

MARS

ONE THOUSAND ONE



EDUCATOR GUIDE

Table of Contents

- 3 Mars Timeline**
- 6 Histogram Activity of Martian Exploration**
- 8 Mars Quick Guide**
- 10 Earth, Mars, and Titan: Similarities and Differences**
- 12 Going to Mars**
- 14 Landing Site Selection**
- 17 Ice as a Mineral**
- 19 Hydroponics**
- 21 Selected Resources**
- 22 Bibliography & Sites Used in Activities**

Contributors

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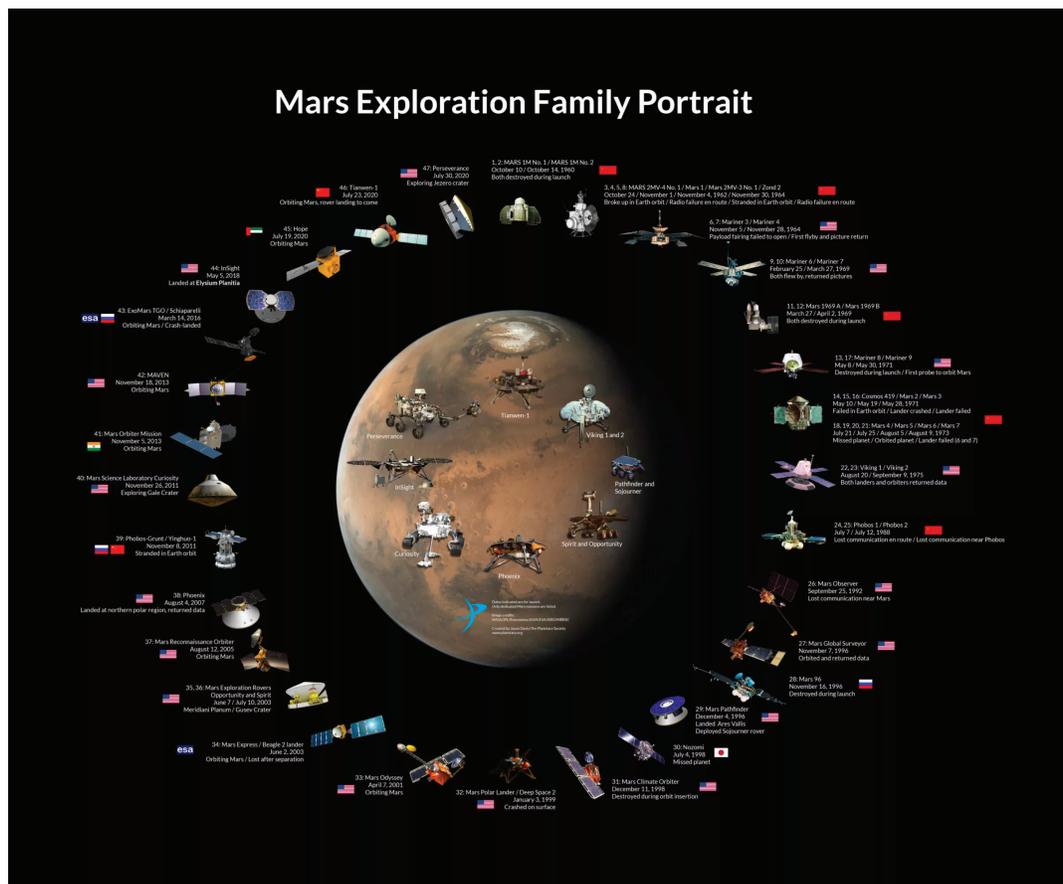
Designed by
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Mars Timeline

There are more spacecraft on or around Mars than any planet except Earth. Our love of the red planet has its basis in literature and mythology. In addition, if mankind is to live on another surface, Mars or the moon are most likely. After reading through the timeline, answer the questions that follow.

Notes:

1. Unless otherwise noted, all of these are successful US missions.
2. Dates are the dates of the object's time on or around Mars, not its launch date.
The ending date is when transmissions from Mars ended.
3. The websites given have photos.



NASA/JPL/Roscosmos/JAXA/ESA/ISRO/MBRSC/Jason Davis/The Planetary Society <https://www.planetary.org/space-images/the-mars-exploration-family-portrait>. This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported License. For uses not allowed by that license, contact us to request publication permission from the copyright holder.

Mars Timeline Continued

Date	Event
1965	Mariner 4 - first flyby of Mars. https://www.jpl.nasa.gov/missions/mariner-4
1971	Mariner 9 - first spacecraft to orbit Mars. https://photojournal.jpl.nasa.gov/spacecraft/Mariner%2B9
1976-1980	Viking 1 and 2 - first landers to safely touch down on Mars. The twin landers looked for signs of life, sent back enough images to create a 3D image of Mars, and found evidence that water had created many features (like deltas). https://www.jpl.nasa.gov/missions/viking-2 https://www.jpl.nasa.gov/missions/viking-1
1997	Mars Pathfinder (lander) and Sojourner (rover) - analyzed rocks, computed the size of the metal core of Mars, and found water ice clouds https://www.jpl.nasa.gov/missions/mars-pathfinder-sojourner-rover
1997-2006	Mars Global Surveyor - the prolongation of its flight allowed it to see daily events. https://www.jpl.nasa.gov/missions/mars-global-surveyor
2001-present	Mars Odyssey - longest-lasting spacecraft orbiting Mars. It has helped discover the chemical make-up of Mars and has assisted two of the rovers with communications. https://www.jpl.nasa.gov/missions/mars-odyssey
2003-present	Mars Express - European Space Agency's (ESA). Its primary mission is to search for water below the surface of Mars. It launched a lander (Beagle 2) which crashed. https://www.esa.int/Science_Exploration/Space_Science/Mars_Express
2004-2018	Spirit and Opportunity - twin rovers launched about a month apart to explore the surface of Mars, study its geology, and find out about the history of water. https://www.jpl.nasa.gov/missions/mars-exploration-rover-spirit-mer-spirit https://www.jpl.nasa.gov/missions/mars-exploration-rover-opportunity-mer
2006-present	Mars Reconnaissance Orbiter - studies the surface of Mars up to 1.2 miles underground. https://www.jpl.nasa.gov/missions/mars-reconnaissance-orbiter-mro
2008	Phoenix lander - landed in the far north of Mars - found water ice and saw snow! https://www.jpl.nasa.gov/missions/phoenix
2012-present	Curiosity - rover sent to see if microbial life ever lived on Mars. https://mars.nasa.gov/msl/home/
2014-present	Maven - orbiter sent to study the atmosphere to help understand climate change. https://mars.nasa.gov/maven/
2014-present	Mars Orbiter Mission (MOM) - India's first space probe orbiting Mars https://www.isro.gov.in/pstv-c25-mars-orbiter-mission
2018-present	InSight - first lander to examine the interior of Mars. Its mission is to look at the makeup of the planet's core, crust, and mantle. https://mars.nasa.gov/insight/
2021-present	Perseverance - a rover sent to look for life and collect rock samples. Ingenuity, a helicopter, was the first powered flight on Mars. https://mars.nasa.gov/technology/helicopter/ https://mars.nasa.gov/mars2020/
2021-present	Hope Mars Mission - United Arab Emirates mission to orbit Mars - first Arab-Islamic mission https://emiratesmarsmission.ae/
2021-present	Tianwen-1 - orbiter for China's first Mars mission. Zhurong is the rover that was launched from Tianwen-1 and is looking for water beneath the surface. https://news.cgtn.com/news/2021-04-24/China-s-first-Mars-rover-named-Zhurong--ZliGQ5pcSQ/index.html



Mars Timeline Continued

Questions:

1. What pattern do you notice in the mission arrival dates?
2. Why do you think that pattern occurs?
3. WNASA launched no missions to Mars from 1976-1996. Propose some possible explanations for this.
4. What does NASA propose for the future of Mars?
5. If you were to design a mission to Mars, what would you like to learn?



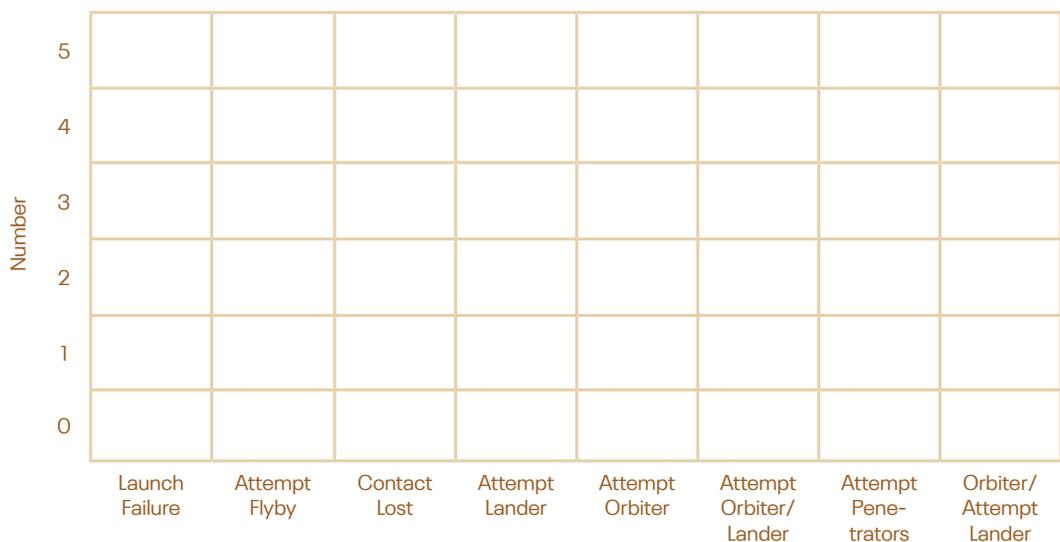
Histogram Activity of Martian Exploration

Step 1: According to NASA's Chronology of Mars exploration, there have been 26 successful missions and 24 unsuccessful missions. What percent were successful and what percent were unsuccessful? http://nssdc.gsfc.nasa.gov/planetary/chronology_mars.html

Number of Successful Missions	Percent Successful	Number of Unsuccessful Missions	Percent Unsuccessful
26		24	

Step 2: Based on that same website, below is a table giving the cause of the failure of the unsuccessful missions. Create a histogram (bar graph) for the unsuccessful missions by cause.

Number	Cause
5	Launch failure
2	Attempted flyby
4	Contact lost
4	Attempted lander
4	Attempted orbiter/lander
2	Attempted orbiter
1	Attempted penetrators
2	Orbiter/attempted lander





Histogram Activity of Martian Exploration Continued

Step 3: Answer these questions:

1. Over time, the success rate of the missions has improved. Why do you think that is?
Explain your answer.

2. What nations/space agencies have successfully orbited a robot around Mars?

3. What nations/space agencies have successfully landed a robot on Mars?

Mars Quick Guide

In 1781, Uranus became the first planet to be discovered with a telescope. Prior to that, people only knew as much about each planet as they could see with the naked eye. Mars, known as the Red Planet because of its coloring, was named for the Roman god of war. It is the fourth planet from the Sun.

Like all planets, Mars has an elliptical orbit. An ellipse is a geometric figure that has two center points, called foci, whereas a circle has one central point.



Because the orbit is not perfectly round, Mars can be as little as 206.7 million km (128.4 million miles) or as far as 249.2 million km (154.8 million miles) from the Sun. Its average distance is 227.7 million km (141.5 million miles).

According to https://mars.nasa.gov/internal_resources/815/, depending on how close Earth and Mars are, radio signals take between 2½ minutes and 20 minutes to travel one way between the planets.

Mars and Earth have very different atmospheres.

Earth's Atmosphere	Mars's Atmosphere
Nitrogen 78%	Carbon Dioxide 95.3%
Oxygen 21%	Nitrogen 2.7%
Argon 0.9%	Argon 1.6%
Other Gases 0.1%	Other Gases 0.4%

Mars's gravity is 38% of ours and its mass is 1/10 of ours which helps to explain why its atmospheric pressure is less than 1/100th of Earth's. Mars is also much colder. Why do you think that is? On Earth, temperatures range from 56.7°C to -94.4°C or 134°F to -138°F. On Mars, however, temperatures range from 27°C to -128°C or 80°F to -199°F. Which planet has a wider temperature range?

Mars Quick Guide Continued

Here's a quick comparison of Earth and Mars.

	Earth	Mars	Notes
Diameter	40,075 km or 24,901 miles	6,780 km or 4,217 miles	About ½ the size of Earth (about twice the size of our moon)
Axis Tilt	23.43 degrees	25.19 degrees	Similar seasons, although Mars's seasons are about twice as long because its year is about twice as long
Day	23 hours, 56 minutes	24 hours, 37 minutes	
Year	365 days	687 Earth days	
Average Distance from the Sun	152 million km or 94.4 million miles	227.7 million km or 141.5 million miles	
Highest Point	Mt. Everest 8,848 meters or 29,029 feet	Olympus Mons 27,000 meters or 84,480 feet	Olympus Mons covers an area about the size of Arizona.
Deepest Canyon	Yarlung Zangbo Grand Canyon in Tibet 5,300 meters or 17,490 feet	Valles Marineris 10,000 meters or 31,680 feet	If you superimposed Valles Marineris on a map of the USA, it would run from New York City to San Francisco.
Moons	Luna, diameter: 3,475 km or 2,159.2 miles	Phobos's diameter 22.5 km or 14 miles	Phobos (meaning fear) and Deimos (meaning terror) are names for the sons of the Greek god of war, Ares

Earth, Mars, and Titan: Similarities and Differences

Step 1: For each fact below, use the following choices and place the letter that best applies to the statement in the blank provided to the left of the number.

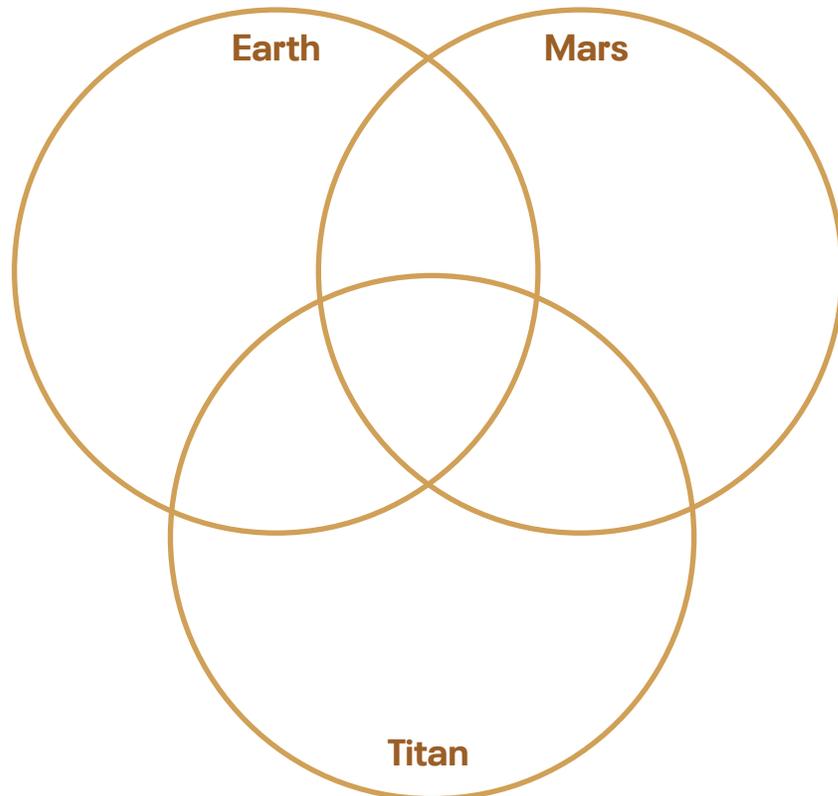
- | | |
|---------------------|--------------------------|
| A Earth only | E Earth and Mars |
| B Mars only | F Mars and Titan |
| C Titan only | G Earth and Titan |
| D All three | H None of them |

For example, given the statement, "It has an atmosphere."; you'd respond, "D", applies to all three (Earth, Mars and Titan), since all three have an atmosphere of some sort.

- _____ 1. It has liquid on its surface now.
- _____ 2. It has an atmosphere composed mostly of nitrogen.
- _____ 3. It has gravity.
- _____ 4. It is the largest moon of Saturn.
- _____ 5. It has the thickest atmosphere.
- _____ 6. It has rovers like Curiosity collecting data on its surface.
- _____ 7. You can see its icecaps.
- _____ 8. It has the thinnest atmosphere.
- _____ 9. It is larger than Mercury and Pluto.
- _____ 10. It was landed on by the Huygens probe in January 2005.
- _____ 11. It is the hottest of the three.
- _____ 12. It is the coldest of the three.
- _____ 13. There is evidence of liquid water on its surface
- _____ 14. Carbon dioxide is the major gas in its atmosphere.
- _____ 15. It has weather.
- _____ 16. It is made mostly of gas.
- _____ 17. It orbits the Sun.
- _____ 18. It has day and night caused by rotation on its axis.
- _____ 19. When seen from space, it is an orange-red color.
- _____ 20. We cannot see its surface from space in visible light.

Earth, Mars, and Titan: Similarities and Differences Continued

Step Two: Develop a three-way Venn diagram that describes the answers obtained above.



Step Three: Based on your answers above, which is more similar to Earth: Mars or Titan? Explain your choice.



Going to Mars

1. Do you want to go to Mars? Create a T Chart. On one side, put what you would miss if you went to Mars. On the other side, put what benefits you would gain if you went to Mars. Remember, you will be gone for a minimum of 4 years. Then write a good paragraph explaining whether or not you would like to go to Mars.
2. Whether or not you want to go to Mars, plan what you would take with you. You are very limited in the amount of space allotted to you personally. You may take no more than 1 cubic meter or 27 cubic feet (a box that is 1x1x1 meter or 3x3x3 feet). The container does not have to be the same dimension on each side, but must take up no additional space). You need to include your clothes, music, books, hobby supplies, etc.
3. If you could choose the name of the rocket that would take you (or others) to Mars, what would it be? What is the meaning of the name? Why did you choose that name? What are 2 other names that could be used? Explain why you think they might be good names.

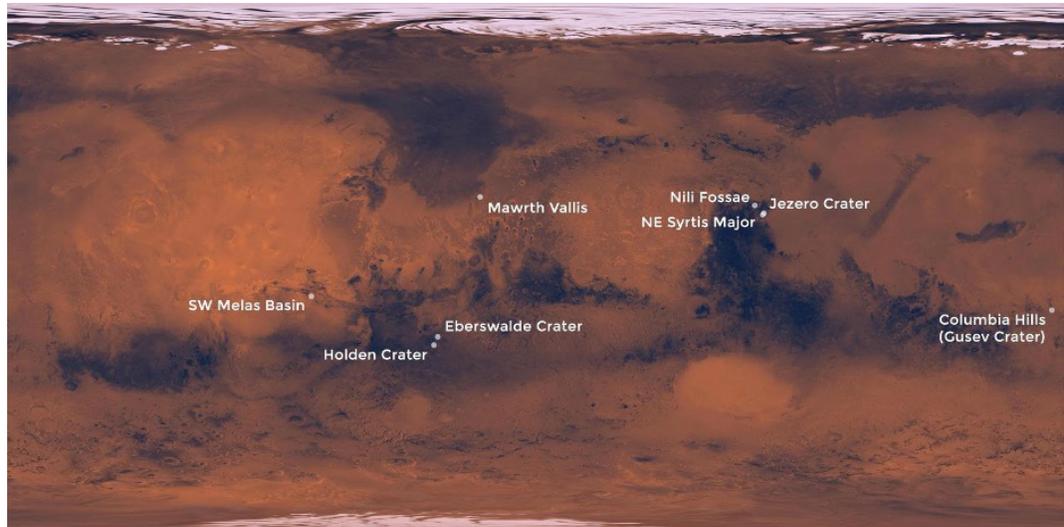


Going to Mars Continued

4. What supplies/equipment would you need to have on Mars before you or other humans get there? Why?

5. What will you or other people actually do on Mars? Why are these activities important?

Landing Site Selection



<https://mars.nasa.gov/resources/landing-sites-under-consideration-for-the-mars-2020-rover/>

The Perseverance rover is, of course, safely on the surface of Mars.



Perseverance sent back this image, a remnant from the river delta in Jezero Crater, in March 2021

<https://mars.nasa.gov/resources/25695/perseverance-view-of-the-delta-in-jezero-crater/>



Landing Site Selection Continued

Back in 2015, NASA scientists and engineers were hot on the question of where to land a rover on Mars in 2021. Eight landing sites made the semifinals.

Use this website to answer the first two questions below.

<https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/>

Questions:

1. What are two main questions that scientists and engineers have to answer?
2. What features do all of the final 3 candidate landing sites share?
3. Why did NASA choose to fly the helicopter Ingenuity on Mars?
4. Upload and describe 5 images from the website <https://mars.nasa.gov/mars2020/multimedia/images/> that Perseverance or Ingenuity have taken so far that tell the story of Jezero crater.
5. Which of the science objectives criteria does your chosen site meet? In what ways? NASA's science objectives are found here: <https://mars.nasa.gov/mars2020/mission/science/objectives/>



Landing Site Selection Continued

Next consider sending another rover to Mars.

6. Put the “Key Questions for Deciding on the Mars 2020 Rover’s landing Site” in order of their importance to you in deciding on your landing site selection and explain your reasoning. <https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/>
7. Assuming that NASA keeps the remaining seven sites under consideration for future Mars missions, which one would you choose to send a rover to in the future? Use the following website to research the remaining possibilities. Do not include the Jerezo Crater as this is the one that NASA has already sent Perseverance to. <https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/eight-potential-sites/>
8. Pictures, please! What makes your selected site so appealing visually? When in the landing site selection meeting for Apollo XV, Commander Dave Scott pointed out that “one should be aware of grandeur”. With that in mind, make the case for your site and include at least three interesting images! Use the search feature of the NASA photojournal site, and type in the name of your feature in the top search box <https://photojournal.jpl.nasa.gov/Help/PIADetQuery.html>

Finally, think about a human mission to Mars.

9. What criteria would be important for a human mission landing on Mars?
10. Based on the criteria you selected in question 9, would the landing site you chose be a good one for human explorers? Why or why not?

Extension: Using what you’ve learned in this investigation, can you identify another good landing site for humans?



Ice as a Mineral

Mars has a great deal of surface ice, which human explorers will probably harvest to use as a ready supply of water.

Practical Note: The properties of ice change rapidly at room temperature. Leave the ice in the freezer as long as possible.

Safety Note: When doing this lab, please wear safety glasses, especially when hammering!

Part One: Field Hardness Test:

Hardness is defined as resistance to scratching.

Materials: Refrigerated butter pat, frozen nail, frozen OLD penny (prior to 1980, so there is no zinc in the penny), unpolished fingernail (still attached to one's finger), block of Ice (bigger is better).

Step 1: Fill a large baggie 2/3 full of water (>1 Liter), then freeze it 48 hours prior to beginning this activity. Put the penny and the nail in the freezer at the same time.

Step 2: Hypothesize which materials will scratch the ice by writing "yes" or "no" in the table below. **Note:** The numbers next to each tool indicate their hardness on Moh's Hardness Scale.

Refrigerated Butter (1)	Fingernail (2)	Frozen Penny (3)	Frozen Nail (5)

Step 3: Assemble the test materials. Try to scratch the ice with each test material (butter, nail, penny, fingernail).

Step 4: Fill in the data sheet below by writing "yes" or "no" to indicate if each of the tools scratched the ice. **Note:** The numbers next to each tool indicate their hardness on Moh's Hardness Scale.

Items	Notes (include whether or not you were correct in your hypotheses)
Refrigerated butter (1)	
Unpolished Fingernail (2)	
Frozen Penny (3)	
Frozen Nail (5)	



Ice as a Mineral Continued

Part Two: Answer the Following Questions

1. Based on the data, what is the range of the hardness of ice near its melting point? That is, the range is between the highest number that does not scratch the ice and the lowest number that does scratch the ice.

2. The ice you are using is around 0°C . If the ice were -100°C , would the ice be harder or softer? Explain your answer.

3. What mineral on Moh's hardness scale most closely matches ice?

Part Three: Fracture vs. Cleavage

Hit the ice with a hammer (**goggles on**) and immediately observe the fragments.

1. Do the fragments break along smooth, even lines (cleavage), or are the breaks uneven like broken glass (fracture)?

Part Four: Extension Activity

Repeat these tests on a block of dry ice (frozen carbon dioxide) - available at many grocery chains or other establishments. **Note: you MUST handle dry ice with gloves.**



Hydroponics

You may want to use https://www.nasa.gov/mission_pages/station/research/10-074.html to research growing plants in space.

Hydroponics is a way to grow plants without soil. There are a few things you need:

- **Water** - with a pH level around 6–6.5.
- **Oxygen** - Most plants get oxygen from the soil surrounding the roots. Without soil, you will need to leave space between the roots and the water so that the plants can get oxygen from the air or you need to oxygenate the container with an air pump.
- **Root Support** - Roots need something to hold on to like peat moss or coconut fiber. Don't use sand, which might become compacted, or gravel which won't retain moisture.
- **Nutrients** - Plants need nutrients which they usually get from the soil, but you can add the nutrients to the water you use. Look up what nutrients your plants will need.
- **Light** - either natural or artificial.

According to <https://astrobotany.com/plants-grown-in-space/>, the following plants have been grown in space. After looking over the list, answer the questions that follow.

Year	Type (Research, Sustenance, Ornamental)	Plant Name	Spacecraft
1973	Sustenance	Rice	Skylab
1982	Research	Arabidopsis thaliana (thale cress)	Soviet Salyut 7
1995	Sustenance	Wheat	MIR
1997	Research	Brassica rapa (includes turnip and bok choy)	MIR
1999	Research	Ceratopteris richardii (triangle water fern)	Columbia
2002	Sustenance	Tomato	ISS
2002	Sustenance	Spinach	ISS
2002	Sustenance	Pepper	ISS
2010	Sustenance	Mizuna Lettuce	ISS
2012	Sustenance	Zucchini	ISS (grown in a Ziplock plastic sandwich bag)
2012	Sustenance	Sunflower	ISS
2015	Sustenance	Red Romaine Lettuce	ISS
2016	Ornamental	Zinnia	ISS
2018	Research	Brachypodium distachyon (purple false brome)	ISS
2018	Sustenance	Broccoli	ISS
2019	Research	Cotton	Chang'e-4 (on the surface of the moon)
2020	Sustenance	Radish	ISS



Hydroponics Continued

1. Rank the type of plant (research, sustenance, ornamental) in order of importance. Why have each type been grown?
2. Which plant did you expect to see on the table that was there? Which plant surprised you the most? Explain your answer.
3. Which plant would you like to see grown in space? Why?
4. Why are scientists looking at growing plants hydroponically on Mars?
5. Think about the purpose of plants. They provide us with many needed things. What do you think the first plants grown on Mars should be? Be specific. Why did you choose those plants?

Selected Resources

Below is a list of resources you may want to use to extend or co-teach your lessons. There are both fiction and nonfiction works listed. As always, before sharing any of these resources with your students, preview them. Some contain mature language/ideas/visuals.

Books

Welcome to Mars: Making a Home on the Red Planet (nonfiction) by [Buzz Aldrin & Marianne Dyson](#)
Curiosity: The Story of a Mars Rover (nonfiction children's book) by [Markus Motum](#)
The Martian Chronicles (fiction) by [Ray Bradbury](#)
Stranger in a Strange Land (fiction) by [Robert Heinlein](#)
John Carter of Mars series (fiction) by [Edgar Rice Burroughs](#)
The Fated Sky (fiction) by [Mary Robinette Kowal](#)
Before Mars (fiction) by [Emma Newman](#)
Mission To Mars (nonfiction) by [Buzz Aldrin](#)
The Martian (fiction) by [Andy Weir](#)
The Case for Mars (nonfiction) by [Robert Zubrin](#)

Films & TV

The Martian
The Right Stuff
Apollo 13
Gravity
Mars Attacks!
The Simpsons: Deep Space Homer

Music

Blue Telescope by [John Hiatt](#)
Theme from Mission Impossible composed by [Lalo Schifrin](#)
Variations on Twinkle, Twinkle Little Star
OK Computer by [Radiohead](#)
Space Oddity by [Davie Bowie](#)
Is There Life on Mars? by [David Bowie](#)
Don't Stop Me Now by [Queen](#)
Rocket Man by [Elton John](#)

TED Talk

How We'll Live on Mars by [Stephen Petranek](#)

TikTok

[NASA's Perseverance Rover](#)
[Perseverance Rover](#)
[First Sounds from Mars](#)

Bibliography

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<https://astrobotany.com/plants-grown-in-space/>
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<https://mars.nasa.gov/mars-exploration/missions/express/>
<https://mars.nasa.gov/mars-exploration/missions/maven/>
<https://mars.nasa.gov/mars-exploration/missions/viking-1-2/>
<https://mars.nasa.gov/odyssey/mission/overview/>
<https://mars.nasa.gov/resources/25695/perseverance-view-of-the-delta-in-jezero-crater/>
<https://mars.nasa.gov/resources/landing-sites-under-consideration-for-the-mars-2020-rover/>
<https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1965-056A>
<https://solarsystem.nasa.gov/missions/mars-orbiter-mission/in-depth/>
<https://www.lockheedmartin.com/en-us/products/insight-mars-lander.html>
<https://www.nasa.gov/image-feature/mariner-4-image-of-mars>
https://www.nasa.gov/mission_pages/mercury/missions/program-toc.html
<https://www.planetary.org/space-images/the-mars-exploration-family-portrait>
<https://www.planetary.org/space-missions/every-mars-mission>
<https://www.planetary.org/space-missions/mars-exploration-rovers>
<https://www.planetary.org/space-missions/tianwen-1>
<https://www.space.com/17963-mars-curiosity.html>
<https://www.space.com/hope-mars-mission-uae>
<https://www.verticalroots.com/the-what-and-why-of-hydroponic-farming/>

Sites Used in Activities

<https://emiratesmarsmission.ae/>
<https://mars.nasa.gov/mars2020/mission/science/objectives/>
<https://mars.nasa.gov/mars2020/multimedia/images/>
<https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/>
<https://mars.nasa.gov/mars2020/timeline/prelaunch/landing-site-selection/eight-potential-sites/>
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<https://www.jpl.nasa.gov/missions/viking-2>
https://www.nasa.gov/mission_pages/station/research/10-074.html



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