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NASA STEM Facilitation Kit

The Search for Habitable Worlds

NASA @ My Library

STAR net

Science-Technology Activities & Resources For Libraries

NASA@ My Library is based upon work funded by NASA under cooperative agreement No. NNX16AE30A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the *NASA@ My Library* initiative and do not necessarily reflect the views of the National Aeronautics and Space Administration.

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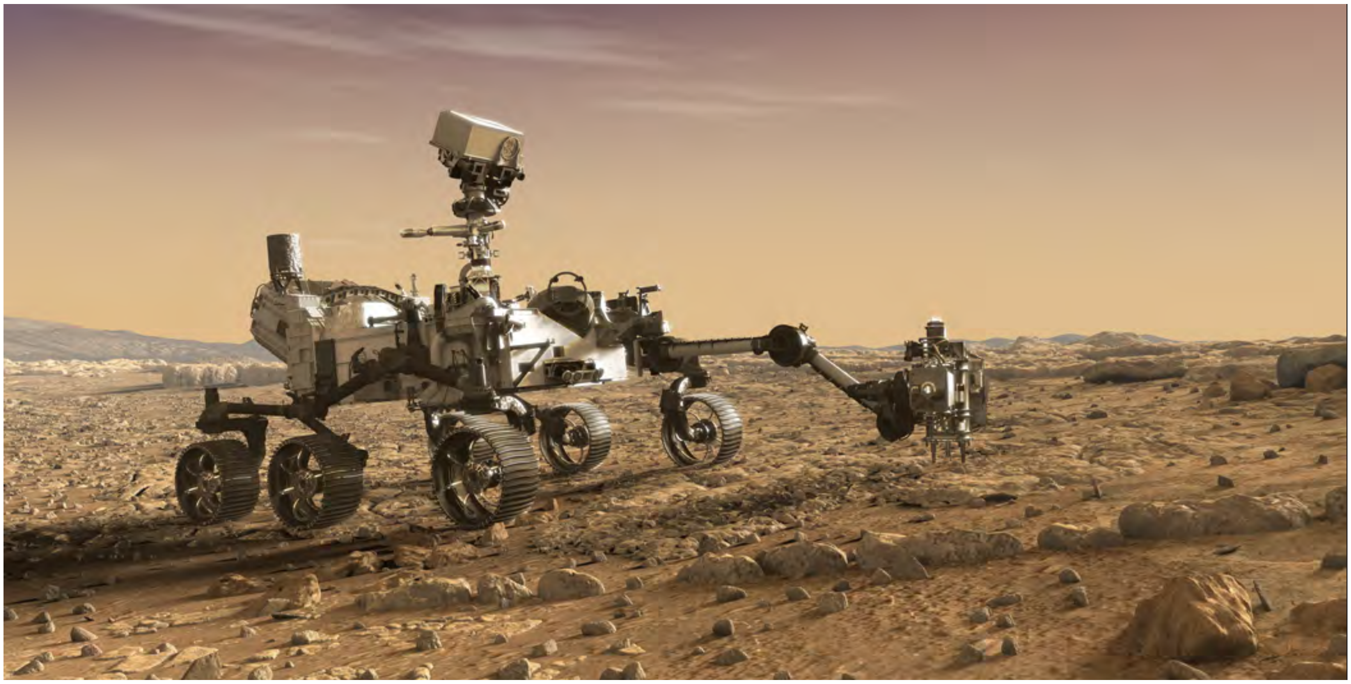
NASA Mission Spotlight: Mars 2020 Rover



Credit: NASA

The **Mars 2020 Rover** mission is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. It addresses high-priority science goals for Mars exploration, including key questions about the potential for life on Mars. The mission takes the next step by not only seeking signs of habitable conditions on Mars in the ancient past, but also searching for signs of past microbial life itself. The Mars 2020 rover introduces a drill that can collect core samples of the most promising rocks and soils and set them aside in a "cache" on the surface of Mars. A future mission could potentially return these samples to Earth. The mission will also include testing a method for producing oxygen from the Martian atmosphere, identifying other resources (such as subsurface water), improving landing techniques, and characterizing weather, dust, and other potential environmental conditions that could affect future astronauts living and working on Mars.

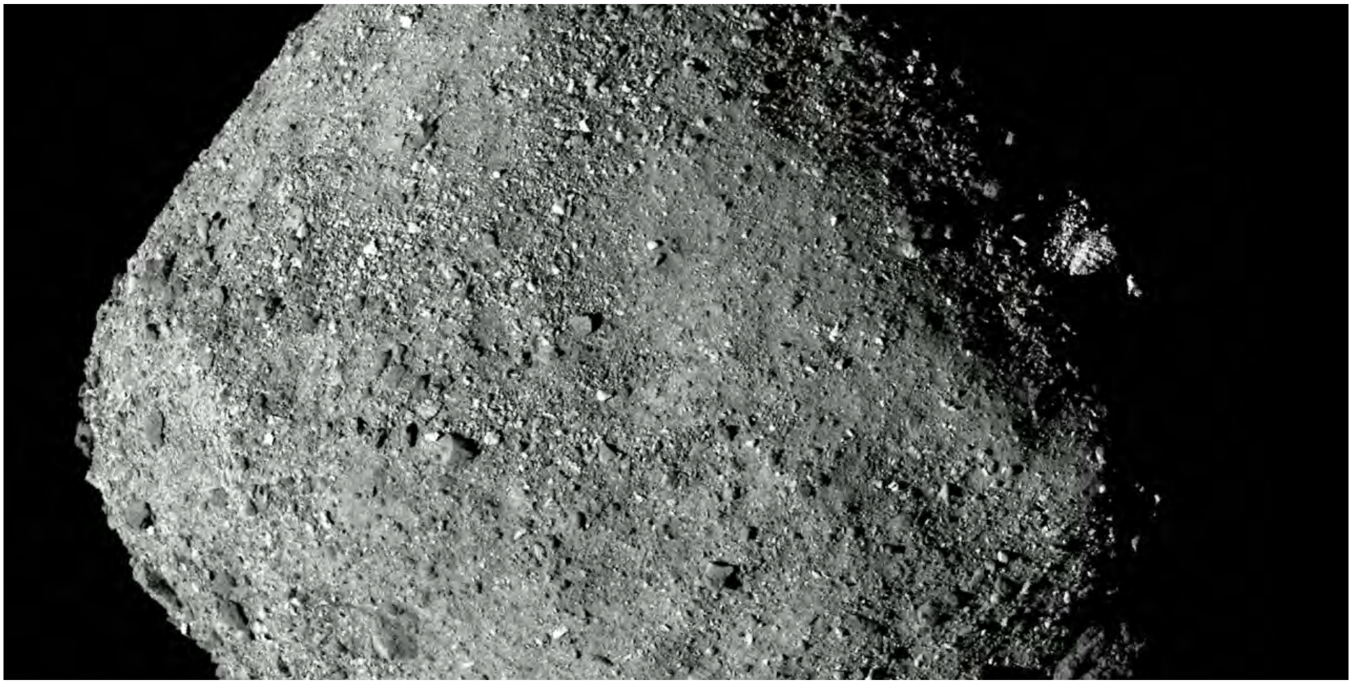
Mars 2020 launches on an Atlas V rocket in July/August 2020 from Launch Complex 41 at Cape Canaveral Air Force Station, Florida. The mission landing system includes a parachute, descent vehicle, and an approach called a "skycrane maneuver" for lowering the rover on a tether to the surface during the final seconds prior to landing.

Mission Website: https://go.nasa.gov/2PjN5do

In this picture from Sept. 28, 2019, engineers and technicians working on the Mars 2020 spacecraft at NASA's Jet Propulsion Laboratory in Pasadena, California, look on as a crane lifts the rocket-powered descent stage away from the rover after a test.

Credit: NASA/JPL-Caltech

NASA Mission Spotlight: OSIRIS-REx



Credit: NASA

The **OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer)** is a NASA asteroid study and sample-return mission. The mission's main goal is to obtain a sample of at least 60 grams (2.1 oz) from Bennu, a carbonaceous near-Earth asteroid, and return the sample to Earth for a detailed analysis. The material returned is expected to enable scientists to learn more about the formation and evolution of the Solar System, its initial stages of planet formation, and the source of organic compounds that led to the formation of life on Earth. If successful, OSIRIS-REx will be the first U.S. spacecraft to return samples from an asteroid. Working with NASA's OSIRIS-REx team, the International Astronomical Union's Working Group for Planetary System Nomenclature (WGPSN) approved the theme "birds and bird-like creatures in mythology" for naming surface features on asteroid Bennu.

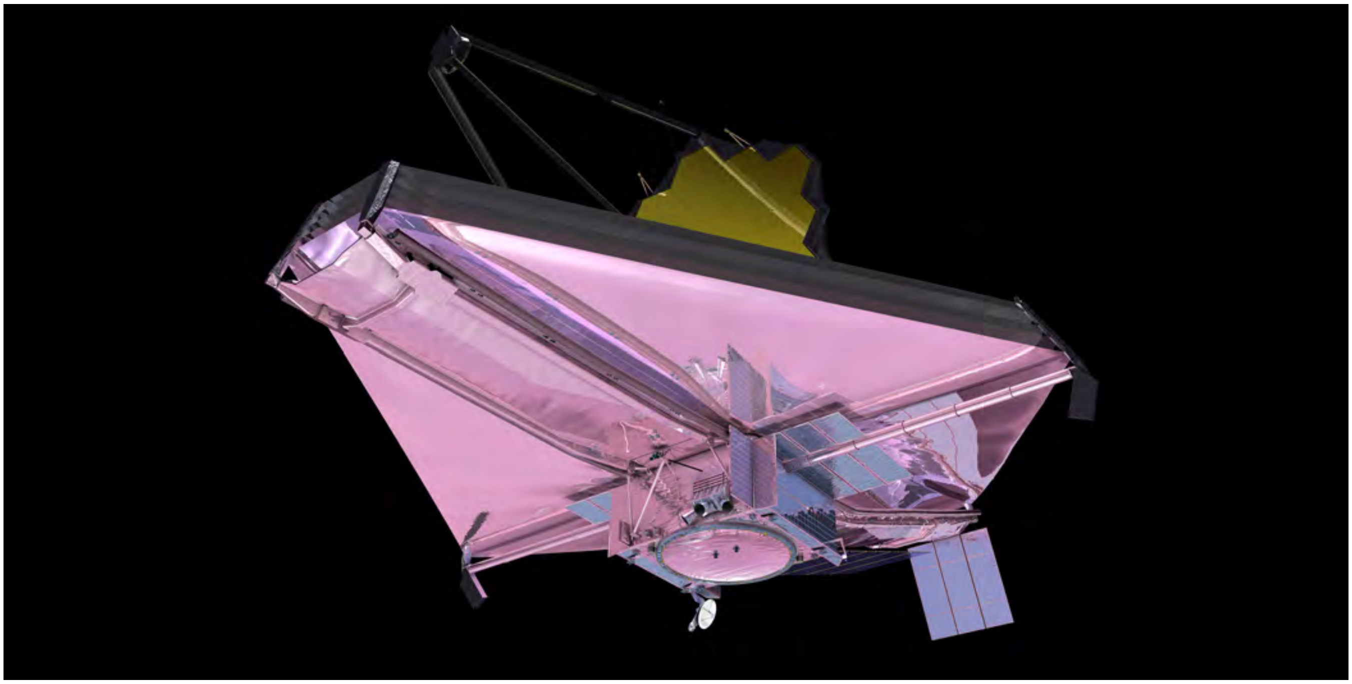
Since its arrival in December 2018, the OSIRIS-REx spacecraft has mapped the entire asteroid in order to identify the safest and most accessible spots for the spacecraft to collect a sample. Four sites have been selected and will be studied in order to select the final two sites – a primary and backup – in December 2019.

Mission Website: http://bit.ly/2qEghSm

On Sept. 8, 2016 at 7:05 pm EDT, OSIRIS-REx departed from Cape Canaveral Air Force Station aboard a United Launch Alliance Atlas V 411 rocket.

Credit: United Launch Alliance/NASA

NASA Mission Spotlight: James Webb Space Telescope



Credit: NASA

The **James Webb Space Telescope (JWST or "Webb")** is a space telescope that is the successor to the Hubble Space Telescope. Its planned launch date is March 2021 on an Ariane 5 rocket. JWST will provide greatly improved resolution and sensitivity over the Hubble. It will enable a broad range of investigations across the fields of astronomy and cosmology, including observing some of the most distant events and objects in the Universe, such as the formation of the first galaxies. Other goals include understanding the formation of stars and planets, and direct imaging of exoplanets and novas.

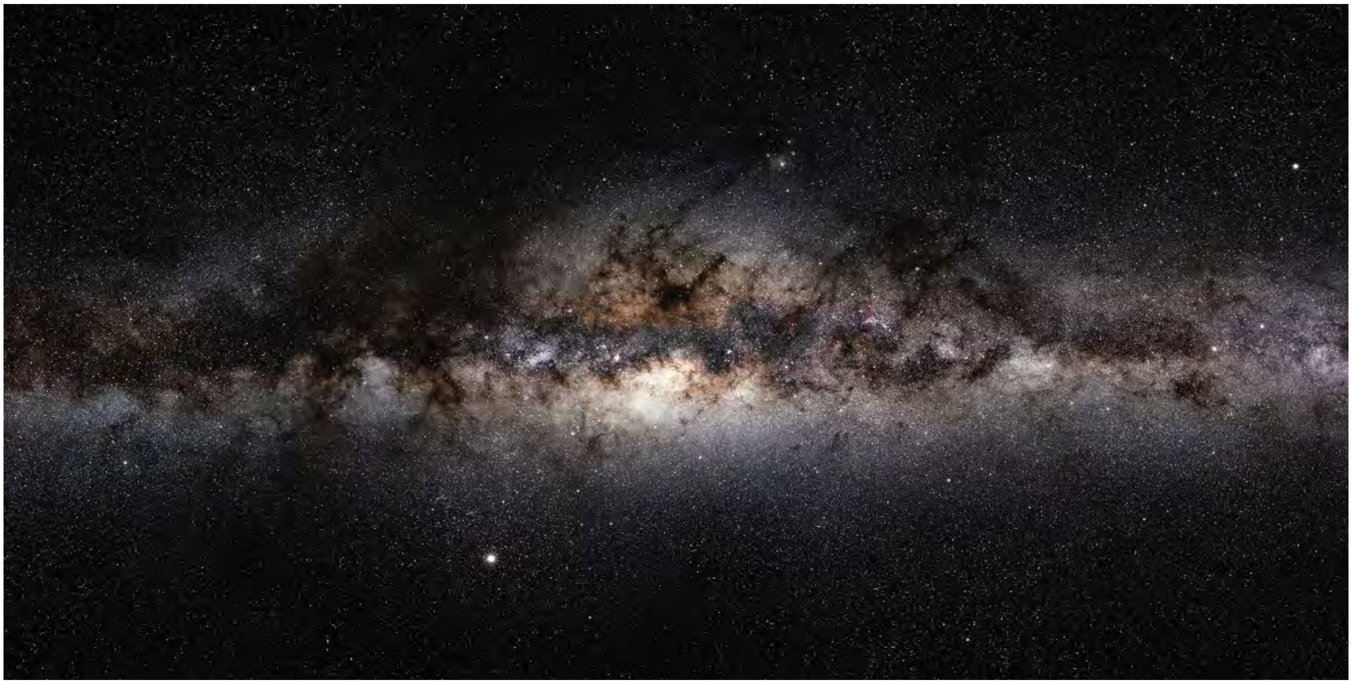
JWST will operate approximately 1,500,000 km (930,000 mi) beyond Earth's orbit. By way of comparison, Hubble orbits 550 km (340 mi) above Earth's surface, and the Moon is roughly 400,000 km (250,000 mi) from Earth. This distance makes post-launch repair or upgrade of the JWST hardware virtually impossible. The prime contractor is Northrop Grumman.

Mission Website: https://go.nasa.gov/33WWyvA

Reaching a major milestone, engineers successfully connected the two halves of NASA's James Webb Space Telescope for the first time at Northrop Grumman's facilities in Redondo Beach, California (August 2019). To combine both halves of Webb, engineers carefully lifted the space telescope (which includes the gold-plated mirrors and science instruments) above the already-combined sunshield and spacecraft using a crane.

Credit: NASA

NASA Program Spotlight: Astrobiology



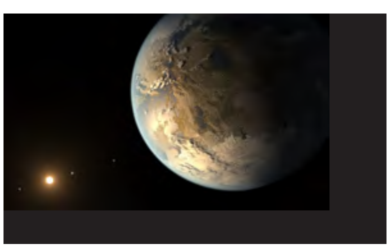
Billions of stars light up a panorama of our Milky Way galaxy. Astronomers now think that most stars in the galaxy have at least one planet. Many planets orbit sun-like stars that could host life. Credit: ESO/S. Brunier

Are We Alone?

Astrobiology is an interdisciplinary scientific field concerned with the question of whether life beyond Earth exists, and if it does, how humans can detect it. The **NASA Astrobiology Program** supports research that leads to a better understanding of how life emerged and evolved on Earth, what conditions make environments in our Universe capable of supporting life, and what the distribution of habitable worlds and life beyond Earth might be. Astrobiology is focused on characterizing habitability and detecting evidence of microbial life.

Astrobiology involves many scientific fields including molecular biology, biophysics, biochemistry, chemistry, astronomy, physical cosmology, exoplanetology and geology. Scientists from these disciplines come together collaboratively to investigate life's origins and the possibility of life on other worlds.

Program Website: https://go.nasa.gov/32GwQuN
Program Contact: Daniella Scalice, Education and Communications Lead, NASA Astrobiology Program



Mars, and moons such as Europa (orbiting Jupiter) and Enceladus (orbiting Saturn), are prime locations for finding signs of life. Beyond our Solar System, scientists have discovered thousands of exoplanets orbiting stars in our Milky Way galaxy. This artist concept depicts Kepler-186f, the first validated Earth-sized planet to orbit a distant star in the habitable zone – a range of distance from a star where liquid water is stable on the planet's surface.

Credit: NASA Ames/JPL-Caltech/T. Pyle

Eclipse Resources

Between March 2016 and December 2020, four total solar eclipses occur in the world – one in the southwestern pacific, one in the U.S. and two in South America. These sequential eclipse events provide an unprecedented opportunity to build and scaffold public engagement in science. *Navigating the Path of Totality* is a public education program produced by the Exploratorium scientists, educators and media production staff that make use of these total solar eclipses as platforms for sparking public engagement and learning about the Sun, heliophysics, and the STEM content related to both.

http://bit.ly/2XEiYCi

Girl Scout Resources

The Girl Scouts: Reach for the Stars aims to enhance STEM experiences for Girl Scouts in grades K-12 through the national Girl Scout Leadership Experience. SETI Institute leads the experienced space science educators at Astronomical Society of the Pacific, University of Arizona, and ARIES Scientific. Girl Scouts of the USA leads dissemination of Girl Scout Stars to Councils with support of Girl Scouts of Northern California. New space science badges are being created for every Girl Scout level. The Girl Scout Volunteer Tool Kit taps into the wealth of online materials provided by NASA for the new space science badges.

http://bit.ly/31R8iy7

Digital Resources

Arizona State University strives to develop next-generation, digital, adaptive learning experiences that are compelling to learners of all ages and use NASA science, visualizations, and stories. *Infiniscope* is not only creating activities, but training a community of educators to create their own adaptive learning experiences that provide feedback and pathways to meet the needs of their individual learners and communities. Not just another internet portal, Infiniscope is a digital platform that empowers a community of educators to connect, collaborate, and create, next-generation exploratory activities.

http://bit.ly/2NoDlvU

Earth Resources

The NASA Earth Science Education Collaborative (NESEC) builds pathways between NASA's Earth STEM assets to large, diverse audiences in order to enhance K-12 teaching and learning, and opportunities for lifelong learners. STEM assets include subject matter experts, science and engineering content, and authentic STEM experiences. NESEC is a partnership between the Institute for Global Environmental Strategies (IGES) and NASA Earth science divisions at three NASA Centers: Goddard Space Flight Center, Jet Propulsion Laboratory, and Langley Research Center.

http://bit.ly/2PpHsdZ

Planetary Surface Resources

NASA's Solar System Treks project produces a suite of online, web-based, interactive visualization and analysis portals. These tools enable mission planners, planetary scientists, students, and the public to explore the surfaces of a growing number of planetary bodies as seen through the eyes of many different instruments aboard a variety of spacecraft. Views can be stacked and blended. Users can interactively fly over peaks and down into valleys in 3D mode; measure distances, heights, and depths of landforms; and mark areas for output to 3D printers. The project is managed by NASA's Solar System Exploration Research Virtual Institute and developed at NASA's Jet Propulsion Laboratory.

https://go.nasa.gov/2PwRkCR

NASA Space Place

NASA Space Place was created in 1998 as a premier science communications website. It was the first NASA website designed almost exclusively for a younger audience. This award-winning website engages upper-elementary-aged children in space and Earth science through interactive games, hands-on activities, fun articles, and short videos. NASA Space Place has numerous resources for parents and teachers, and produces materials in both English and Spanish.

https://go.nasa.gov/2oqDhUb

Digital Space Exploration Resources

Experience Earth and our Solar System, the universe and the spacecraft exploring them, with immersive apps for Mac, PC and mobile devices. This resource is produced by NASA's Jet Propulsion Laboratory.

https://go.nasa.gov/2po96x8

Museum Alliance

It was created to be the "front door" to NASA for the world of informal education. Likewise, for NASA programs, the Alliance is the "front door" to access the world of informal education. The Alliance is meant to be the starting point for all informal educators who are seeking free NASA educational resources and services. On the other side, the Alliance is also the place where NASA experts can find a ready-made audience who can engage the worldwide public about their work, their information, and their educational products and services. This program is managed by NASA's Jet Propulsion Laboratory.

https://go.nasa.gov/2JoiO9N

Universe of Learning Resources

NASA's Universe of Learning provides resources and experiences that enable educators to engage their audiences in the science, the story, and the adventure of NASA's scientific explorations of the Universe. There integrated team of scientists, educators, and communications professionals work together and with the education community to strengthen science education and scientific literacy, and to enable youth, families and lifelong learners to discover the Universe for themselves.

http://bit.ly/345Tld9

Informal Learning Resources

Arizona State University - National Informal STEM Education Network (NISE Net) is a community of informal educators and scientists dedicated to supporting learning about STEM in communities across the United States. NISE Net is utilizing NASA subject matter experts, SMD assets and data, and existing educational products and online portals to create compelling learning experiences that will be widely used to share the story, science, and adventure of NASA's scientific explorations of planet Earth, the solar system, and the universe beyond.

http://bit.ly/2pjQ4rT

Section 2:

Activity Guides

Rover Races

Participants work in teams to model the process for communicating with a rover on Mars, to build programming skills, and understand the effects of time-delay.

Credit: NASA/JPL-Caltech

Key Concepts

- Teams of scientists and engineers use robotic vehicles to explore other worlds.
- There's a time delay in sending and receiving signals from planetary missions.
- Rover missions require careful planning and programming on Earth.

Content Area – Astronomy and Space

Ages – Family, Elementary, Tweens

Activity Time – 20-40 minutes

Prep Time – 20-40 minutes

Difficulty Level – Medium

Mess Level – Medium

Materials List – Large open space to play game; 12 sheets of construction paper per team, varying colors; Masking tape or sidewalk chalk; 1 pen per team of participants; 30 index cards per team; 1 copy of the map per team; (Optional) 3 rocks per team

Build a Program with Related Resources

Learning about how we use rovers to explore other worlds is exciting! Bolster your knowledge by checking out NASA's Mars Exploration Program (https://mars.nasa.gov/) to learn more about how scientists are studying Mars and for details on the rovers and orbiters used to explore the planet.

Consider showing this Mars Rover Video (https://vimeo.com/245835422) at the beginning of this activity to give your patrons a look into what rovers look like, how they move, and how they collect data on Mars!

Mars Rovers, *Trip to Mars*, and *Rover Designs* are other hands-on activities included in this kit that can help your patrons experience the phenomenal ways we communicate with far away rovers. Some additional STEM Activity Clearinghouse activities that can help patrons develop their understanding of how computer programming works are *My Robotic Friends and Graph Paper Programming*.

Need more ideas? Visit our *STEM Activity Clearinghouse* (http://clearinghouse.starnetlibraries.org)

STEM ACTIVITY Clearinghouse

Add Your Review of This Activity

There are many STEM educational resources available to use in programs. We hope that you will give this activity a try! Then, **help others find the "best of the best" by writing a review** on the STEM Activity Clearinghouse. Email your favorite activities directly to a colleague!

Originating Source:
Rover Races was originally developed on behalf of NASA's Mars Exploration Program by Arizona State University's Mars Education Program, and was collaboratively modified by the Lunar and Planetary Institute and the STAR Library Network

Activity Guide

Rover Races

NASA @ My Library

STAR net
Science-Technology Activities & Resources For Libraries

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Overview

Participants work in teams to model the process for communicating with a rover on Mars, to build programming skills, and understand the effects of time-delay.

This activity was modified from
https://www.nasa.gov/pdf/392975main_Rover_Races_Activity.pdf
by *STAR Net* and Lunar Planetary Institute

Credit: Space Science Institute/NCIL

Key Concepts

- Teams of scientists and engineers use robotic vehicles to explore other worlds.
- There is a time delay in sending and receiving signals from planetary missions.
- Rover missions require careful planning and programming on Earth.

Intended Audience
Family, Early Elementary, Upper Elementary, Tweens (9-12)

Preparation Time
20-40 minutes

Activity Time
15 minutes, although participants may opt to repeat the game multiple times.

Materials

For Each Facilitator:

- Large open space to play the game
- 12 sheets of construction paper per team, varying colors
- Masking tape or sidewalk chalk
- 1 pen per team of participants
- 30 index cards per team
- 1 copy of the map for each team
- (**Optional**) 3 rocks per team—for activity extension

Materials (continued)

- (**Recommended**) Mars in a Minute: How Do Rovers Drive on Mars? https://www.jpl.nasa.gov/edu/learn/video/mars-in-a-minute-how-do-rovers-drive-on-mars/

- (**Recommended**) Projector and computer to show video to participants

- (**Optional**) Exploring the Solar System: Mars Rover Content Training Video from the Explore Science: Earth & Space 2018 Toolkit. https://vimeo.com/245835422. ***Please note that in this revised activity, no blind folds are used, and teams are competing against each other to be first.***

Preparation

Before the Event:

- (**Optional)** Review Mars Rover Content Training Video at https://vimeo.com/245835422. ***Please note that in this revised activity, no blindfolds are used, and teams are competing against each other to be first.***

- Create a grid that represents a "Marscape" using masking tape if indoors, or sidewalk chalk if outdoors (see the attached example, which you can use or modify).

- Randomly place colored construction paper within the grid (these will represent hazards and end points).

- Determine a starting point for each human rover and an end point, and place one of the construction sheets at the end point. Make sure that the end points are not obvious.

- (**Recommended**) Set up projector and computer to show the video ***Mars in a Minute: How Do Rovers Drive on Mars?***

- (**Recommended**) If more than 3 teams are playing, consider asking another adult to assist in facilitating the game.

Activity

1. Share Ideas and Knowledge.

- Ask the participants what they know about robotic spacecraft on other planets.
  - Do they know the names of any rovers on Mars?
  - What are some of the reasons that it's difficult to operate a rover on Mars?

- Share that one of the challenges is the great distance to other worlds. It might take an hour to receive a signal from a rover on Mars and send a response. So, driving rovers on Mars is not like driving a remote- controlled car. Mission teams instead need to send a carefully planned series of directions—commands— to the rover.

- (**Recommended**) Show participants the video ***Mars in a Minute: How Do Rovers Drive on Mars?***

As much as possible, encourage the participants to offer information and to respond to others' questions, rather than answering them yourself. Use phrases like "What do the rest of you think?", "Do you agree with ___________?", "Do you have any additional ideas?"

2. Explain the Game

Let the participants know that they will be working in teams to get a human "rover" from its starting position to its goal.

- One person on each team will be the rover, which follows directions, such as "Take 3 steps forward," "Turn right," or "Turn left." ***[Possible modification: for participants over 11 years, consider allowing specific numbers of degrees, such as "Turn 45 degrees right" or "Turn 90 degrees left."]***

- One person on each team will be the "programmer." Only the programmer will know what the goal is for their rover.

- The remaining members will act as radio signals ("relays"), taking turns to deliver a command to their rover.

- Some of the colors of construction paper are "hazards" --places to avoid, where a rover might get stuck. If your rover accidentally steps on a "hazard", you will receive an instruction from the facilitator to stand still for 20 seconds. Only your team's programmer will know which colors are hazards.

- The first team whose rover reaches its end point wins the race.

3. Play the Game

- Arrange the participants in teams. [Each team should have at least 3 people. The number of teams should be limited by the space and the number of facilitators.]

- Each team selects their "programmer." Hold a brief private conversation with all the programmers; provide them with a copy of the map, identifying the construction sheet that is their team's goal and which of the colored sheets of construction are hazards. ***Stress that they cannot share their end point or the hazards with their teammates.***

- Each team should determine which participant is their "rover." Show the rovers to their starting positions.

- The programmer writes a series of instructions, one on each card, to direct their rover to its end point. For instance, the cards may include:

- 3 steps forward	- Turn left	- 2 steps forward	- Turn right
- Pick up rock	- Turn left	- 4 steps forward	

Modification for young participants or limited time: the programmer writes a single instruction (such as "take 3 steps") at a time, then waits to write the next step after the first has been completed. Or, invite younger participants to draw their instructions (such as a stick figure picking up a rock) if they are unable to write.

Modification for ESL participants: Encourage students to use arrows and other symbols as their instructions.

- The race starts! The programmer gives the first message to a "relay" to bring to the rover. Once the rover has completed the instruction, another "relay" can give the next message.

- If a rover steps on a "hazard" the facilitator stops all action and orders that rover to halt for the next 20 seconds and invites the other rovers to continue. (If more than 3 teams are playing, you may need additional facilitators to assist with this.)

Activity (continued)

- If a rover is badly off course, the programmer can write a command to "stop" and send it to the rover via a relay, then write new commands for the rover based on the rover's new position.
- The team with the first rover to reach its end point wins; the remaining teams may continue toward their end point. Encourage the team that finished first to cheer on the remaining teams!
- If desired, repeat the game, changing the roles for the rovers, programmers, and relays.

4. Conclude

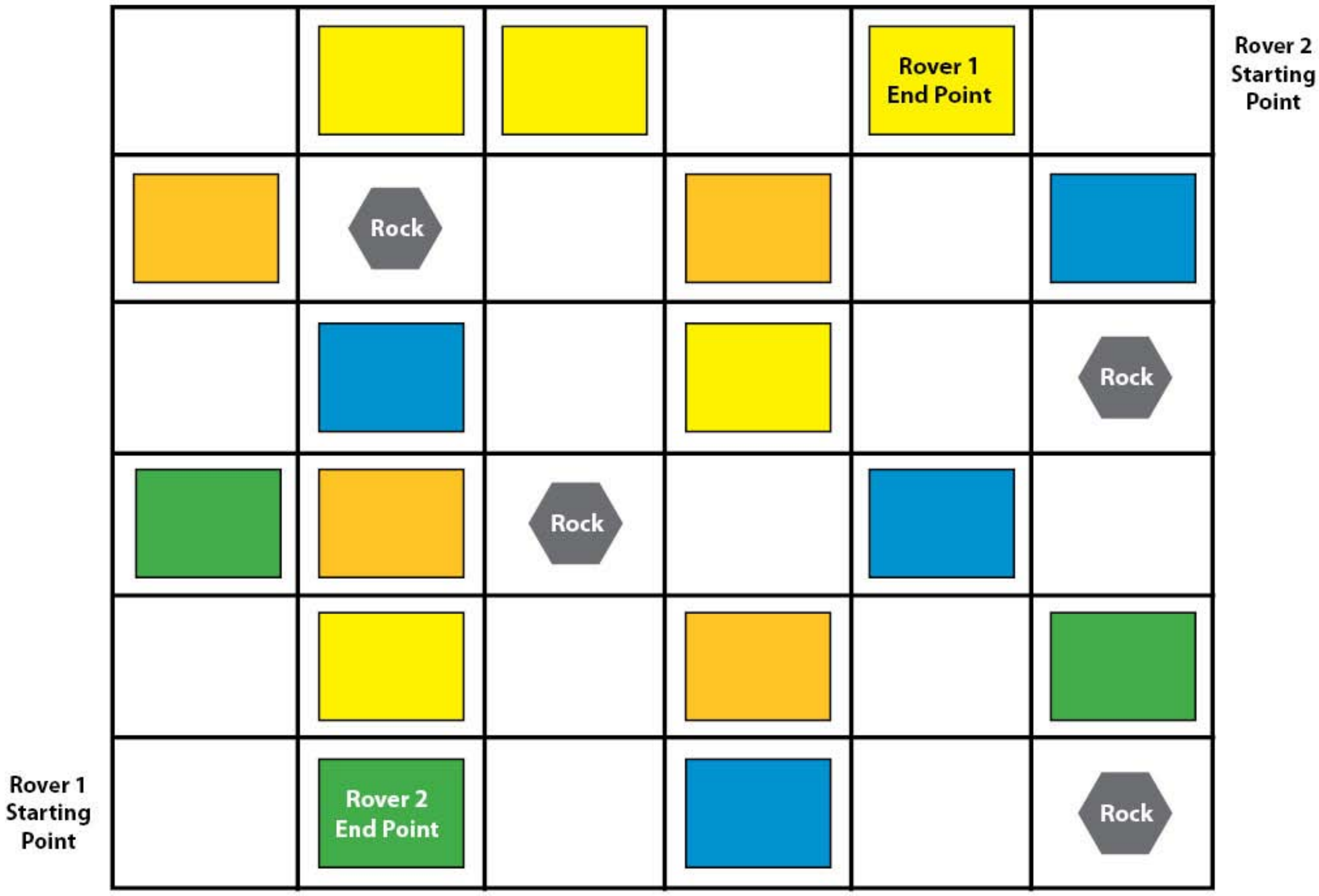
Draw on the participants' observations and reflections:

- Was it difficult to send the rover to the correct locations? How could you improve the "programming"?
- What are some of the problems that might come up during a rover's mission?
- Programming requires very explicit (specific) language. How is communicating with a robot, or a computer, different from communicating with a human?

Extensions

- Play the game again with a modification: invite the rovers to compete to see which can collect the most rock samples.
- Explain that the rovers will be collecting rocks to cache for return to Earth; the rover will need to first travel to and pick up a rock. Each rock sample would need to be cached at the end point before the second rock sample is collected.
- Before starting the game, scatter rock samples on some of the sheets of construction paper.
- Set a specific time limit (such as 5 minutes): the team whose rover collects the most rocks and returns them to its cache (end point) within the allotted time wins.

“Marscape” Map Example



All Orange spots are hazards for Rover 1 | All Blue spots are hazards for Rover 2

Next Generation Science Standards

Science and Engineering Practices

- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Obtaining, Evaluating, and Communicating Information
- Constructing Explanations and Designing Solutions

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solution to other people.

ETS1.C: Optimizing the Design Solution

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Crosscutting Concepts

- Patterns
- Structure and Function
- Interdependence of Science, Engineering, and Technology

Computer Science Teachers Association Standards

- 1B-AP-10: Create programs that include sequences, events, loops, and conditionals
- 1B-AP-11: Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process
- 1B-AP-12: Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features
- 1B-AP-15: Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended
- 1B-AP-16: Take on varying roles, with teacher guidance, when collaborating with peers during the design, implementation, and review stages of program development
- 2-AP-19: Document programs in order to make them easier to follow, test, and debug
- 3B-AP-11: Evaluate algorithms in terms of their efficiency, correctness, and clarity

Illustrated Instructions

Rover Races

Illustrations by Kevan Mills

Rover Races

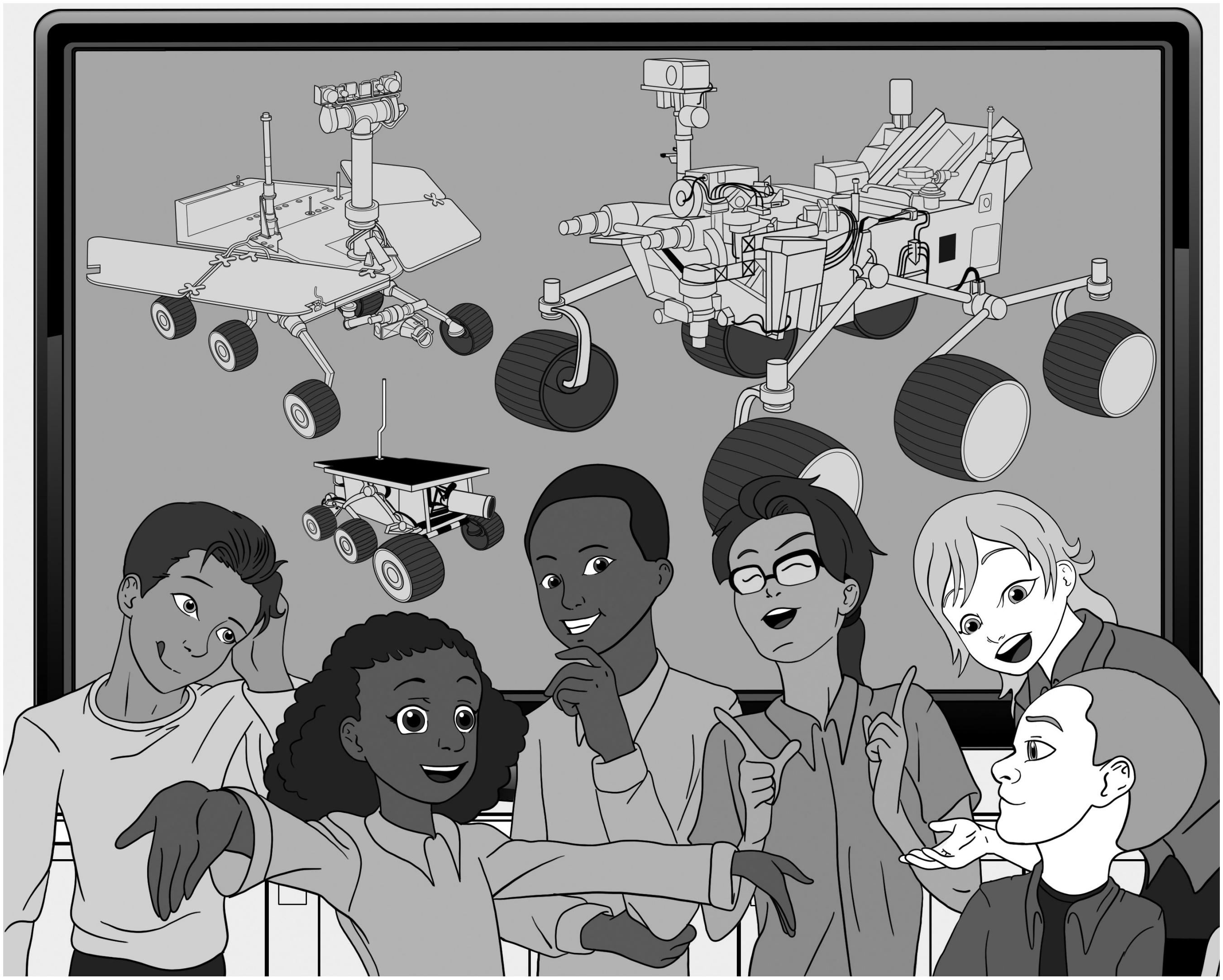


Image 1: Share Ideas and Knowledge

- What are the names of any rovers on Mars?
- What are some of the reasons that it's difficult to operate a rover on Mars?

Rover Races

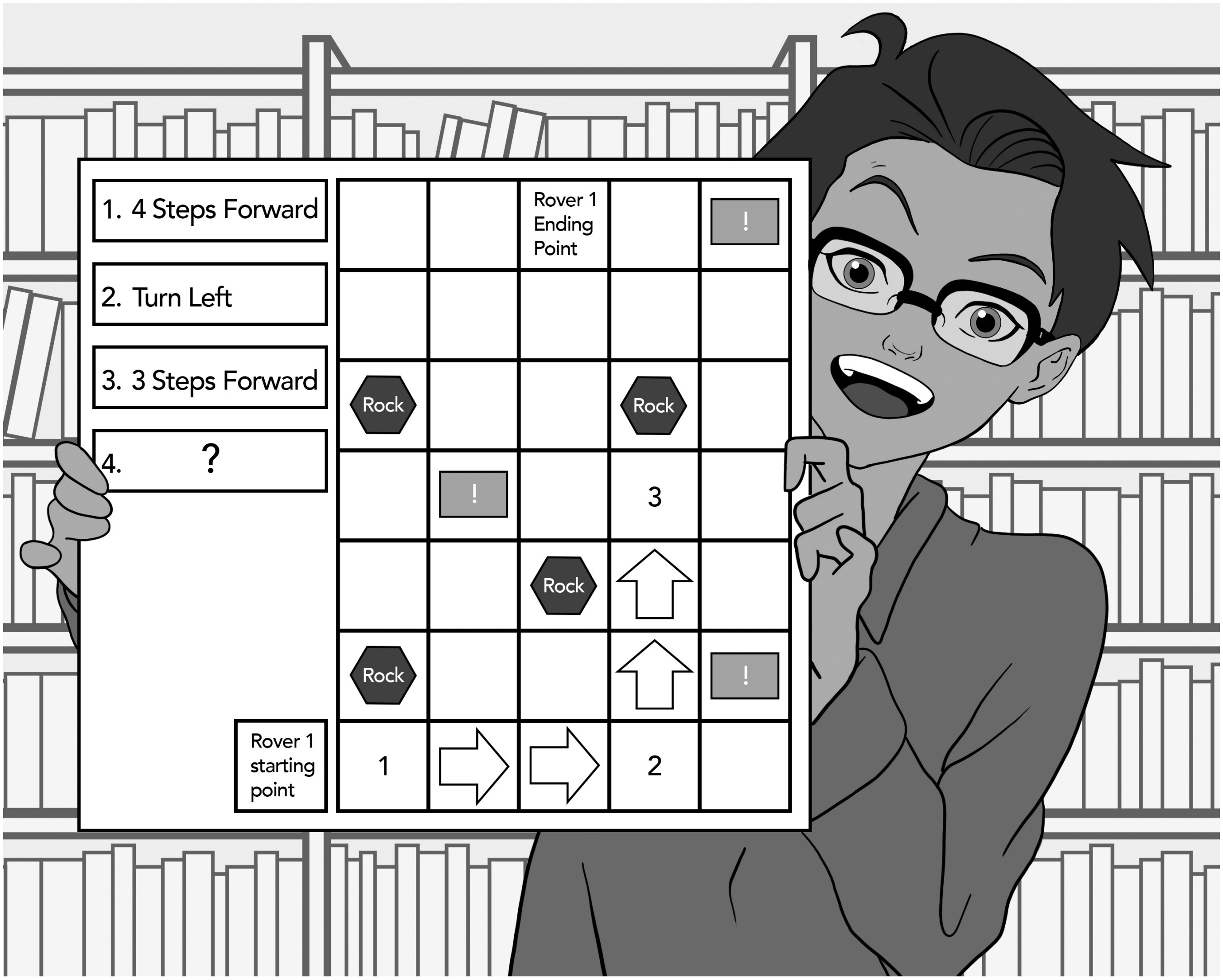


Image 2: Explain the Game

Participants will be working in teams to get a human "rover" from the starting point to the ending point.

- One person on each team will be the rover, which follows directions such as "Take 4 steps forward," "Turn Left," or "Pick up Rock."
- One person on each team will be the "programmer." Only the programmer will be able to see the map.
- The remaining members will act as radio signals ("relays"), taking turns to deliver a command from the programmer to the rover.
- Some of the colors of construction paper are "hazards" – place to avoid. If your rover accidentally steps on a "hazard," you will receive an instruction from the facilitator to stand still for 20 seconds. Only your team's programmer will know which colors are hazards.

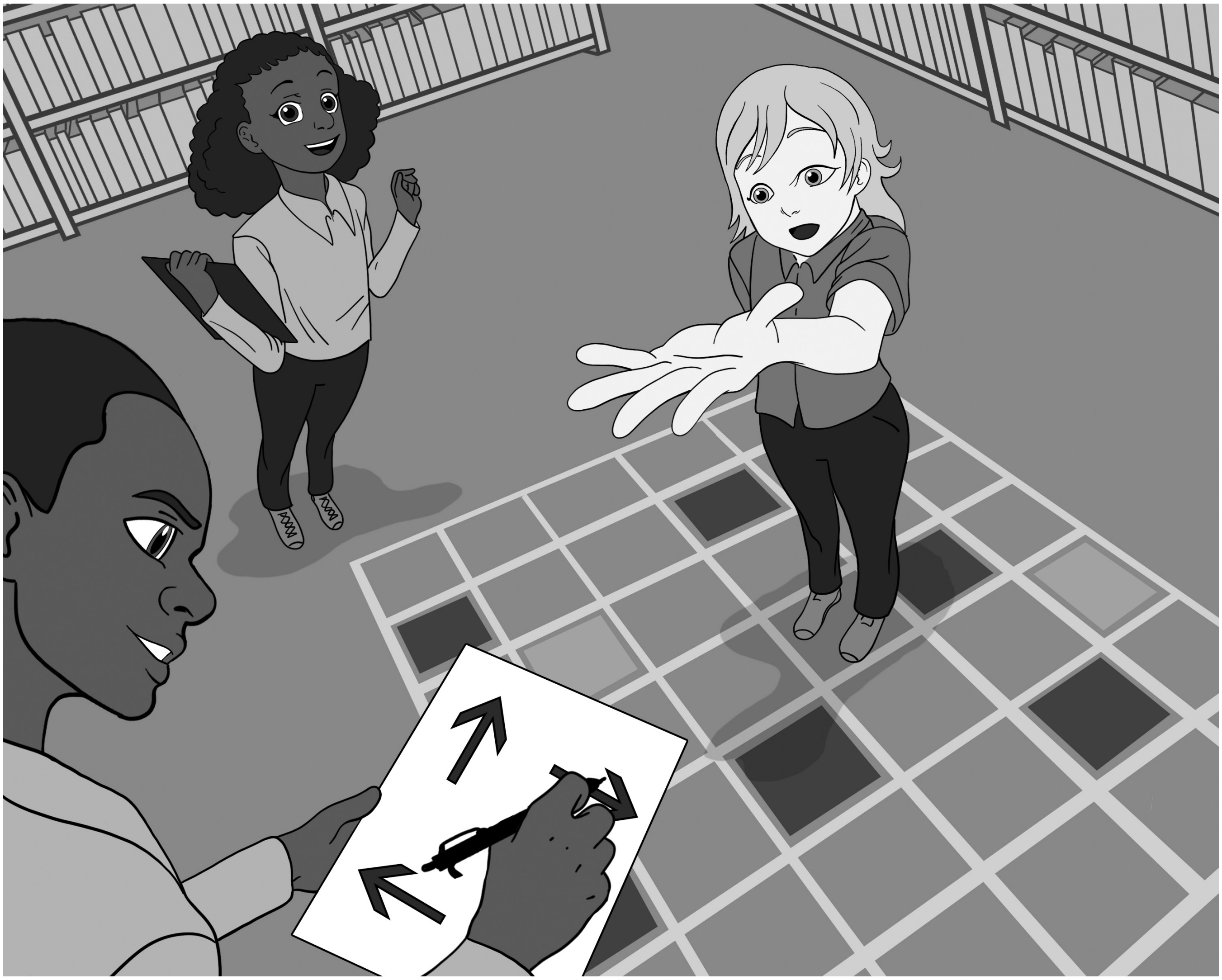


Image 3: Play the Game!

- The first team whose rover reaches its end point wins the race; cheer on the remaining teams as they continue toward their ending point.
- If desired, repeat the game, changing the roles for the rovers, programmers, and relays.

Activity Guide

Searching for Life

Patrons observe cups of soil containing different materials and search for different characteristics of life.

View the online activity guide at: https://bit.ly/2UNBCEU

Credit: Oregon Department of Transportation

Key Concepts

- Life as we know it only exists on Earth, but NASA has missions planned to explore other candidates, including Mars, Europa and exoplanets beyond our Solar System.
- Mars is our closest neighbor, and a likely candidate for finding (microscopic) life in our Solar System.
- Extremophiles on Earth can give us clues about life on other planets and even moons like Titan, which orbits Saturn.

Build a Program with Related Resources

Use the associated illustrations, found in this binder and on the *STEM Activity Clearinghouse*, to help patrons that may benefit from visual instructions. Additionally, these illustrations may help you facilitate this activity in a Station format.

View the activity's how-to video (https://youtu.be/19MsbyQgPT8) for guidance on how to facilitate this activity!

This activity pairs well with *Nurturing Life*, an activity that has participants create their own small gardens and is also featured in this kit.

This activity complements the Mars Engineering activity and can be combined with a presentation by an astrobiologist, planetary scientist, or NASA Solar System Ambassador, if desired.

Need more ideas? Visit our *STEM Activity Clearinghouse* (http://clearinghouse.starnetlibraries.org)

STEM ACTIVITY Clearinghouse

Add Your Review of This Activity

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Content Area – Biology

Ages – Family, Upper Elementary, Tweens

Activity Time – 40 min-1 hour

Prep Time – 10-20 minutes

Difficulty Level – Medium

Mess Level – Medium

Materials List – 3 (clean) plastic cups (5–8 oz.) clear if available, ¾ to 1 cup of sand, enough to fill each cup ¼ full, 3 teaspoons (tsp.) sugar o 1 teaspoon (tsp.) instant active dry yeast, 1 tablet of crushed (as finely as possible) Alka-Seltzer® or comparable fizzing tablets, hot water, enough to cover the sand in each cup (not hot enough to kill the yeast), 1 pitcher, carafe, or other appropriate container for the hot water, optional: library books related to the topic, optional: a variety of colorful Post-It® notes

Originating Source:
Searching for Life was developed by the Lunar and Planetary Institute and was adapted from "It's Alive!" from Destination: Mars, NASA Johnson Space Center, 2002.

Illustrated Instructions

Searching for Life

Illustrations by Kevan Mills

NASA @ My Library

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Searching for Life

Image 1

Look at what is in the cups. What do you see? Discuss with others.

Searching for Life

Image 2

Smell what is in the cups. What do you smell? Discuss with others.

Searching for Life

Image 3

What did you observe when you looked at and smelled the materials in the cup? Write down and discuss your observations.

Searching for Life

Image 4

Carefully pour hot water into the cups. **BE CAREFUL WITH HOT WATER** and ask an adult for assistance.

Searching for Life

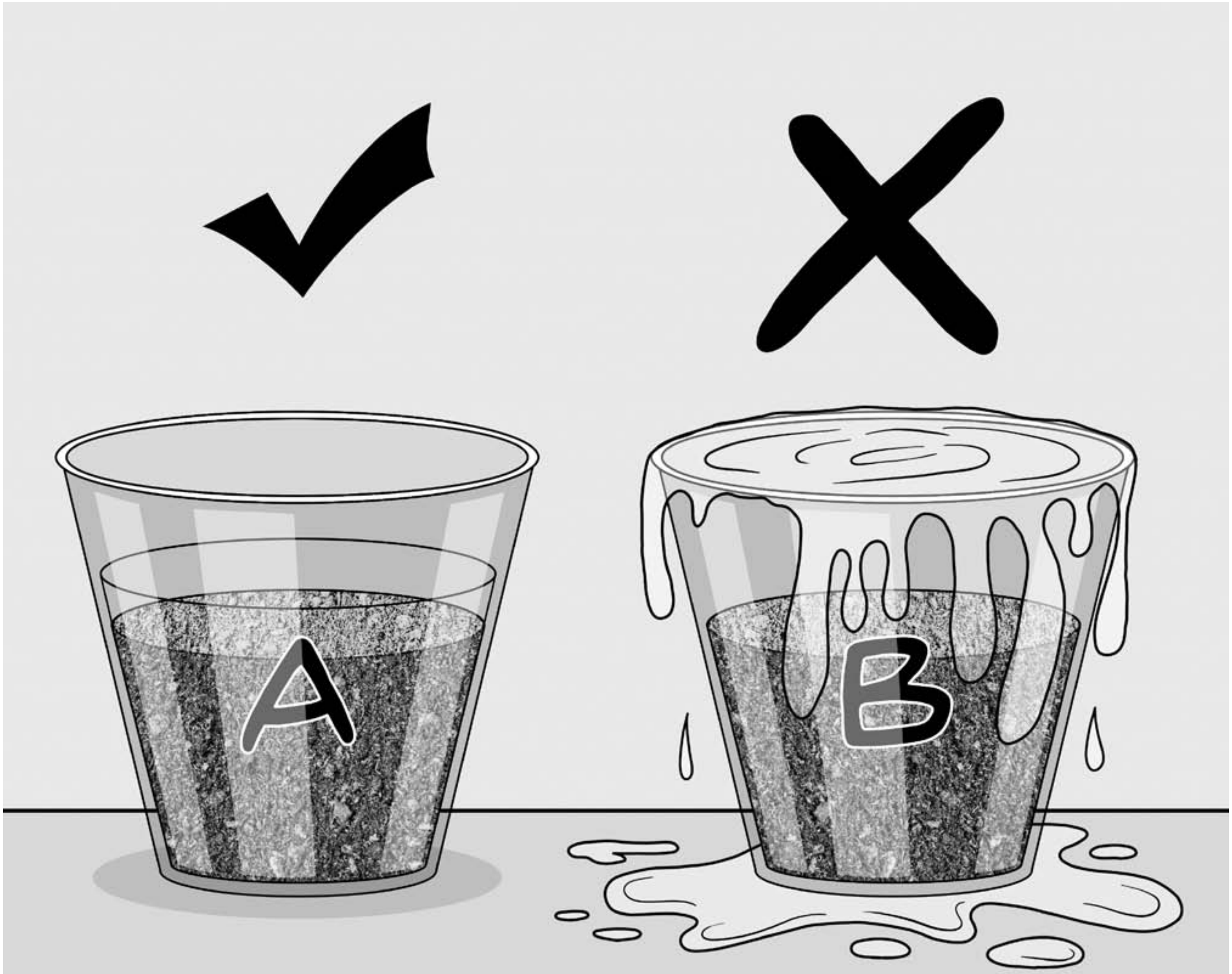


Image 5

Pour enough hot water to fill the cups halfway. The water should barely cover the top of the sand mixture. **DO NOT FILL THE CUPS ALL THE WAY**.

Searching for Life

Image 6

DO NOT TASTE OR DRINK WHAT IS IN THE CUPS

Searching for Life

Image 7

Observe the water-filled cups for 10 minutes. What do you see?

Searching for Life

Image 8

Smell the cups. What do you smell?

Searching for Life

Image 9

Discuss your observations and write them down!

Searching for Life

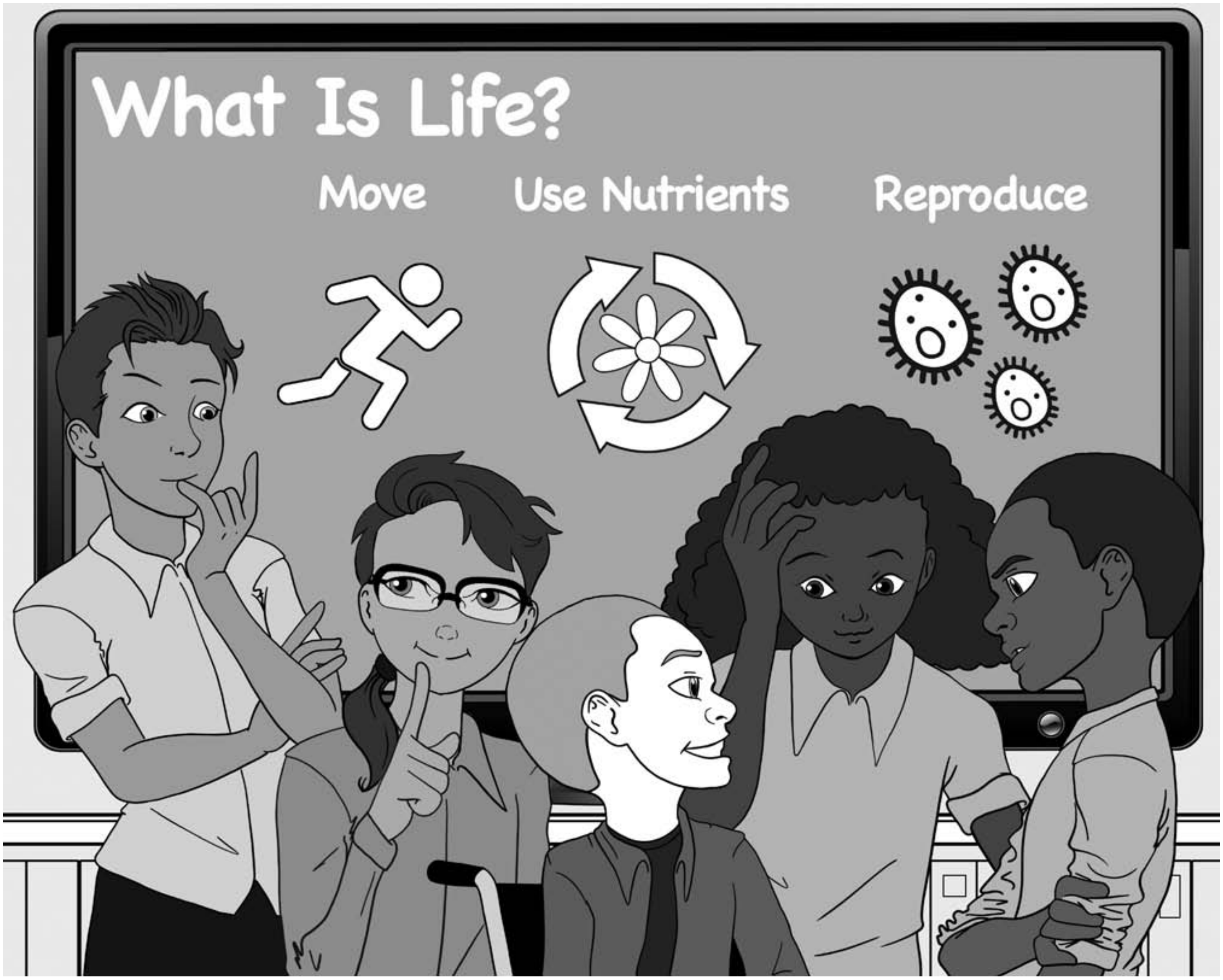


Image 10

- What are the characteristics of life?
- What are some examples of living things?
- What are some examples of non-living things?
- How do you know that something is alive?

Nurturing Life

A garden can be a reminder of life's needs and our connection to the planet we call home. Children consider the requirements of living things and compare the surface conditions on Mars to those found on Earth as they create take-home gardens out of plastic bottles. Gardening tips and options for indoors and outdoors are provided.

View the online activity guide at: https://bit.ly/2N5DvsA

Key Concepts

- Life as we know it only exists on Earth, but NASA has missions planned to explore other candidates, including Mars, Europa and exoplanets beyond our Solar System.
- Mars is our closest neighbor, and a likely candidate for finding (microscopic) life in our Solar System.
- Extremophiles on Earth can give us clues about life on other planets and even moons like Titan, which orbits Saturn.

Build a Program with Related Resources

Use the associated illustrations, found in this binder and on the *STEM Activity Clearinghouse*, to help patrons that may benefit from visual instructions. Additionally, these illustrations may help you facilitate this activity in a Station format.

Reach out to a local garden or garden supply shop to see if they are interested in helping facilitate this activity.

This activity pairs well with *Searching for Life*, an activity where patrons look for characteristics of life in different types of soil.

This activity complements the Mars Engineering activity and can be combined with a presentation by an astrobiologist, planetary scientist, or NASA Solar System Ambassador, if desired.

Need more ideas? Visit our *STEM Activity Clearinghouse* (http://clearinghouse.starnetlibraries.org)

STEM ACTIVITY Clearinghouse

Add Your Review of This Activity

There are many STEM educational resources available to use in programs. We hope that you will give this activity a try! Then, **help others find the "best of the best" by writing a review** on the STEM Activity Clearinghouse. Email your favorite activities directly to a colleague!

Content Area – Biology, Earth Science

Ages – Family, Early Elementary, Upper Elementary, Tweens (9-12)

Activity Time – 1-2 hours

Prep Time – 20-40 minutes

Difficulty Level – Medium

Mess Level – Medium

Materials List – Select regionally-appropriate seeds or plants, ½ cup to ¾ cup of Gravel or pea rock for the bottoms of containers, 1 clean, empty 1L or 20 oz. plastic bottle (no lid/cap), 2 cups of Soil (sandy mix described in the "Preparation" section or a "succulent and cactus" mix), ½ cup of Water, duct tape (in fun colors, if possible), approximately 4–6 inches per child, 1 plant care label/card, including plant name, lighting, temperature, and watering/feeding requirements

Originating Source:
Nurturing Life was developed by the Lunar and Planetary Institute

Illustrated Instructions

Nurturing Life

Illustrations by Kevan Mills

NASA @ My Library

The material contained in this product is based upon work supported by NASA under grant award No. NNX16AE30A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

Nurturing Life

Image 1: Think and Discuss

- "What is a scientist?"
- "What is biology?"
- "What is astrobiology?"

Nurturing Life

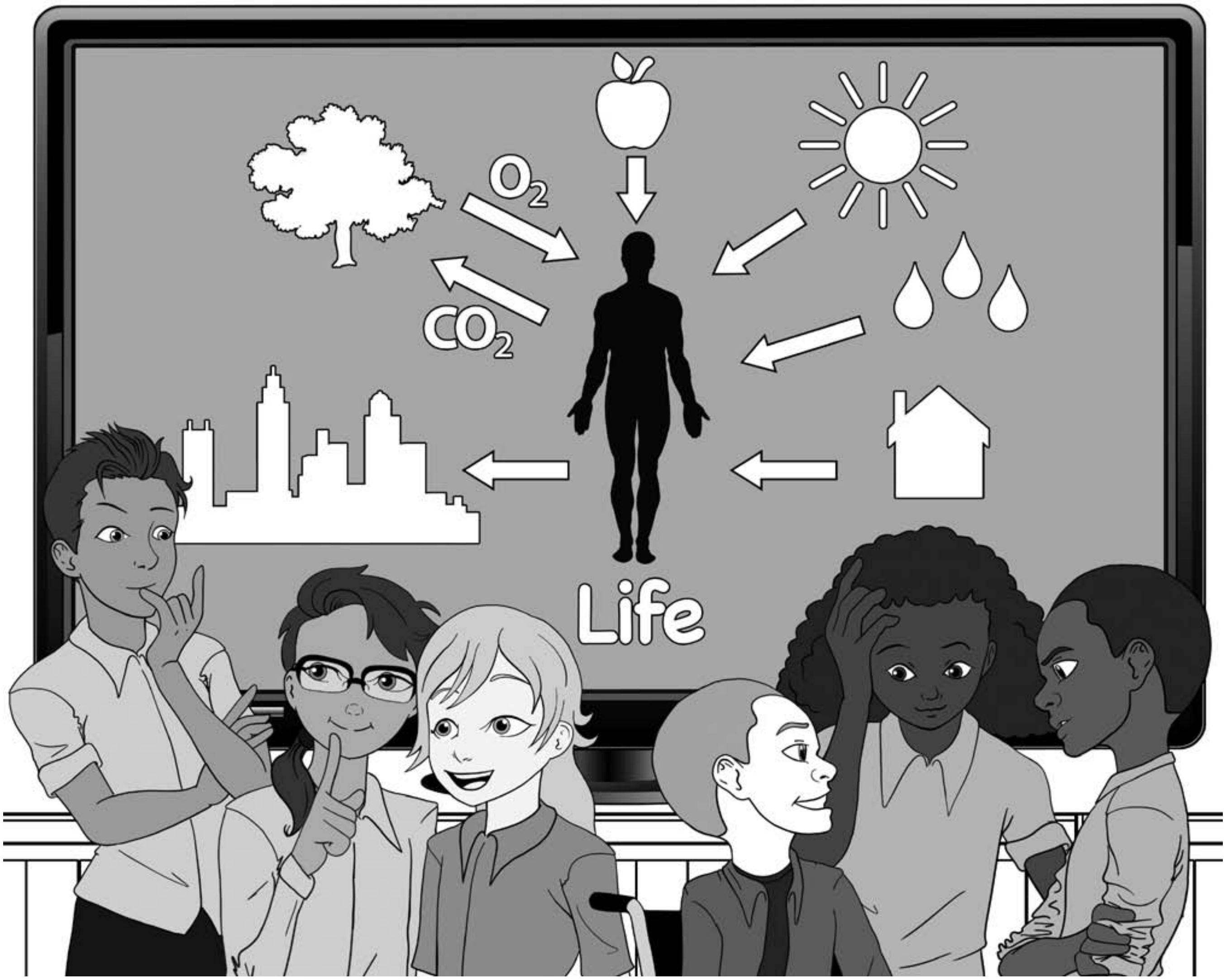


Image 2: Think and Discuss

- "What do we need for life?"
- "What do living things need to survive?"

Nurturing Life

Image 3: Think and Discuss

- "What is it like on Mars?"
- "What would it be like to live on Mars?"

Nurturing Life

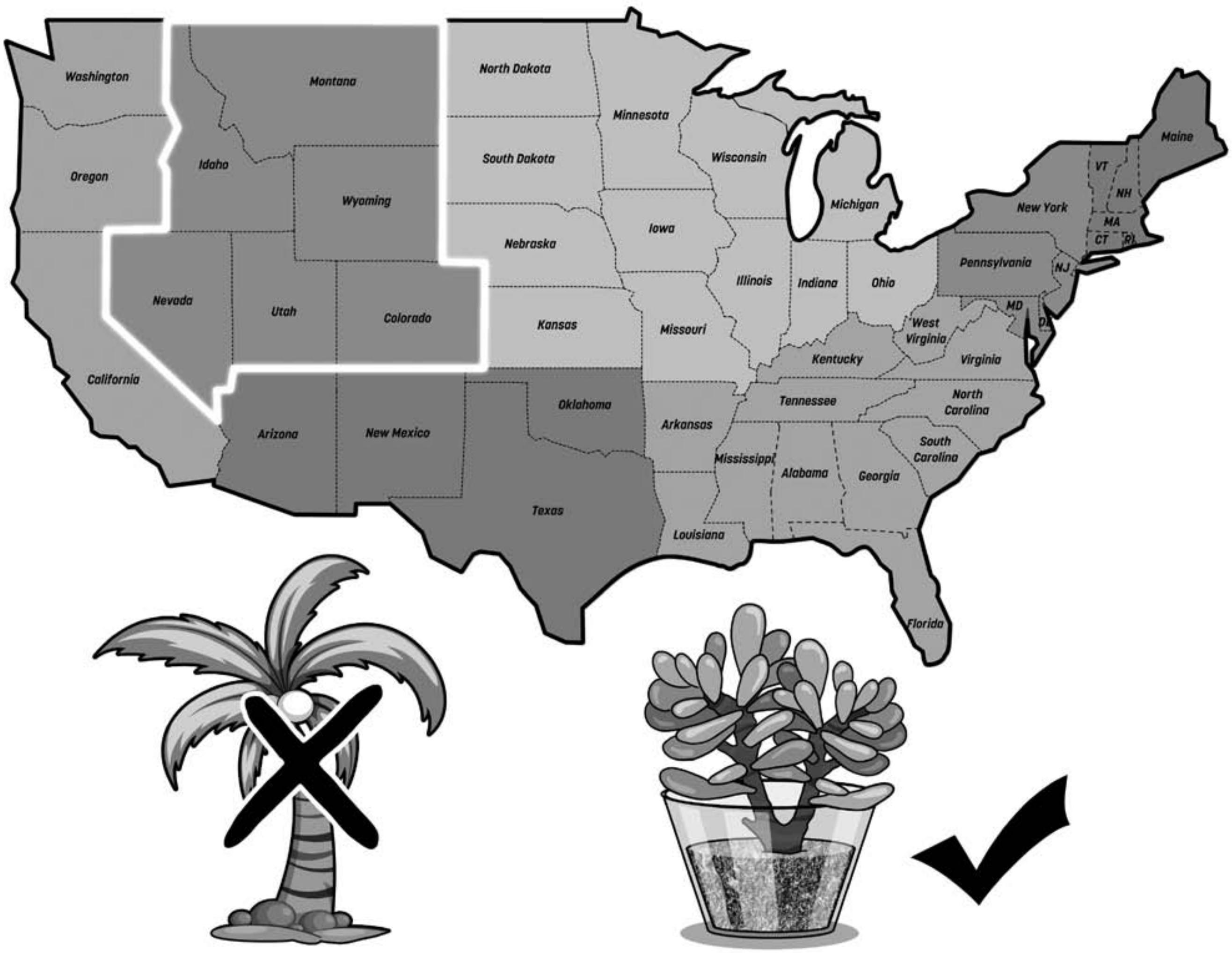


Image 4

Select seeds or plants that can grow and survive in a small container and will do well in the region that you live. For example, a jade plant is a great choice if you live in Colorado or Utah. A coconut tree would be a bad choice!

Nurturing Life

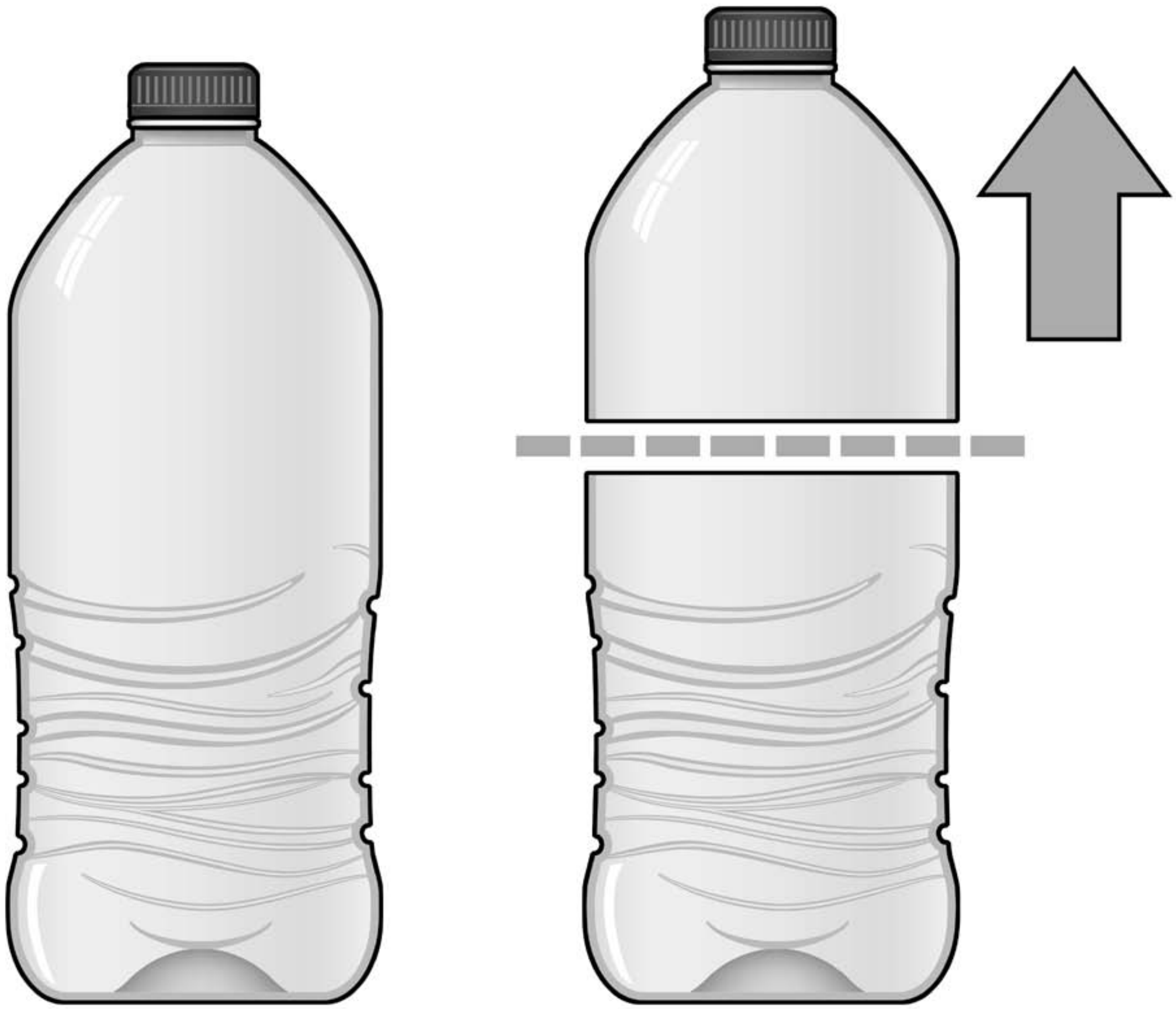


Image 5

Remove the top of the bottle from the lower part of the bottle. Your bottle should already be separated. If your bottle is not separated, ask an adult for help.

Nurturing Life

Image 6

Pour ½ - ¾ cup of small rocks or gravel into the bottom of the bottle.

Nurturing Life

Image 7

Add 2 cups of your soil mix into the bottle.

Nurturing Life

Image 8

Plant your plants or seeds according to package directions.

Nurturing Life

Image 9

Add about ½ cup of water to your bottle, or until there is around 1 inch of water in the bottom of the bottle (in the rocks).

Nurturing Life

Image 10

Replace the top of the plastic bottle so that it fits around the outside of the bottom. Secure the top of the bottle (without a cap) in place with a piece of tape.

Nurturing Life

Image 11

Take your "garden in a bottle" home with you. Keep a daily journal of your plant's growth and changes.

"The Search for Habitable Worlds" Collection

The following list contains activities in the STEM Activity Clearinghouse that are relevant to Kit D: The Search for Habitable Worlds. These activities are, of course, timeless and can be conducted whenever the desire strikes, but they were added to the binder to provide an idea of the great breadth and depth of material available to support this particular STEM facilitation kit. Enjoy!

Rover Designs
Participants explore programming concepts by "coding" one another to build space designs using uniform blocks, such as Keva Planks.
http://bit.ly/2JG56iq

Mars Rovers
Players acting as "Mission Control" and a "Rover" must work together to navigate a large obstacle course – with blind folds!
http://bit.ly/31ytqJf

Binary Bead Craft: Bracelet (or Necklace) Version
Write your own name or nickname in binary code using beads on a bracelet.
http://bit.ly/2N8xBpY

Binary Bead Craft: Pin Version
Write your initials in binary code to create beaded pins.
http://bit.ly/2Je5Qv1

Anomaly Adventures: Space Through the Eyes of a Computer
Humans are excellent at spotting the differences between two images, but we need computers to help us explore the universe and study our own planet. Children compare space images to find differences – just like computers use the process of "anomaly detection."
http://bit.ly/2N9XbfP

I Want to Hold Your Hand
NASA uses robotic explorers to collect information about places where humans cannot travel. This activity leads patrons to build and test a robotic-like hand.
http://bit.ly/2BwPmtO

Space Forts: Exploring Computer Processing Systems
Patrons learn about parallel and serial processing computer systems by racing the clock to build a fort with stackable blocks.
http://bit.ly/2PEgXBI

Passion for Pixels
Learn about how remote-sensing satellites transmit data and digital images by creating an image on grid paper and then use a code of zeros and ones to transmit the image to a partner.
http://bit.ly/35Y8XkL

How Do We Find Planets Around Other Stars?
Discover the techniques scientists use to find planets orbiting distant stars: use a foam ball, a toothpick, and a small ball of clay.
http://bit.ly/2oUPfWt

Coloring the Universe (with Pencil Code)
Participants use pencilcode.net to undertake a series of simple programming exercises, including recoloring images of scenes, everyday objects, and finally, a supernova and region where stars are forming.
http://bit.ly/2pJTYKi

Exploring the Colors of Mars
Patrons examine satellite and rover images to learn about the various surface features that cause the different color of Mars, then create an art concept of the planet.
http://bit.ly/2MzVLdY

Animal Remix
Design a mythical animal through collage and illustration! This activity builds creativity as children combine items in new ways.
http://bit.ly/2PcOXEW

Adaptions of Cave Critters
In this activity, patrons explore their creativity while they learn about a cave environment and create an organism that lives there!
http://bit.ly/2W2XNXn

Mars Engineering
Mars is a good candidate for finding past and/or present life beyond Earth. Groups of participants design Mars rovers that could search for the building blocks of life in martian rocks and build model rovers out of everyday materials.
http://bit.ly/32EZxbw

Trip to Mars
Participants play a game that steps through a human mission to Mars, to learn about the variety of people on the ground supporting missions, and the factors that can affect a mission outcome.
http://bit.ly/2N1lpY8

Section 3:

Quick Facilitation Guides

Code & Go Robot Mouse

This *Quick Facilitation Guide* provides tips on using the Code and Go Robot Mouse, and provides suggestions for engaging activities. For more in-depth instructions, please also see the instructions provided in the Mouse box.

Key Concepts

- NASA uses smart spacecraft and robotic explorers to explore worlds humans can't safely visit (yet).
- Mars is our closest neighbor, and a likely candidate for finding (microscopic) life in our Solar System

Ages: Pre-K, Elementary, Tweens, Teens, Family

Material List: Code and Go Robot Mouse and accessories

Activity Time: 5-60 minutes

Type of Program: Stations, Stand-alone Activity, Facilitated Activity

Simple Instructions

- Create your own maze for your mouse (Colby) to navigate through. Use the Mars map to really drive home that Colby represents a Mars rover.
- Make sure your mouse is turned on, and the batteries are charged.
- Step 1 for patrons is to use the Code Cards to determine their mouse's path. This allows them to "run" the code in their head before just guessing. (Remind patrons that each instruction moves Colby approximately 5 inches)
- Step 2 for patrons is to input their code into Colby. Simply push the colored buttons in the order the cards were placed.
- Step 3, push GO! (The center button). It's very unlikely they get it right on the first try. Encourage them to go back to their cards, rather than just try to make changes directly on Colby.
- Step 4, press the CLEAR button to try the new code. • Can your patrons get Colby to follow the Rover tracks on the Mars map?

Suggestions for Use

- Can your patrons get Colby to follow the Rover tracks on the Mars map?
- Ask them to send Colby to various features on the Mars map. Have them guess whether or not these features would actually be this easy to get to if they were really on Mars
- Create a Rube Goldberg machine with the robots, and other items in your library! Can your patrons use multiple robots to accomplish the task?
- Please visit http://bit.ly/2NjDDEg for downloadable resources related to this activity.

Connections to Other Kit Materials

- We provided rechargeable batteries in Kit A, make sure you use them!
- This activity works really well with the provided Mars map, infusing Martian geology into coding activities!
- If you're using the Code and Go Robot Mouse in stations, consider also using the Code-a-pillar, and Code Hopper activities!"
- With younger patrons, have them try the Code Hopper activity first, to help them to better understand sequencing.

Connections to *STAR Net* Activities

- Please visit the *STEM Activity Clearinghouse* at www.clearinghouse.starnetlibraries.org and check out the "Computational Thinking" collection to find great activities on coding and other similar activities!

Code Hopper

This *Quick Facilitation Guide* provides tips on using the Code Hopper tiles, and provides suggestions for engaging activities.

Key Concepts

- Following directions
- Thinking computationally

Ages: Pre-K, Early Elementary, Family

Material List: Code Hopper Tiles

Activity Time: 5-30 minutes

Type of Program: Stations, Stand-alone Activity, Facilitated Activity

Simple Instructions

The Code Hopper tiles provide an easy to understand introduction to coding that helps children develop skills following direction, and also incorporates some physical activity!

Although this activity is very simple to complete and implement,it's actually teaching algorithmic thinking. The components of algorithmic thinking are sequencing (DO this), Conditionals (IF, then), and Repetition (REPEAT).

You can either sequence the tiles for children to complete, or let them work together to make their own program!

Details

Sequence – When you or the patrons put the mats in order, you've created a "sequence" or a program!

Conditionals – The "Yes/No" mat lets participants use conditional commands called "branching". For example, if the purple mat that says "Do you see a triangle" is the next command, they'll move a different direction depending on what they see!

Repetition – The "Repeat" mat says how many times to do a certain activity, or even a set of activities!

Suggestions for Use

- Before doing a whole sequence, have your patrons try each mat, so they know what the action looks like!
- Consider starting with the "regular action" mats before adding the repeats. This lets patrons get comfortable going through the "code."
- When you add the question mats, feel free to change the question (just use a sticky note!) to make it relevant to your space. "Do you see a cat?" or "Do you see a book bigger than your face?"
- For more advanced patrons, add a second set of mats, or even create your own!

Connections to Other Kit Materials

- If you're planning on having younger kids play with the robots included in the kit, using the Code Hopper tiles first is a great way to get them into a "coding" mindset!

Connections to *STAR Net* Activities

- Please visit the *STEM Activity Clearinghouse* at www.clearinghouse.starnetlibraries.org and check out the "Computational Thinking" collection to find great activities on coding and other similar activities!

Quick Facilitation Guide

Code-a-Pillar Twist

This *Quick Facilitation Guide* provides tips on using the Code-a-Pillar, and provides suggestions for engaging activities.

Key Concepts

- Following directions
- Thinking computationally

Ages: Pre-K, Early Elementary, Family

Material List: Code Hopper Tiles

Activity Time: 5-30 minutes

Type of Program: Stations, Stand-alone Activity, Facilitated Activity

Simple Instructions

The Code-a-pillar provide an easy to understand introduction to coding that helps children develop skills following direction, and works really well with other items in the kit!

Although this activity is very simple to complete and implement, it's actually helping participants understand sequencing, and is a fantastic analogue for a Mars Rover, which must receive multiple commands at once.

Details

The Code-a-Pillar works by twisting each dial (on each section of the Code-a-Pillar) to the activity you want it to do. The options are:

- Turn Left
- Move Straight
- Turn Right
- Play Music
- Make Various Sounds

When you press "go", the Code-a-Pillar will do all the commands in order, just like a Rover!

Suggestions for Use

- Before doing a whole sequence, have your patrons try each command, so they know what the action looks like!
- Create an obstacle course!
- Talk about "testing" the Code-a-Pillar. How can patrons determine the right actions to complete a task?
- Please visit http://bit.ly/2NjDDEg for downloadable resources related to this activity.

Connections to Other Kit Materials

- The Code-a-Pillar works great in stations with the Code and Go Robot Mouse, and prior kit activities.
- Check out the "Story-time Script" document for a suggested hour-long program using the Code-a-pillar, Robot Mouse, and provided books!

Connections to *STAR Net* Activities

- Please visit the *STEM Activity Clearinghouse* at www.clearinghouse.starnetlibraries.org and check out the "Computational Thinking" collection to find great activities on coding and other similar activities!

Winogradsky Column

This Quick Facilitation Guide is adapted from the American Museum of Natural History's activity "How to Make a Winogradsky Column." It provides instructions on how to make a Winogradsky Column and provides suggestions for how to make it an ongoing experiment in your library.

Credit: Space Science Institute/NCIL

Key Concepts

- Microorganisms have a wide array of conditions they can live in, ranging from anaerobic (no oxygen) to aerobic (oxygen present).
- The byproducts (such as oxygen and other gas exchanges) of some organisms can provide the conditions that other organisms require for life.
- Different microbes are adapted to different environmental conditions (such as light and nutrient availability), but their metabolism processes lead to the formation of niches for other microbes creating intersecting, cooperative ecosystems.
- NASA's Astrobiology Program (astrobiology.nasa.gov) supports cutting edge research to better understand how life formed on Earth and whether it exists beyond Earth. The search begins with understanding extreme life on Earth, such as the microorganisms that can survive in anaerobic (no oxygen) conditions!

Intended Audience
- Families or other mixed-age groups, including children as young as 10 years old with assistance from an older child, teen, or adult.
- School-aged children ages 10 and up.
- Tweens & Teens

Activity Time – 8-10 weeks

Type of Program – Facilitated hands-on

Originating Source – American Museum of Natural History

Materials

- One clear 16 oz bottle per column (if using a water or soda bottle, you will need scissors to cut the tops off)
- Permanent marker
- Shovel or trowel
- Two buckets
- Two mixing bowls
- Newspaper or plain paper (shredded)
- Scissors
- A raw egg
- Plastic wrap
- Rubber bands (one per column)
- Access to a muddy stream, pond, lake, or marsh
- Rubber boots and old clothes that can get muddy (optional)
- Data collection notebook

Preparation

1. Prepare the bottle: if using a plastic water or soda bottle, carefully cut off the top of the bottle. Draw two short lines on the bottle: one a quarter from the bottom, the other a quarter of the way from the top.
2. Cut a quarter sheet of newspaper (or plain paper) into thin strips and then again into small rectangles. **This will be a source of carbon for the microbes.**

Collection

3. Dig up mud from a pond or riverbed and fill your bucket with enough mud to fill the bottle. **Microbes live in the mud!**
4. Transfer enough mud into a mixing bowl to fill ¾ of the bottle. Add water (from the pond/river or tap water) and stir until it is the consistency of a milkshake.
5. Transfer about ¼ of the mud mixture into the other mixing bowl. Stir in a handful of the shredded newspaper and add one egg yolk. **The yolk will be a source of sulfur for the microbes.**

Credit: Space Science Institute/NCIL

Make the ecosystem

6. Shovel the yolk and newspaper mud mixture into the bottom quarter of the bottle (to the lower line). Gently tap the bottle to release air pockets as the mud settles.
7. Add the regular mud mixture to the bottle until it is about a quarter of the way from the top (to the upper line).
8. Add water, leaving an inch of air at the top.
9. Cover the pottle with plastic wrap and secure with a rubber band or tape.
10. Place your column in a well-lit location where it can be undisturbed for 8-10 weeks.

Credit: Space Science Institute/NCIL

Record your observations over time

11. As time goes on, observe various color changes as the microbes separate into their various environments. **Different colors represent different species of microorganisms.**
12. Record your observation in a journal or bulletin board display, noting colors, changes in the sediment, and any differences between multiple columns if you made more than one. Leave a magnifying glass next to the column for closer inspections and take a photo of the column each week to visually compare changes over time. Always include the photo's date and time.
13. Use online tools to identify the microbes:
    https://www.amnh.org/
    http://www.mbio.ncsu.edu/mb452/winogradsky_columns/wc.html

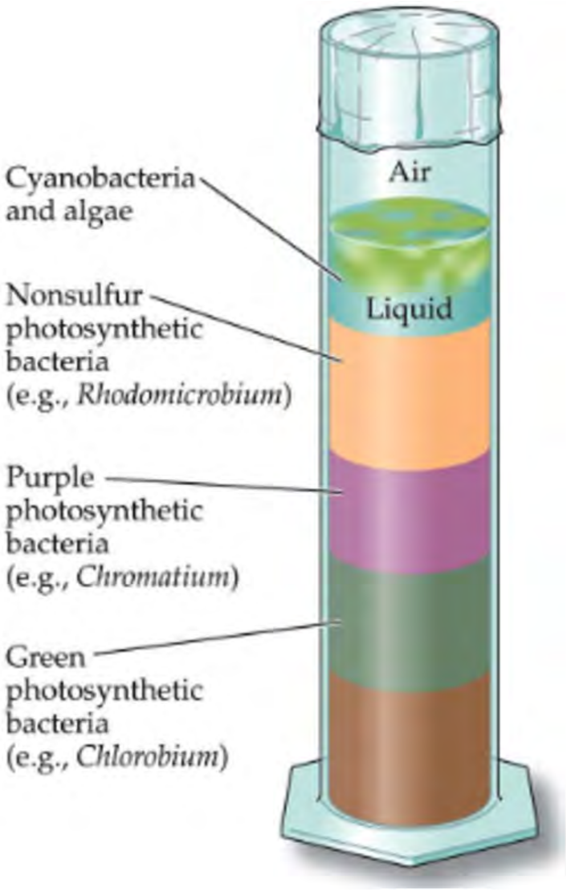
Credit: Space Science Institute/NCIL

Winogradsky Columns

A Dynamic Ecosystem in a Bottle!

What do you see?
It can take months for microbial communities to develop. Use the magnifying glass to spot changes in texture or color throughout the column!

Could this be what life is like on other worlds?
NASA's Astrobiology Program supports cutting edge research to understand how life formed on Earth and whether it exists elsewhere. The search begins with understanding extreme life on our planet!



- Microbes have a wide array of conditions they can live in.
- These conditions range from anaerobic (no oxygen) to aerobic (with oxygen).
- Byproducts of some microbes provide conditions for other organisms to live.
- These processes lead to the formation of intersecting, cooperative ecosystems!

Image Credit: NaturalGreen

An Enclosed, Self-Sustaining Microbial Ecosystem

The **Winogradsky Column** is a simple device for culturing a large diversity of microorganisms. Invented in the 1800s by Sergei Winogradsky, the device is a column of pond or creek mud and water mixed with a carbon source, such as newspaper, and a sulfur source, such as egg yolk. Incubating the column in sunlight for months results in the growth of different microorganisms, including several species of bacteria, cyanobacteria, and algae.

These columns showcase how sulfur-and nitrogen-dependent microbes derive their energy from chemical reactions in a process called chemoautotrophy. Sunlight, water, and organic material from the sediment will fuel the growth of life. Over time, microbial communities grow, with different colors indicating different types of microorganisms. Together, they will make up an intersecting, cooperative ecosystem!

Section 4:

Science Books and Related Resources

Science Books

1) On the Space Station (Carron Brown)

This book is appropriate for pre-k through elementary audiences, and can easily be used for in-person or online story-time. A flashlight is required to view the interactive pages (cell phone lights work well).

2) Birthday on Mars (Sara Schonfeld and Andrew J. Ross)

This book is appropriate for pre-k through elementary audiences. This book is well-suited for in-person or online storytime. Kids especially love singing Happy Birthday to the Rover! For in-person programming, consider combining with the Mars map and robots to act out the story! Also consider adding "Moon's First Friends".

3) 8 Little Planets (Chris Ferrie)

This sturdy board book is appropriate for pre-k through elementary audiences. Also great for check-out.

4) Future Astronaut (Lori Alexander and Allison Black)

This book is most appropriate for pre-k storytime audiences. Contains humor that parents and library staff will appreciate. Also a good item for circulation.

5) Moon's First Friends (Susanna Leonard Hill)

This book is ideal for elementary audiences. Consider combining with "Birthday on Mars", the Mars map, and robots to create an fun and interactive storytime!

Web Links to Kit Materials

Below you will find a list of web links to resources for your kit.

Activities:

Code-a-Pillar Twist
https://amzn.to/2BJ99pO

Code Hopper
https://amzn.to/2JlrKfU

Searching for Life
Yeast (6 packets)
https://amzn.to/2MLyOER

Cups (5)
https://amzn.to/33ULA9C

Alka Seltzer (3 packets)
https://amzn.to/2oeBpO5

Code & Go Robot Mouse
https://amzn.to/2N5aAV2

Rover Races (stress reliever gray rock)
http://bit.ly/2W9mP6Y

Sugar (5 packets)
https://amzn.to/2PcfYZf

Sand (1 bag)
https://amzn.to/2N8T6qX

Books:

Future Astronaut (Lori Alexander)
https://amzn.to/361Sgov

Birthday on Mars (Sara Schonfeld)
https://amzn.to/2pNf4Yw

On the Space Station (Carron Brown)
https://amzn.to/2Wb6tuE

Moon's First Friends (Susanna Leonard Hill)
https://amzn.to/2JhzmjA