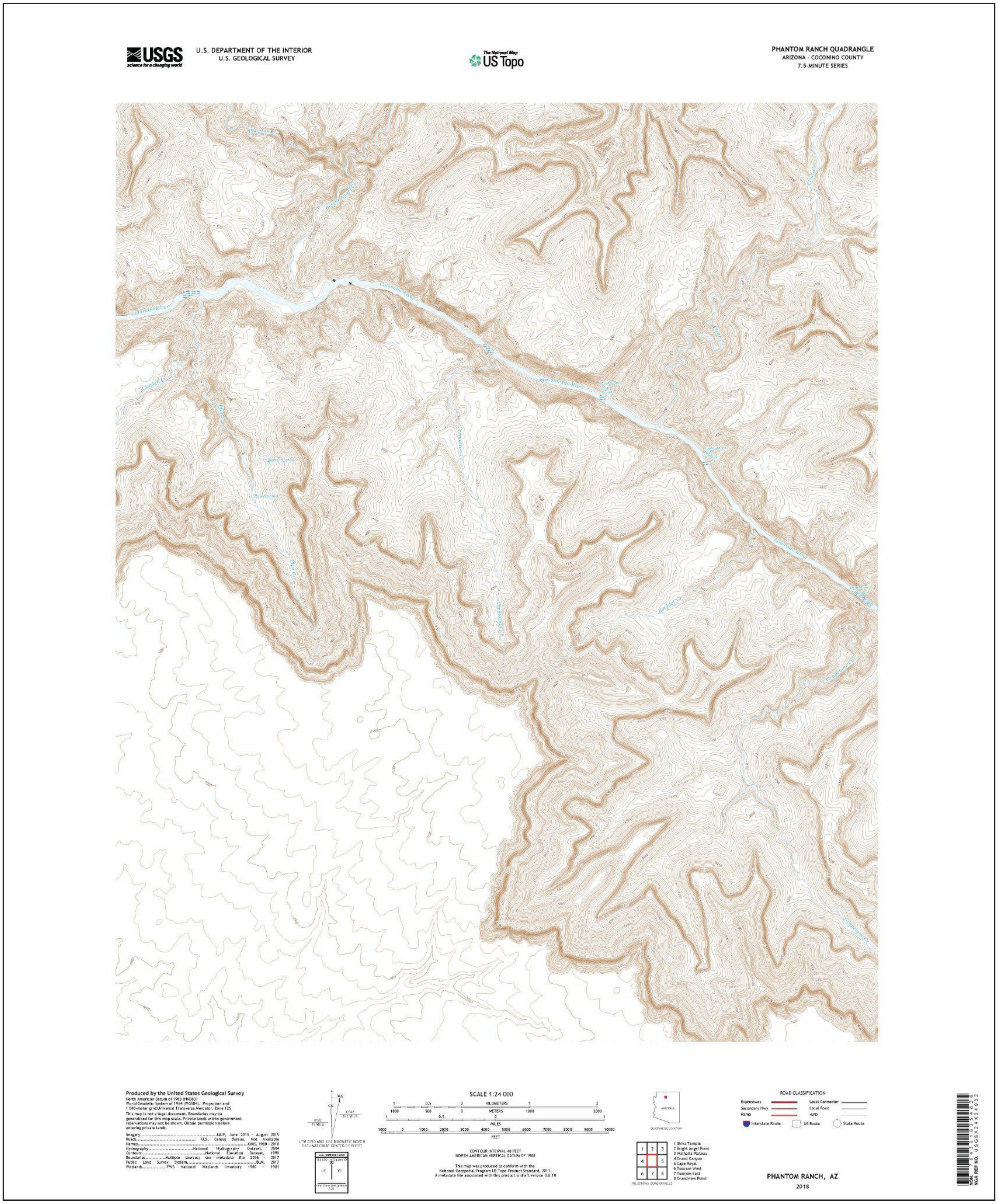
weblink: https://hov.to/248cf0d9

Topography Template

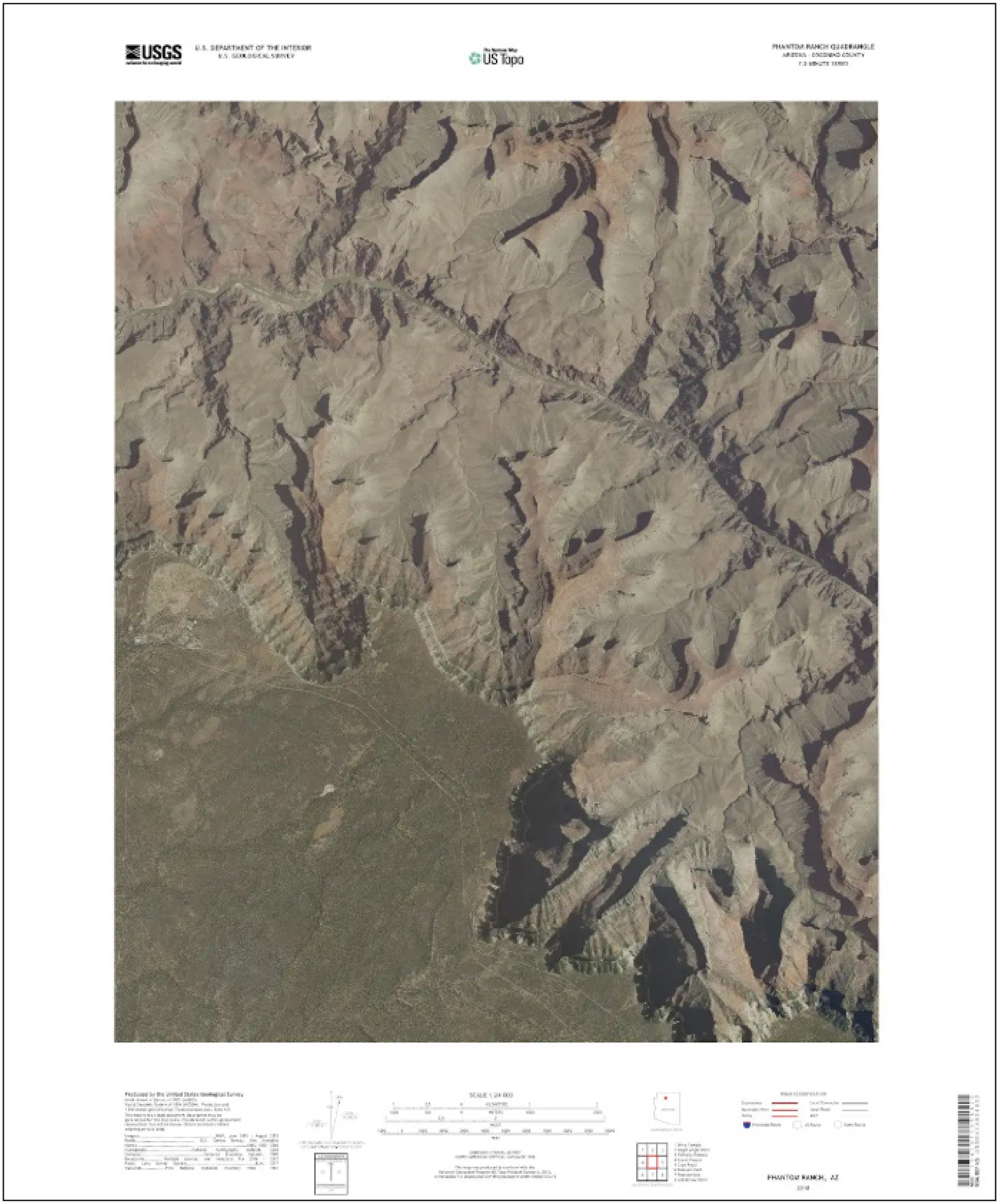
Cut out each layer and use it as a template to cut seven pieces of craft foam. Tape layers together to create a three-dimensional topographic model.



Grand Canyon Topographic Map



Grand Canyon Aerial Photo



Educator Guide

Science Activity 5: Cliffs and Craters: Exploring Topography on Mars

Educator Preview

Activity Snapshot

Learners interpret topographic maps of Mars to identify safe and interesting landing sites.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Analyze Landing Sites	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–45 min. each

Prep Snapshot*

Prep Time **30 min.**

Print resources for the Activity.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data
- Planning Investigations

Guiding Question

How can topographic maps help us choose a safe and interesting landing site on Mars?

Learners Will Do

Interpret topographic maps of Mars to identify flat areas and landforms.

Learners Will Know

Scientists use topographic maps to make decisions.

Connecting Across Activities

Activity 4: Introducing Topography	Activity 5: Exploring Topography on Mars	Activity 6: Introducing Spectroscopy
Last time, learners deepened their under-standing of landforms by considering topography.	**Today**, learners interpret topographic maps of Mars to locate interesting landforms and to determine the safest place for a rover to land. These maps are the second set of data they will use to choose a landing site.	**Next time**, they will learn how to interpret spectra of light reflected from various objects, which will later help them identify minerals from a distance.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/175aa080

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
- Play Doh or clay (optional)

For each learner

- Science Notebook (PDF)

For each group of four

- Science Activity 3 Landforms on Mars Data Packet (PDF)
- Science Activity 5 Mars Landing Site Topography Data Packet (PDF) (in page protectors, if possible)
- 1 Landing Site Oval (PDF) from Science Activity 3
- 1 dry-erase marker, fine point (optional, if using page protectors)

Activity 5 Materials Preparation (10 min.)

Ahead of Time

1. Review the *Our Ideas* poster *"In-Use Example"* in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Make copies of Science Activity 5 Mars Landing Site Topography Data Packet (PDF) for each group of four. Note: Data Packets are large files and should be downloaded and printed ahead of time. Consider laminating the pages of *Science Activity 5 Mars Landing Site Topography Data Packet* or placing them into plastic page protectors to prevent them from getting damaged.
3. Optional: Print the images in *Science Activity 5 Mars Landing Site Topography Data Packet* on swell paper with these printable files (weblink).

4. Optional: Create a clay model of each of the landing sites in Science Activity 5 Mars Landing Site Topography Data Packet (PDF) to provide a tactile version of the data. The models can be estimations based on the color changes; they do not need to follow the lines exactly.

An example tactile clay model of Gale Crater

In Your Space

5. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally. Add a section divided into two columns. Title one column “Gale Crater” and the other “Jezero Crater.”

Level Up!

If you are using the advanced version of this pathway with four possible landing sites, use the advanced version of the Science Activity 5 Mars Landing Site Topography Data Packet with Level Up (PDF) and add columns titled “Nili Fossae” and “Iani Chaos” to the *Our Ideas* poster.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We built 3D models of topography and turned them into 2D maps. We learned how to interpret topographic maps*). Indicate the information about topography on the *Our Ideas* poster.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**
3. Say: **Today, we'll continue to focus on choosing a safe landing site.** Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can topographic maps help us choose a safe and interesting landing site on Mars?**
4. Organize learners into groups of four and distribute Science Notebooks.

Analyze Mars Landing Sites (25 min.)

5. Say: **Now that you understand how to read a topographic map, you are ready to explore topographic maps of Mars. To help scientists study the topography of Mars, engineers developed an instrument that gathers information about the size and height of landforms by bouncing a laser off them and measuring how long it takes the light to come back. By measuring the height of millions of different points on the surface using this laser, scientists know the topography of the entire surface of Mars.The technology is called *Li*ght *D*etection *a*nd *R*anging, or LiDAR.** Record the term *LiDAR* on the *Our Ideas* poster.
6. Provide a *Science Activity 3 Landforms On Mars Data Packet* and a *Science Activity 5 Mars Landing Site Topography Data Packet* to each group. Demonstrate as you say: **Examine the topography data packet and compare it to the landforms data packet**. After a few minutes, ask questions to ensure learners notice the following:
   - These topographic maps show the same area of interest as the Context Camera images for each of the landing sites they explored earlier.
   - The colors match the color scale on the topographic maps they made in Activity 4 (if they followed the suggested key).

Support Thinking

To help learners understand LiDAR, show the videos Using Light to Measure Distance (LiDAR Theory) and Using Light to Map Surfaces (LiDAR Uses).

Level Up!

Although this activity lists two possible landing sites, if you have time, the activity is more interesting and enriching with four choices. If you choose this option, make sure to reference the two additional options as you go.

7. Say: **Turn to *Jezero Crater: Topography, pg. 5,* in the *Science Activity 5 Mars Landing Site Topography Data Packet*. What do you think the color scale, or the difference in color and shading, means?** *(The colors represent height. Yellow represents high areas and blue represents low areas. [If printed in grayscale, brighter represents high areas and darker represents low areas.] The color scale shows the direction of the slope.)* **What do you think the lines mean?** *(As on the topographic maps earlier, each line represents a particular height.)*

Level Up!

The Engineering Pathway, [Worlds Apart: Engineering Remote Sensing Devices (PDF)], goes into detail on how LiDAR works and challenges learners to engineer a model LiDAR device to capture the topography of a surface.

8. Say: **Your task is to determine the safest and most interesting areas to land a rover. Examine the data to understand the topography of each location. Remember, your goal is to find evidence of past liquid water, to see if Mars was once habitable, so you will need to use your data about landforms from the *Our Ideas* poster as well.**

9. As groups investigate, ensure they are interpreting the data correctly. Indicate different parts of the crater. Ask: **How steep is this area?** *(Where lines are close together and color varies quickly, the slope is steep, such as on a mountain. Where lines are far apart and color varies slowly, the slope is shallower, such as on a field.)* **What makes a good landing site, and which areas of the map are good landing sites?** *(A safe landing site should be in a flat area. Interesting landing sites include landforms that may have formed in water.)*

10. As they investigate, have learners fill out *Topography We Notice, pg. 7,* in the Science Notebook.

11. Have groups share their observations of the topography of each site with the whole group and record them on the *Our Ideas* poster.

12. Pass out a *Landing Site Oval* from Science Activity 3 and a dry erase marker, if you are using page protectors, to each small group. Say: **A safe landing site should be as flat as possible, while a scientifically interesting landing site should be on or near landforms that indicate past water. At each of the possible landing sites in the data packet, trace one oval showing where you think it might be safe and scientifically interesting to land.**

Level Up!

Tell learners that scientists often like to explore areas with steep slopes or rugged topography, where layers of rock might be exposed. Have them think about why these areas are interesting. (5 min.)

Reflect (10 min.)

13. Ask: **Did your choice of landing site change when you got topographic maps? How or why?** *(We rated flat areas that are safe to land more highly than before, etc.)*

14. Revisit the Guiding Question on the *Our Ideas* poster**.** Ask: **How did topographic maps help us choose a safe and interesting landing site on Mars?** *(They helped us locate a safe, flat landing site near interesting landforms.)* Remind learners of the term *LiDAR*.

15. Ask: **When might it be important to find a flat location on Earth?** (*Pitching a tent, playing soccer, constructing a building, etc.*) Consider returning to learners' ideas at the start of the next activity.

16. Say: **Good job working as scientists today! Next time, you will explore a different type of remotely sensed data that relies on light. These data will help you answer questions about what Mars is made of. The process you are following is similar to the process NASA uses to choose landing sites.**

Support Learner Differences / Level Up!

Invite a family or community member to come in as a special guest and share their knowledge about topography-related topics. See the flyers and ideas on the Remote Sensing Family and Community Connections (weblink) (45 min.)

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 6.
   - Collect the Science Notebooks, *Science Activity 3 Mars Landforms Data Packets, Science Activity 5 Mars Landing Site Topography Data Packets,* and *Landing Site Ovals* from Science Activity 3.

2. Plan ahead for Science Activity 6. See Activity 6 Materials Preparation on pg. 70. The tactile graphs will take time to dry.

3. Take time to reflect on the following educator prompt: **How did you help learners apply what they learned about topographic maps in the previous activity?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Educator Guide

Science Activity 6: Beyond the Rainbow: Introducing Spectroscopy

Educator Preview

Activity Snapshot

Learners interpret the spectra of reflected light from various objects.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Introduce Spectroscopy	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time 50 min.

At least two days ahead, create tactile spectra graphs and allow them to dry.

Determine how learners will access audio files.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practice

- Analyzing & Interpreting Data

Guiding Question

How can measuring reflected light help us identify different materials?

Learners Will Do

Interpret spectra to identify different materials.

Learners Will Know

Spectroscopy measures how much light of different colors (both visible and invisible) is coming from a material.

Connecting Across Activities

Activity 5: Topography on Mars	Activity 6: Introducing Spectroscopy	Activity 7: Using Spectroscopy to Understand Mars
Last time, learners interpreted topographic maps of Mars to locate interesting landforms and to determine the safest place for a rover to land. These maps are the second set of data they will use to choose a landing site.	**Today**, learners learn how to interpret spectra of light from various objects, which will later help them identify minerals from a distance.	**Next time**, they will interpret spectra to identify minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/d728601d

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF)
  Examples | Templates
- Assorted rocks and minerals, small, such as gravel mixture
- Science Activity 6 Audio Files (weblink)
- Audio player and speaker
- School glue or puff paint (optional)
- Sand or glitter (optional)
- Computer with internet access (optional)

Optional: Printed swell paper (webblink) or assembled tactile models, enough for half the groups:

- 3 copies of tactile model of *Electromagnetic Spectrum*, pg. 8 in the Science Notebook (PDF)
- 3 copies of tactile model of *Green Paint*, pg. 9 in the Science Notebook (PDF)
- 3 copies of tactile model of *Red Paint*, pg. 10 in the Science Notebook (PDF)
- 3 copies of tactile model of *Olivine*, pg. 11 in the Science Notebook (PDF)

For each learner

- Science Notebook (PDF)

Activity 6 Materials Preparation (60 min., at least two days ahead of time)

Ahead of Time

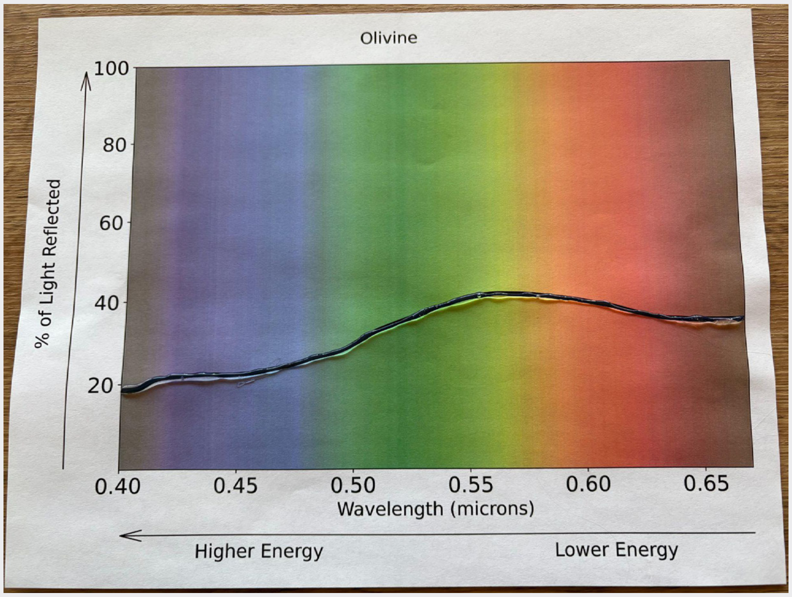
1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Determine how you will share the audio files on the day of the activity with the whole group. You have the option to download the audio files or access audio files online (weblink).

Support Learner Differences

Although it is listed as optional, all learners will benefit from interacting with a tactile version of the spectra, and it will make for a more enriching experience. Learners trace the reflectance lines with their fingers as they listen to the audio files, making them active participants versus passive listeners. This will strengthen their connection to understanding the changes in the light that comes from the materials.

Print these on swell paper with Braille at this weblink or prepare a tactile model by adding a line of glue or puff paint to the data line, to each of the axes, and on either side of the visible spectrum of *Electromagnetic Spectrum, Red Paint, Green Paint,* and *Olivine*, pgs. 8-11 in the Science Notebook (PDF). Ensure you have a space to let the graphs dry.

Consider sprinkling the glue with a bit of fine sand or glitter to add additional texture (see photo below). Make enough for half the learners in your program to access the tactile graphs at once.



A tactile version of the visible portion of olivine's spectrum

Teaching Tip

If you are planning to make the tactile graphs, consider also preparing the tactile graphs for Activity 7 at the same time. See Activity 7 Materials Preparation, pg. 80.

In Your Space

3. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We interpreted topographic data to find interesting landforms and to determine the safety of each landing site*). Draw learners' attention to their findings about landforms and topography on the *Our Ideas* poster.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**
3. Say: **Today we'll focus on what Mars is made of to determine whether water was once there.** Refer to the questions on the *Our Ideas* poster about what the planet is made of, what rocks and minerals are present, and the presence of past water needed for life. If learners do not mention water, ask them what types of things NASA is interested in learning about Mars and why. It is important they focus on water for the rest of the activity. Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can measuring reflected light help us identify different materials?**
4. Organize learners into groups of four and distribute Science Notebooks.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

Teaching Tip

Learners may not have asked questions about minerals directly, but they may have asked related questions. For example, "Was there life on Mars?" can be answered by looking for minerals that form in water. Reinforce the connection between evidence for past water on Mars and the possibility of past life.

Introduce Spectroscopy (25 min.)

5. Give each group some rocks and minerals to examine for several minutes. Write the word *minerals* on the *Our Ideas* poster. Say: **There are not any plants on Mars, but there are a lot of rocks and minerals. Where have you heard the word *mineral*?** *(Precious minerals, minerals in our diet, etc.)* **What do you already know about minerals?** *(Minerals occur naturally and form crystals, including quartz, salt, and diamond.)* Have learners discuss in groups and add their answers to the *Our Ideas* poster.
6. Say: **Each kind of mineral forms in a certain way. Some minerals form only in water, so knowing which minerals are at each landing site can help us understand whether that site once had water.** Ask: **How might we figure out what kinds of rocks and minerals these are?** *(Weighing them, shining light on them, showing them to someone, etc.)*

Teaching Tip

Learners may know the terms *hardness*, *crystal structure*, *luster*, and *streak*, but it is not important to introduce these terms. Focus on the ways someone can collect evidence if they physically have a mineral.

7. Say: **Because we cannot touch the surface of Mars, we cannot use most of the ways scientists identify minerals on Earth. We must rely on cameras and other technologies on spacecraft orbiting Mars and on rovers on the surface. One useful way to learn about the world remotely is through color. That's why humans and many animals have color vision. Let's explore this idea a bit, before we come back to identifying minerals.**

8. Invite learners to review the colors marked "visible spectrum" on *Electromagnetic Spectrum*, pg. 8 in their Science Notebooks. Say: **This diagram describes all types of light, visible and invisible, in a range of colors, or a spectrum.** Write the word *spectrum* on the *Our Ideas* poster. Say: **Notice that the part marked "visible spectrum" is only a small portion of the diagram. Most light cannot be seen by human eyes.** Ask: **What does this visible spectrum remind you of?** *(It looks like a rainbow).* **What do you know about rainbows?** *(They come out after rainstorms and when light passes through prisms.)*

9. Say: **When humans see a rainbow we are actually seeing all the visible colors of light.** Ask: **Besides rainbows, what other kinds of light listed here are familiar to you? What kinds are unfamiliar?** *(Ultraviolet light might be familiar because of sunscreens and blacklights; infrared light can be felt as warmth from heat lamps, etc.)*

10. Invite learners to notice the area marked "energy" on *Electromagnetic Spectrum*, pg. 8. Say: **Light's color is a measure of its energy. In the visible spectrum, violet light has the most energy and red light has the lowest energy.** Point out ultraviolet, x-rays, gamma rays to the left of violet and infrared, microwaves, and radio to the right of red as you say: **Light with more energy than violet and light with less energy than red is invisible to humans.**

11. Say: **To identify different materials, scientists worked with engineers to design a technology that measures the colors of light coming from those materials. Because this technology measures a range of colors, or a spectrum, it is called a *spectrometer*.** Write the word *spectrometer* on the *Our Ideas* poster.

Support Learner Differences

If prepared, distribute the tactile model of *Electromagnetic Spectrum*, pg. 8 in the Science Notebook (PDF).

Support Thinking

Play the video The Electromagnetic Spectrum to support understanding of spectra and spectroscopy.

Level Up!

Tell learners that many planets and moons are exposed to gamma rays and other types of radiation, or light energy from the Sun, that would be hazardous to humans. But just as we can learn information from visible and infrared data, we can learn things from gamma ray and x-ray data. The Mars Odyssey GRS (Gamma Ray Spectrometer) instrument detects gamma rays and other types of radiation to learn about the chemistry of the surface of Mars. The Radiation Assessment Detector on the Curiosity rover on Mars monitors radiation from space and will let us know how much shielding from radiation future Mars astronauts will need to be protected. (<5 min.)

12. Point to the source of light in the room as you say: **When all of the colors in the spectrum come from the same place at about the same brightness, such as from the sun or a light bulb, human brains interpret that as white light. But, when more of one color than the others bounces off or is reflected back from an object, humans perceive it differently. For example, when humans see a stop sign, a lot of red light is reflected back, so we perceive it as red.**

13. Say: **Scientists often display data collected by spectrometers in a graph that is also called a *spectrum*. If we have more than one spectrum, we say *spectra*. We are going to study some spectra now.**

14. Say: **Look at *Green Paint*, page 9 in your Science Notebooks. The graphed line, or spectrum, shows how much light of each color bounces off, or is reflected from, paint. If the sun shines on green paint, the paint absorbs most colors but reflects green light. Where the line is high, that color of light is reflected.** Ask**: Where on the graph does the green paint reflect the most visible light?** *(The peak in the graph is in the green band of light, so the green paint reflects the most visible light in the green range).* **Human eyes perceive objects as being different colors based on how much of each color of visible light they reflect. What color will the paint be to human eyes?** *(You can tell from the peak in the graph on the green band of light that it will appear green).*

Support Thinking

To support understanding of the word spectrometer, display the word and explain that it comes from roots spec, meaning "to observe," and meter, meaning "measure." Have learners think of other words that come from similar roots, such as spectator (someone who observes), spectacle (something people observe), thermometer (a tool for measuring temperature), and pedometer (a tool for measuring steps).

Level Up!

If time permits, allow learners to explore electromagnetic radiation through experience with prisms or heat lamps and explore how wavelength and frequency change based on the amount of energy put into a system using Slinkys. (20 min.)

Learners may also view the NASA Science Activation Network's e Clips videos that talk about and use the electromagnetic spectrum. Based on your group, consider replacing or adding to the above explanation with the video Using Light to Find Out What Things are Made of (Spectroscopy). (5 min.)

Support understanding of spectrometers by having learners build their own spectrometers using the first activity in the PLANETS Remote Sensing @ Home Activity (weblink) or explore resources about spectrometers before introducing the term *spectrometer*. (30 min.)

This unit's engineering pathway activities (pg. vii) challenge learners to design technologies similar to spectrometers that will help scientists distinguish between different materials.

Support Learner Differences

If prepared, distribute tactile models of Green Paint and Red Paint, pgs. 9-10 in the Science Notebook (PDF).

15. Say: **Now look at the spectrum of *Red Paint,* page 10. Where on the graph does this paint reflect the most visible light?** *(In the red band).* **What color will human eyes see?** *(Red)***.**

16. Say: **The amount of reflected light can be represented by lines on a graph, but it can also be represented using sounds. I will play audio files of the spectra for the two colors of paint.** Use hand gestures and your voice to indicate changes as you say: **Before I play them you must know that**

Support Thinking

To help learners understand what they will be doing next, show the translatable video RS Science How To (from 1:08).

- The pitch, or how high or low the sound is,
  matches how much light is reflected as you go from left to right on the graph.
- As the pitch goes down, less light is reflected. As the pitch goes up, more light is reflected.
- Beeps represent the wavelengths on the bottom of the graph.

Green Paint: https://hov.to/a1f474fc

Red Paint: https://hov.to/91f10b77

17. Say: **Compare the audio file of the green paint spectrum to the audio file of the red paint spectrum (links or QR codes above) while exploring the graphs in your Science Notebooks. Trace the graphs with your fingers as you listen to the sounds.** Play the two files a few times. Ask: **What differences do you notice between the sound of the green paint spectrum and the sound of the red paint spectrum?** Encourage learners to use gestures and voice to illustrate their ideas. *(The red paint audio is higher in pitch and is fairly steady. The green paint audio is lower in pitch and fluctuates.)*

18. Say: **Planetary scientists use spectrometers to identify minerals on other planets. Look at the spectrum of a common volcanic mineral called *Olivine* on page 11 of your Science Notebooks.**

Support Learner Differences

If prepared, distribute the tactile model of Olivine, pg. 11 in the Science Notebook (PDF).

19. Say: **Now I will play the audio file of the spectrum of olivine, so you can compare it to the sounds of the paint color spectra. Listen to the audio while exploring the graphs.** Play the audio file of olivine visible only (QR code and link below).

Olivine Visible Only: https://hov.to/1de476a4

20. Ask: **What do you notice about the spectrum of light reflected by olivine? Is olivine's spectrum more like the green paint or the red paint? What color will olivine be to human eyes?** *(In the colors visible to humans, olivine reflects more green than other colors. Its spectrum is more like the green paint's spectrum, so it will appear green to human eyes.)*

Teaching Tip

To learn more about spectroscopy, see this webpage for the Educator Background.

Support Thinking

Contrast LiDAR and spectroscopy. Explain that while LiDAR measures the *time* it takes for light of one energy to bounce between the aircraft and the surface of a planet, spectrometers measure the *intensity* (or *brightness*) of the light the surface reflects at many different energies/colors.

Reflect (10 min.)

21. Revisit the Guiding Question on the *Our Ideas* poster: **How can measuring reflected light help us identify different materials?** *(We can tell what color something is by how much light it reflects.)* Remind learners of the terms *minerals*, *spectrum*, and *spectrometer*. Ask: **What questions do you still/now have?** Allow time for learners to add questions.

22. Ask: **When might it be useful to know about light beyond the visible spectrum?** *(Studying ultraviolet light helps us to develop sunscreens, x-rays help us see broken bones, NASA shields astronauts from gamma rays, etc.)* Consider returning to learners' ideas at the start of the next activity.

23. Say: **Good job working as scientists today! Now you are prepared for next time, when you will use spectra to identify minerals at each of the potential landing sites. Remember, the process you are following is like the process NASA uses to choose landing sites.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 7.
   - Collect the Science Notebooks and tactile spectra.
2. Plan ahead for Science Activity 7. See Activity 7 Materials Preparation, pg. 80.
3. Take time to reflect on the following educator prompts: **How did you connect the topics in this activity, such as colors and types of light, to learners' prior knowledge and experiences? What strategies can you use again in the future?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Educator Guide

Science Activity 7: Hidden Minerals: Using Spectroscopy to Understand Mars

Educator Preview

Activity Snapshot

Learners interpret spectra to identify water-based minerals at potential Mars landing sites.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Analyze Mars Landing Sites	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 20 min. each

Prep Snapshot*

Prep Time 50 min.

At least two days ahead, create tactile spectra graphs and allow them to dry.

Determine how learners will access audio files.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practices

- Analyzing & Interpreting Data

Guiding Question

How can identifying minerals help us choose a landing site on Mars?

Learners Will Do

Interpret spectra to identify minerals on Mars that have formed in water.

Learners Will Know

Scientists can identify materials by looking at their spectra.

Connecting Across Activities

Activity 6: Understanding Spectroscopy	Activity 7: Using Spectroscopy to Understand Mars	Activity 8: Choosing a Landing Site and Preparing for the Science Share-Out
Last time, learners learned how to interpret spectra of light reflected from various objects, which will later help them identify minerals from a distance.	**Today**, learners interpret spectra to identify the types of minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.	**Next time**, they will use the various kinds of data they have collected–landform images, topographic maps, and spectra–to choose a landing site.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/2acd78e1

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
- Science Activity 7 Audio Files (weblink)
- 6 audio player(s) with headphones (or learners' personal devices)
- Wipes to clean headphones after each use (if using)
- School glue or puff paint (optional)
- Sand or glitter (optional)
- Computer with internet access (optional)
- 3 copies of each image in Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)
- 3 additional copies of spectra pages in *Science Activity 7 Mars Minerals Spectroscopy Data Packet* (if planning to make Tactile Spectra Models)
- 6 copies of Science Activity 7 Mineral Fingerprints Handout (PDF)
- 6 additional copies of spectra pages in *Science Activity 7 Mineral Fingerprints Handout* (if planning to make Tactile Spectra Models)
- 1 copy of Mineral Station Signs, pgs. 89-91 (3 signs per station)

Optional: Printed swell paper (weblink) or assembled tactile models:

- 3 copies of tactile model of *Electromagnetic Spectrum*, pg. 8, in the Science Notebook (PDF) from Activity 3.
- 3 copies of tactile models of Gale Crater Data (4 spectra) , pgs. 4-7 from the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) (12 total spectra models)
- 3 copies of tactile models of Jezero Crater Data (3 spectra) , pgs. 10-12 from the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) (9 total spectra models)
- 6 copies of tactile spectra models, odd-numbered pages 1-11, of Science Activity 7 Mineral Fingerprints Handout (PDF) (6 spectra models per station; 36 total spectra models)

For each learner

- Science Notebook (PDF)

Activity 7 Materials Preparation (60 min., at least two days ahead)

Ahead of Time

1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. See Mineral Fingerprints Station Assembly Instructions, pg. 88 for instructions on setting up the tactile and audio stations.
3. Determine how learners will access the audio files on the day of the activity. You have the option to download the audio files (weblink) for each spectrum or use the provided QR codes or links to the files if you plan to have learners access via group or personal devices.

Teaching Tip

Activity Stations will run concurrently, three stations for each landing site (Gale Crater and Jezero Crater). Each site will include visual graphs (spectra), audio files, and optional tactile graphs (spectra) for each of the minerals in *Science Activity 7 Mineral Fingerprints Handout*. Ensure there are enough materials at each station for one group of four.

To reduce the amount of color printing, you (or learners) can color in the visible light spectra on the graphs.

If you are not planning to make tactile graphs, or if you are printing them on swell paper (weblink), you do not need the two-day waiting period and can prepare closer to the start of this activity.

4. Make copies of Science Activity 7 Mineral Fingerprints Handout (PDF), Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF), and the Science Activity 7 Mineral Station Signs, pgs. 89-91. Note: Data Packets are large (1-5 MB) files. Download and print these ahead of time.
5. Print, fill, and copy a Science Activity 7 Share-Out Invitation Handout, pg. 92 for each learner to send home at the end of the Activity in preparation for the Science Share-Out in Activity 9.

In Your Space

6. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally. Add a section divided into two columns. Title one column "Gale Crater" and the other "Jezero Crater."

Level Up!

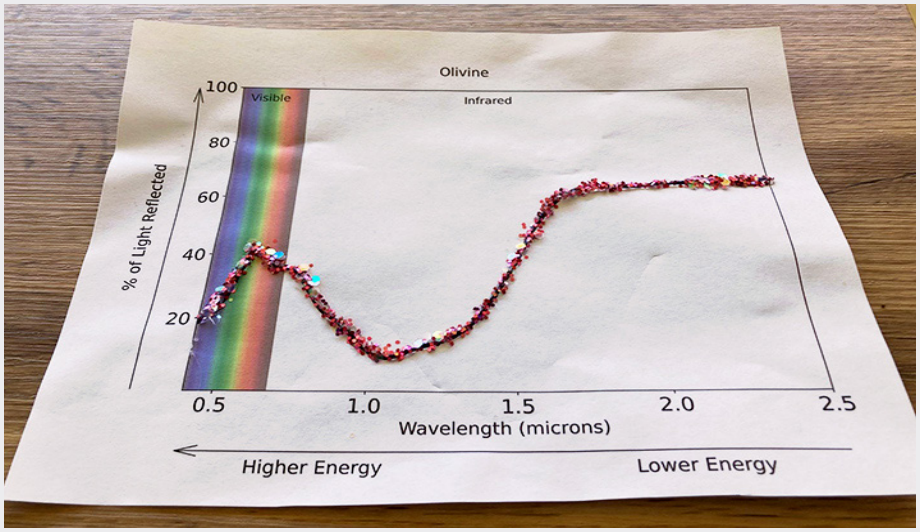
Although this activity lists two possible landing sites, if you have time, the activity is more interesting and enriching with four choices that were all considered by NASA for the Perseverance Rover. To use the additional landing sites, use the advanced Science Activity 7 Mars Minerals Spectroscopy Data Packet with Level Up (PDF) and Science Activity 7 Level Up Audio Files (weblink). Add columns titled "Nili Fossae" and "Iani Chaos" to the *Our Ideas* poster.

Support Learner Differences

Tactile Versions of the Spectra

Although it is listed as optional, like Activity 6, learners will benefit from interacting with a **tactile version of the spectra**, and it will make for a more enriching experience. See Activity 6 Materials Preparation on pg. 70.

You will need to create 21 tactile spectra: three copies each of pgs. 4-7 and 10-12 in the *Science Activity 7 Mars Mineral Spectroscopy Data Packet*. You will also need to create tactile spectra of the six known minerals, the odd-numbered pages 1-11 in the *Science Activity 7 Mineral Fingerprints Handout*. Ideally, you will provide one tactile copy of the entire *Science Activity 7 Mineral Fingerprints Handout* per station, but one or two tactile versions of this resource could be shared among stations. If appropriate, solicit help.



A tactile version of olivine's full spectrum with glitter

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We learned that scientists learn about materials using the light reflected off them. We practiced interpreting spectra using our eyes and our ears, including the spectrum of a mineral called olivine.)* Refer to the terms related to spectra on the *Our Ideas* poster.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**
3. Say: **Today we'll continue to focus on what Mars is made of to determine whether water was once there.** Refer to the questions on the *Our Ideas* poster about what the planet is made of and what rocks and minerals are present to indicate the presence of past water needed for life. If learners do not mention water, ask them what types of things NASA is interested in learning about Mars and why. It is important they focus on water for the rest of the activity. Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can identifying minerals help us choose a landing site on Mars?**
4. Organize learners into groups of four and distribute Science Notebooks.

Support Learner Differences

- If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).
- If prepared, distribute tactile models of *Electromagnetic Spectrum*, pg. 8, *Comparing Green Things–Visible*, pg. 12, and *Comparing Green Things–Visible and Infrared*, pg. 13, in the Science Notebook (PDF).

Analyze Mars Landing Sites (25 min.)

5. Say: **Turn to *Electromagnetic Spectrum*, page 8 in your Science Notebook (PDF).** Give learners a few minutes to review, noticing the visible and invisible portions. Say**: The electromagnetic spectrum includes both visible and invisible light from the Sun.**
6. Say: **Turn to *Green Paint* and *Red Paint,* pages 9-10 in your Science Notebook (PDF)**. Give them a few minutes to review and reorient how to interpret the graphs.
7. Say: **Those spectra were two colors of the same material–paint. Spectrometers were engineered to help scientists identify different types of materials. Turn to *Comparing Green Things–Visible*, page 12 in your Science Notebook (PDF)**. Allow groups a few minutes to notice differences and similarities. Ask: **In the visible spectrum, how does the leaf spectrum compare to the olivine spectrum? What color will these appear to human eyes?** *(The visible spectra are very similar–they all reflect the most green light and will appear different shades of green to human eyes).*

Support Learner Differences

Play the audio files for Activity 6: Green Paint, Red Paint, and Olivine - visible only (weblink).

Say: **Sometimes materials have very similar spectra in the visible range so they look the same to humans. It might be very difficult for scientists to tell these two materials apart, just by looking at their spectra.**

8. Say: **Remember from the *Electromagnetic Spectrum*** pg. 8**, there are colors of light humans can't see. Spectrometers measure infrared light. It is invisible, so it does not affect the colors humans see, but it is important for identifying materials. Turn to *Comparing Green Things–Visible and Infrared*, page 13. Notice the reflection lines don't stop in the visible part of the spectrum. They keep going to the right of red.** Ask: **How does the olivine spectrum compare to the green leaf spectrum in infrared light?** *(They were very similar in visible light, but they have very different spectra in infrared light.)* **That's why scientists examine spectra that include more than just visible light when they are trying to identify materials.**

9. Say: **Spectrometers measure both visible and invisible light reflecting off objects to create spectra like these. Every material has a one-of-a-kind spectrum. That means the shape of spectra can be used like fingerprints to identify unknown materials. As scientists, we can interpret the shapes of different spectra and match them to the shapes of spectra from the laboratory to identify unknown materials.**

10. Say: **Engineers designed a spectrometer that is onboard a spacecraft orbiting Mars. The spectrometer has measured the visible and infrared light reflecting off minerals at each landing site location. You are now ready to interpret these spectra to find out if there are any minerals that form in water at each of the possible landing sites.**

11. Explain the Site Data Stations:
    - Demonstrate as you say: I have set up stations around the room. Each station represents a landing site, Gale Crater or Jezero Crater. Your notebook includes QR codes to audio files (weblink) for each landing site and spectra of different minerals.
    - Show learners the ***Science Activity 7 Mineral Fingerprints Handout*** as you say: This is a list of minerals and how they form. Some of these minerals form in water, indicated by a water droplet, and some do not. When you get to a station, preview the ***Mineral Fingerprints*** pages. You will need to find the minerals that form in water, because these will provide evidence of habitability. Demonstrate by finding the information on the first fingerprint page.

Support Learner Differences

Play the audio files for Science Activity 7: Green Leaf (weblink), and Olivine (weblink).

Level Up!

Show the video Why Do Scientists Need to Measure Infrared Light? (5 min.)

Some animals can see colors of light that humans can't, and vice versa. If learners are interested in how different animals see color differently, point them to the RadioLab episode "Rippin' the Rainbow a New One." (20 min.)

Support Thinking

Show the video How We Use Spectroscopy to Learn About Other Planets to help learners understand how spectroscopy is used to identify minerals on planets like Mars.

- Show learners the ***Science Activity 7 Mars Minerals Spectroscopy Data Packet*** as you say: Each site also includes a map showing the location of some unknown minerals at that landing site. Your task is to use the audio files and/or spectra to identify the unknown minerals at each site. As you investigate, fill out Minerals We Notice, pg. 14 in your Science Notebook (PDF).

12. Invite learners in groups of four to visit each Site Data Station and use spectroscopy data to identify the unknown minerals. As they work, remind them to look for minerals that form in water because they might indicate evidence of past liquid water (and therefore habitability).

13. As learners explore, ask: **What do you gain by identifying minerals using audio as compared to the visual and tactile models?** *(It is easier to notice certain aspects of the data in one form rather than another.)*

14. When they have finished exploring, invite small groups to share their observations of the minerals at each site with the entire group. Record them on the *Our Ideas* poster. Ask: **Using the information you gathered about minerals, which sites do you think might have had water in the past?** *(Both sites have minerals that form in water.)* Say: **With your group, rank the sites based on the number of water-based minerals present at each site.**

Support Thinking

Remind learners to trace what the pitch of the sound is doing with their finger on the table while they listen to the audio.

Teaching Tip

You can have groups stay together or have members split up and go to different stations.

Suggest roles that group members can fill, such as referring to observations, moderating discussion, and recording the group's choices.

Support Thinking

If learners are having trouble interpreting the spectra, emphasize that each material has a one-of-a-kind spectrum. Although it is better if learners understand what the graphs are showing, this activity still works as a simple matching exercise: to identify the mineral, find the spectrum with the same shape.

Teaching Tip

Refer to the following list of minerals at each site but do not share it with learners:

Gale Crater: Mineral 1 is nontronite (forms in water), mineral 2 is kieserite (forms in water), mineral 3 is gypsum (forms in water), mineral 4 is olivine.

Jezero Crater: Mineral 1 is pyroxene, mineral 2 is kaolinite (forms in water), mineral 3 is olivine.

The patterned areas on the mineral maps in the *Science Activity 7 Mars Minerals Spectroscopy Data Packet* are idealized and simplified, but they are based on actual observations of these locations on Mars. The minerals listed really are at these locations!

Reflect (10 min.)

15. Revisit the Guiding Question on the *Our Ideas* poster: Ask: **How can identifying minerals help us choose a landing site on Mars?** *(Spectroscopy data can show us minerals that form in water, which means liquid water was at a location in the past. That location would be a good landing site.)*

Level Up

To make this activity more challenging, have learners consider which water-based minerals the rover could reasonably access from a safe landing oval, and which minerals might be too far away or in places with dangerous topography.

16. Ask: **When might measuring reflected light (spectroscopy) help us?** *(Paint color matching; at crime scenes; identifying crops or minerals on Earth, etc.)* Consider returning to learners' ideas at the start of the next activity.
17. Say: **Spectroscopy is used to identify unknown materials on Earth, on other planets, and in distant galaxies. This tells us something important about the universe: it is all made of the same stuff and science works the same everywhere. We can use our knowledge of science and engineering on Earth and know that it also applies to everywhere else in the universe!**
18. Ask: **What questions do you still have?** If there are unanswered questions on the *Our Ideas* poster, encourage learners to do some research on their own using these resources:
    - https://science.nasa.gov/mars/facts/
    - https://mars.nasa.gov/#red_planet/0
    - https://en.wikipedia.org/wiki/Mars
19. Say: **Good job working as scientists today! Now you are prepared for next time, when you will put together all the information you have gathered to choose a site for the rover to land on Mars. Remember, the process you are following is like the process NASA uses to choose landing sites.**

After the Activity

1. Clean up:
    - Keep the *Our Ideas* poster for use in Activity 8.
    - Collect the supplies from each station: audio player, *Science Activity 7 Mars Minerals Spectroscopy Data Packet* and tactile graphs, *Science Activity 7 Mineral Fingerprints Handout* and tactile graphs, and *Science Activity 7 Station Signs*. Save for use in future activities.
2. Plan ahead for Science Activity 8. See Activity 8 Materials Preparation, pg. 94.
3. Take time to reflect on the following educator prompt: **How did you help learners apply what they learned about minerals and light in the previous activity?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Mineral Fingerprints Station Assembly Instructions

There will be six stations that run concurrently, three stations for each landing site (Gale Crater and Jezero Crater).

Each of the materials lists below is for one setup; however, to accommodate 24 learners, each landing site station needs three setups. Prepare and include the tactile spectra models with each station, (see Advance Preparation, pg. 82, Support Learner Differences) with each station, if you think learners would benefit from these.

To assemble each station, arrange all the materials for a station on a table or desk, leaving room for learners to move between the stations.

Gale Crater Station materials for one setup:

- Science Activity 7 Mineral Fingerprints Handout (PDF)
- Science Activity 7 Mineral Fingerprints Data Audio Files (weblink) (if not using QR codes on *Science Activity 7 Mineral Fingerprints Handout* - 6 files)
- Science Activity 7 Mars Minerals Spectroscopy Data Packet
- Science Activity 7 Gale Crater Unknown Minerals Audio Files weblink (if not using QR codes on *Science Activity 7 Mars Minerals Spectroscopy Data Packet* - 4 files)
- Optional:
  - Tactile versions of *Science Activity 7 Mars Minerals Spectroscopy Data Packet*
  - Tactile model of *Science Activity 7 Mineral Fingerprints Handout*
- Gale Crater station sign
- audio player with headphones
- cleaning wipes

Jezero Crater Station materials for one setup:

- Science Activity 7 Mineral Fingerprints Handout (PDF
- Science Activity 7 Mineral Fingerprints Data Audio Files (weblink) (if not using QR codes on *Mineral Fingerprints Handout* - 6 files)
- *Mars Minerals Spectroscopy Data Packet*
- Science Activity 7 Jezero Crater Unknown Minerals Audio Files (weblink) (if not using QR codes on *Science Activity 7 Mars Minerals Spectroscopy Data Packet* - 3 files)
- Optional:
  - Tactile versions of *Science Activity 7 Mars Minerals Spectroscopy Data Packet*
  - Tactile model of *Science Activity 7 Mineral Fingerprints Handout*
- Jezero Crater station sign
- audio player with headphones
- cleaning wipes

Teaching Tip

If learners have their own devices and headphones and access to the internet, you have them scan the QR code to each audio file. You could also provide links to the audio files and use a computer or tablet. Find a quiet area for the audio stations, if possible.

Mineral Station Signs

GALE CRATER

GALE CRATER

Mineral Station Signs

GALE CRATER

JEZERO CRATER

Mineral Station Signs

JEZERO CRATER

JEZERO CRATER

Science Share-Out Invitation

You're invited to the Science Share-Out

Come see your young scientist showcase their Mars Rover Landing Site!

Date: ______________________________

Time: ______________________________

Location: ___________________________

Grantee

Science Activity 8: Destination Mars: Choosing a Landing Site and Preparing for the Science Share-Out

Educator Preview

Activity Snapshot

Learners combine multiple data sets to choose a safe and scientifically interesting landing site for a Mars rover. They then prepare to share their findings with the whole group and with invited guests.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Choose a Landing Site and Prepare for the Share-Out	25 min.
Reflect	10 min.
Total	**45 min.**

Prep Snapshot*

Prep Time 40 min.
(several days in advance)

Send Science Share-Out Invitations to people from the community.

**See Materials & Preparation for full info.*

21st Century Skills

Connection
- Communication

Science Practices
- Interpreting Data
- Constructing Explanations
- Communicating Information

Guiding Question

Which landing site on Mars do we recommend, and why?

Learners Will Do

Choose a landing site that is scientifically interesting and safe.

Learners Will Know

Scientists must consider a lot of data to understand an area.

Connecting Across Activities

Activity 7: Using Spectroscopy to Understand Mars	Activity 8: Choosing a Landing Site and Preparing for Science Share-Out	Activity 9: Science Share-Out
Last time, learners interpreted spectra to identify the types of minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.	**Today**, they use the various kinds of data they have collected–landform images, topographic maps, and spectra–to choose a landing site.	**Next time**, they will share their findings.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/1ef83b5f

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF) Examples | Templates
- ***Science Activity 7*** Audio Files (weblink)
- Optional: Tactile Science Activity 7 Mineral Fingerprints Handout (PDF) from Science Activity 7
- Optional: Tactile Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)
- Devices for listening to audio

For each small group

- Science Activity 7 Mineral Fingerprints Handout (PDF)
- Data Packets from Science Activities 3 (PDF), 5 (PDF), and 7 (PDF)
- Landing Site Ovals from Science Activity 3 (PDF)

For each learner

- Science Notebook (PDF)

For community members

- Science Share-Out Invitation Handouts from Activity 7, pg. 92

Activity 8 Materials Preparation (15 min.)

Ahead of Time

1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. If you have not already, send *Activity 7 Science Share-Out Invitation Handouts, pg. 92,* to invite people from the community, including families and friends of learners, to the Science Share-Out.

3. For reference:
   - download the *Science Activity 7* Audio Files (weblink) for each spectrum and set up a listening station center for learners to refer to as they choose. Place one copy of the Science Activity 7 Mineral Fingerprints Handout (PDF) and one copy of the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) at the center.
   - optional: place tactile *Mineral Fingerprints Handout* and tactile *Science Activity 7 Mars Minerals Spectroscopy Data Packet* at a center that is accessible to all learners so they can refer to these as they choose.

In Your Space

4. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** *(We interpreted spectra to identify unknown minerals at each potential landing site. We ranked the sites based on the number of minerals present that form in water)*. Draw learners' attention to their findings about minerals on the *Our Ideas* poster.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**

3. Refer to the *Our Ideas* poster. All questions related to this activity should have been answered. If there are unanswered questions, encourage learners to do some research on their own using the links on Learner Resources weblink. Say: **When it's time to choose a landing site for a mission to another planetary body, NASA assembles a large team to pinpoint the best locations. They examine a lot of different types of data to make a decision. Today, you will consider all the data you have collected–on landforms, topography, and minerals–and choose the landing site you decide is safest and most likely to have evidence of past liquid water.** Share the Guiding Question with learners aloud and write it on the *Our Ideas* poster (using multiple languages as needed): **Which landing site on Mars do we recommend, and why?**

4. Organize learners into groups of four and distribute Science Notebooks.

Level Up!

Have learners find out more about picking the candidate landing sites for the Artemis III mission in "NASA Identifies Candidate Regions for Landing Next Americans on Moon." (5 min.)

Choose a Landing Site and Prepare for the Share-Out (25 min.)

Choose a Landing Site (10 min.)

5. Say: **What are some things you have to think about when choosing a landing site?** *(The landforms, the minerals present, the landing site perimeter, the safety.)* Say: **In your groups, you will need to decide on one landing site. You will need to consider which site would offer the most interesting science but also consider the safety of the site. Sometimes one site might be the safest, but not the most interesting.** *(Use hand gestures as if you are weighing the options.)* **So you will have to consider or weigh all the factors and try to reach a decision that best balances all the factors. When you think about all of the factors and options, you are considering the compromise, or *tradeoff*, between site safety and interesting science**.

6. Say: **In your groups, review the data for (1) landforms, which you detected from images, (2) safety, which you found from topographic maps, and (3) minerals, which you detected from spectroscopy.** As you mention each type of data, refer to the Science Notebooks, the charts on the *Our Ideas* poster, or other shared documents from Science Activities 3, 5, and 7.

Prepare for the Share-Out (15 min.)

7. After about 10 minutes, say: **Once your group chooses a landing site, decide how you would like to share information about that site. You will share with the whole group and any invited guests.** Ask**: What are the important ideas you think we should share?** *(Our role as scientists; the problem of gathering information from a distance; the definition of remote sensing; questions we were trying to answer, the benefits of each site, the tradeoffs, etc.)* **How do you think we should share our findings?** *(Posters; drawings, mapping or graphing our findings; recording a video or audio message; staging a performance; writing a description, etc.)* Say: **If you want to, you can use the sentence starters on *Make the Case for Your Site, page 15,* in the Science Notebooks, to get started.**

8. As groups are working, help guide their thinking by asking one or more of the following questions: **What evidence can you use to help you choose your landing site? Which site do you think will be the most scientifically interesting? Why? Which is more important: site safety or interesting science? Why?**

9. The Share-Out is a chance for learners to explain their thinking and reflect on what they learned about remote sensing throughout the unit. As a group, agree upon a structure for the Share-Out. Possible structures include the following:
   - **Storytelling**: Groups use the evidence they've collected to tell stories about the Test Sites and what the scientists might find there.
   - **Gallery Walk**: Groups stand at their stations and explain their technologies, posters, graphs, maps, writings, drawings, or audio or videos on small devices.
   - **Pair-Share**: Groups pair off and share their choices with one another.
   - **Screening**: The whole group watches video or audio files that learners have created. If time permits, they can make slideshows or animations.
   - **Performance**: Some people play scientists asking questions about learners' remote sensing devices. You can develop script cards to include adults in the play.
   - **Discussion**: Learners and community members share their knowledge. You can write discussion prompts to lead this discussion.

Support Thinking

Allow learners to reference the audio and tactile data as needed. If time permits, let learners research unanswered questions from the *Our Ideas* poster.

There is no "right" answer to which site to select. Gale Crater and Jezero Crater were both selected as landing sites for NASA rovers. The Level Up Nili Fossae and Iani Chaos sites were both considered as possible landing sites, and Nili Fossae was a finalist in site selection for both the Curiosity and Perseverance rovers.

Teaching Tips

Before learners begin, consider suggesting roles that group members can fill, such as one member referring to observations from previous activities, another member tracing the landing oval on maps, and a third recording the group's choices.

If all of your groups seem to be choosing the same landing site, you can gently encourage some groups to choose a different option, which will lead to more interesting discussion and debate.

Reflect (10 min.)

10. Revisit the Guiding Question on the *Our Ideas* poster. Ask: **Which landing site on Mars do we recommend, and why?** Learners should refer to their own work to answer the question. Help learners to accept that other groups may have made a different choice, and that's fine as long as they can support their choice using the data they collected.

11. Say: **Sometimes, many sites seem interesting, so the evidence scientists use to explain their reasoning is important. A site may be "best" in terms of science, but not good for safety, so scientists need to consider tradeoffs. Important decision making requires looking at the problem in different ways, working as a group, and compromise.** Ask: **When might it be useful to work with others, consider a problem in different ways, and compromise?**

12. Say: **Good job working as scientists today! Now you are prepared for next time, when you will present to each other and to our guests. Remember, the process you are following is like the process NASA uses to choose landing sites.**

Support Learner Differences

Some learners may disengage if the Share-Out contains too much whole-group discussion. Think about what your learners need and ensure they choose an appropriate Share-Out structure.

If you have learners who speak multiple languages, encourage them to share in their preferred languages. Circulate and ask groups: **Where can you include your preferred language or other languages you know in your share-out?** Encourage learners to make welcome signs and present in different languages spoken by the audience.

All learners should contribute to the Share-Out, but not everyone will feel comfortable presenting in the same style. Indigenous learners may feel it is inappropriate to present directly as the center of attention. Ensure nonverbal presentation methods are available, and encourage participation behind the scenes, not just in presenting in front of the class.

Teaching Tip

Provide time for learners to practice their share-out in pairs or small groups.

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for use in Activity 9.
   - Collect the Science Notebooks, *Science Activity 3 Mars Landforms Data Packets, Science Activity 5 Mars Landing Site Topography Data Packets, Science Activity 7 Mineral Data Packets,* and *Landing Site Ovals.*
   - If you set up listening and tactile stations, collect the materials from each.
2. Plan ahead for Science Activity 9. See Activity 9 Materials Preparation on pg. 102.
3. Take time to reflect on the following educator prompt: **What methods did learners choose to present their ideas? How did you support multiple means of expression?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Educator Guide

Science Activity 9: Sum It Up: Science Share-Out

Educator Preview

Activity Snapshot

Learners share their recommendations for the safest and most scientifically interesting Mars rover landing site.

Timing | 45 minutes

Get Ready and Team Up	5 min.
Science Share-Out	30 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time **40 min.**
(several days in advance)
Send Science Share-Out Invitations to people from the community.

**See Materials & Preparation for full info.*

21st Century Skills

Connection
- Communication

Science Practices
- Interpreting Data
- Constructing Explanations
- Communicating Information

Guiding Question

Which landing site on Mars do we recommend, and why?

Learners Will Do

Communicate Mars landing site choice to others and support the decision with evidence.

Learners Will Know

Scientists have valuable knowledge to share about the problem they solved.

Connecting Across Activities

Activity 8: Choosing a Landing Site and Preparing for the Science Share-Out	Activity 9: Science Share-Out	Engineering Pathway
Last time, learners used the various kinds of data they collected–landform images, topographic maps, and spectra–to choose a landing site.	**This time**, they share their findings.	**Next time**, learners experience engineering related to this topic in the PLANETS Worlds Apart Engineering Pathway (optional).

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/03b6987b

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF)
  Examples | Templates
- *Science Activity 7* Audio Files (weblink)
- Devices for listening to audio
- Optional: Tactile Science Activity 7 Mineral Fingerprints Handout (PDF)
- Optional: Tactile Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF)

For each small group

- Science Activity 7 Mineral Fingerprints Handout (PDF)
- Data Packets from Science Activities 3 (PDF), 5 (PDF), and 7 (PDF)
- Landing Site Ovals from Science Activity 3 (PDF)

For each learner

- Science Notebook (PDF)

For community members

- Science Share-Out Invitation Handouts from Activity 7, pg. 92

Activity 9 Materials Preparation (15 min.)

Ahead of Time

1. If you have not already, send out Science Share-Out Invitations to invite people from the community, including families and friends of learners, to the Science Share-Out.

2. For reference:
   - download the audio files (weblink) for each spectrum and set up a listening station center for learners to refer to as they choose. Place one copy of the Science Activity 7 Mineral Fingerprints Handout (PDF) and one copy of the Science Activity 7 Mars Minerals Spectroscopy Data Packet (PDF) at the center.
   - optional: place tactile *Mineral Fingerprints Handout* and tactile *Science Activity 7 Mars Minerals Spectroscopy Data Packet* at a center that is accessible to all learners so they can refer to these as they choose.
3. Decide what to do with learners' designs and presentation materials after the activity.

In Your Space

4. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Activity Guide

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

Get Ready and Team Up (5 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We revisited the landform, topographic, and spectroscopy data to choose the safest and most scientifically interesting site to land a rover on Mars. We prepared to share our findings with the group and invited guests*).
2. Remind learners of the Guiding Question on the *Our Ideas* poster: **Which landing site on Mars do we recommend, and why?** Say: **Today, you will present your choice to the group and invited guests.**
3. Organize learners into the same groups as the previous activity.

Science Share-Out (30 min.)

4. Remind learners of the structure they have planned for the Share-Out. Say: **The Share-Out is a chance for you to display your ideas, explain your thinking, and reflect on what you learned about remote sensing throughout the unit.**
5. Provide time for learners to make any last-minute preparations.
6. When learners are ready, invite guests into the room and explain how the Share-Out will proceed. Carry out the steps of the Share-Out as the group has planned.
7. As they experience the Share-Out, invite families and other guests to think about their family, cultural, or other knowledge related to what they observe here today and share that knowledge with learners individually or during the event as a whole.

Reflect (10 min.)

8. After all groups have shared, ask learners to reflect on the sites selected. Ask: **Did all groups agree on where the rover should land? Why or why not? Would you have made the same recommendation if you were missing some of the data from the packets? For example, how would your recommendation be different if you had no data about landforms?** *(We could not have chosen our site if we didn't know about its landforms, topography, and minerals. Using different kinds of remote sensing together gives a much more complete understanding of a site, much like how a person uses all their senses to understand the world, not just one.)*
9. Say: **Good job working as scientists today! The process you've followed is like the process NASA uses to choose landing sites.** Tell learners what really happened when scientists and engineers had to choose landing sites for prior Mars missions:
   - **NASA chose Gale Crater as the landing site for its Curiosity rover, which landed on Mars in 2012 and has been exploring ever since.**
   - **NASA chose Jezero Crater for its Perseverance rover. The rover launched in 2020 and landed in 2021.**

After the Activity

1. Clean up:
   - Collect the Science Notebooks, *Data Packets,* and *Landing Site Ovals*.
   - Decide if you want to keep the *Our Ideas* poster. Term cards can be kept for the future.
   - If you set up listening and tactile stations, collect the materials from each.
   - Reset the space in which you held the Share-Out.
   - Consider saving materials to use if you teach these activities again in the future.
2. Take time to reflect on the following educator prompt: **How did you create opportunities for interaction with community members? How can you do so in other situations in the future?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9

Level Up!

For more on Curiosity, share an exciting NASA video, *Curiosity's Seven Minutes of Terror*, about the challenges of landing Curiosity at Gale Crater. Learn more about the Curiosity rover and see pictures from inside Gale Crater. (30 min.)

If learners examined all four sites, add: **NASA also considered Iani Chaos and Nili Fossae as landing sites for Perseverance but ruled out both. Iani Chaos is too rough, and although both sites have water-related minerals, they lack water-related landforms.** (5 min.)

If you have time, show the image "Mars Probe Landing Ellipses," which compares landing ellipses for different Mars missions over time. (5 min.)

If your learners enjoyed this planetary science challenge, they would also enjoy the Rover Observation and Discoveries in Space (ROADS) student challenges. Show your learners the NASA National Student Challenges weblink. (10 min. to review website, 10–15 hours per challenge)