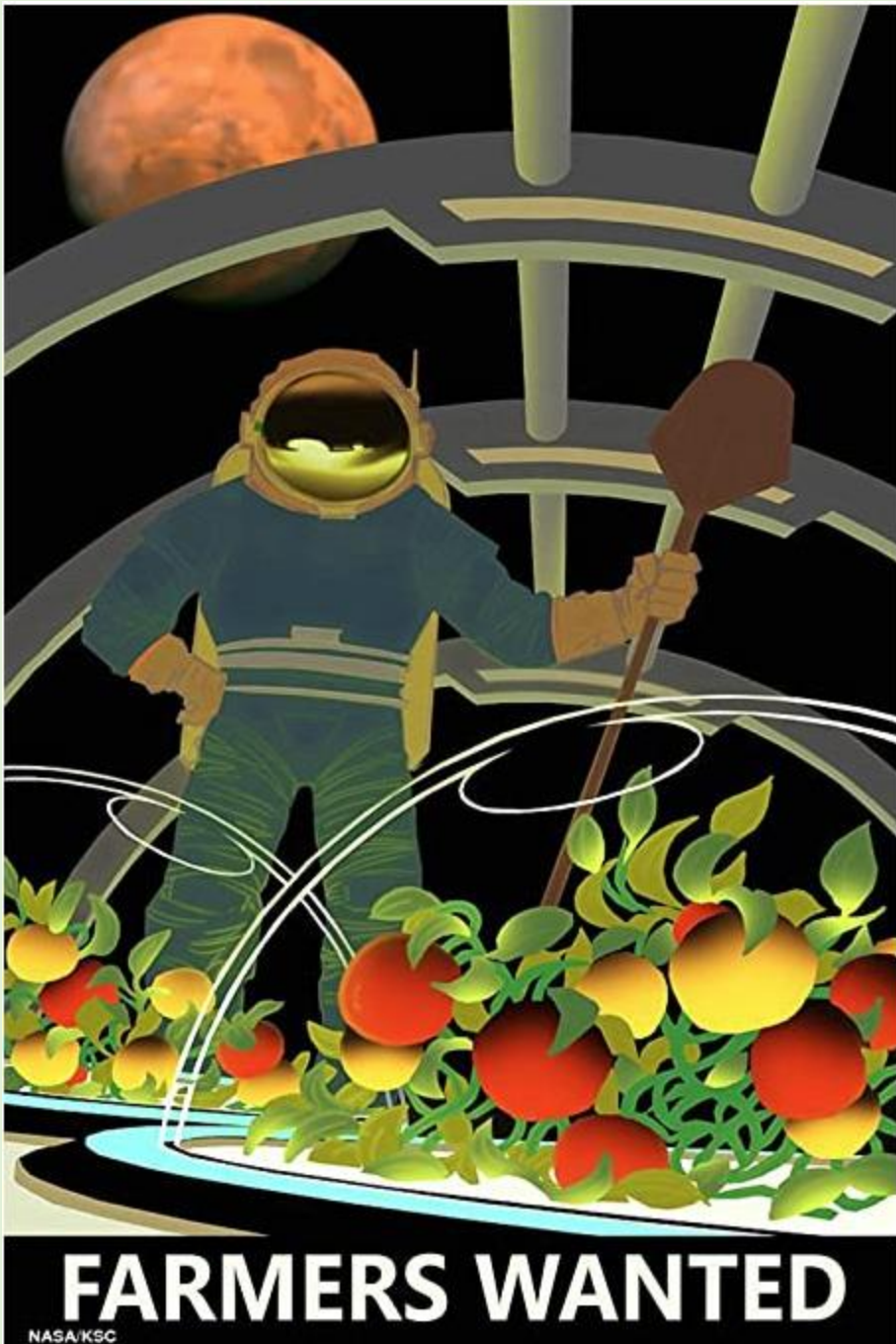


Planting Other Worlds



Lina Dupuy
Plant the Moon Challenge, State Coordinator
Florida Space Grant Consortium

Melissa Sleeper
NASA/JPL Solar System Ambassador
Nourish the Future, Teacher Leader
Holy Trinity Episcopal Academy



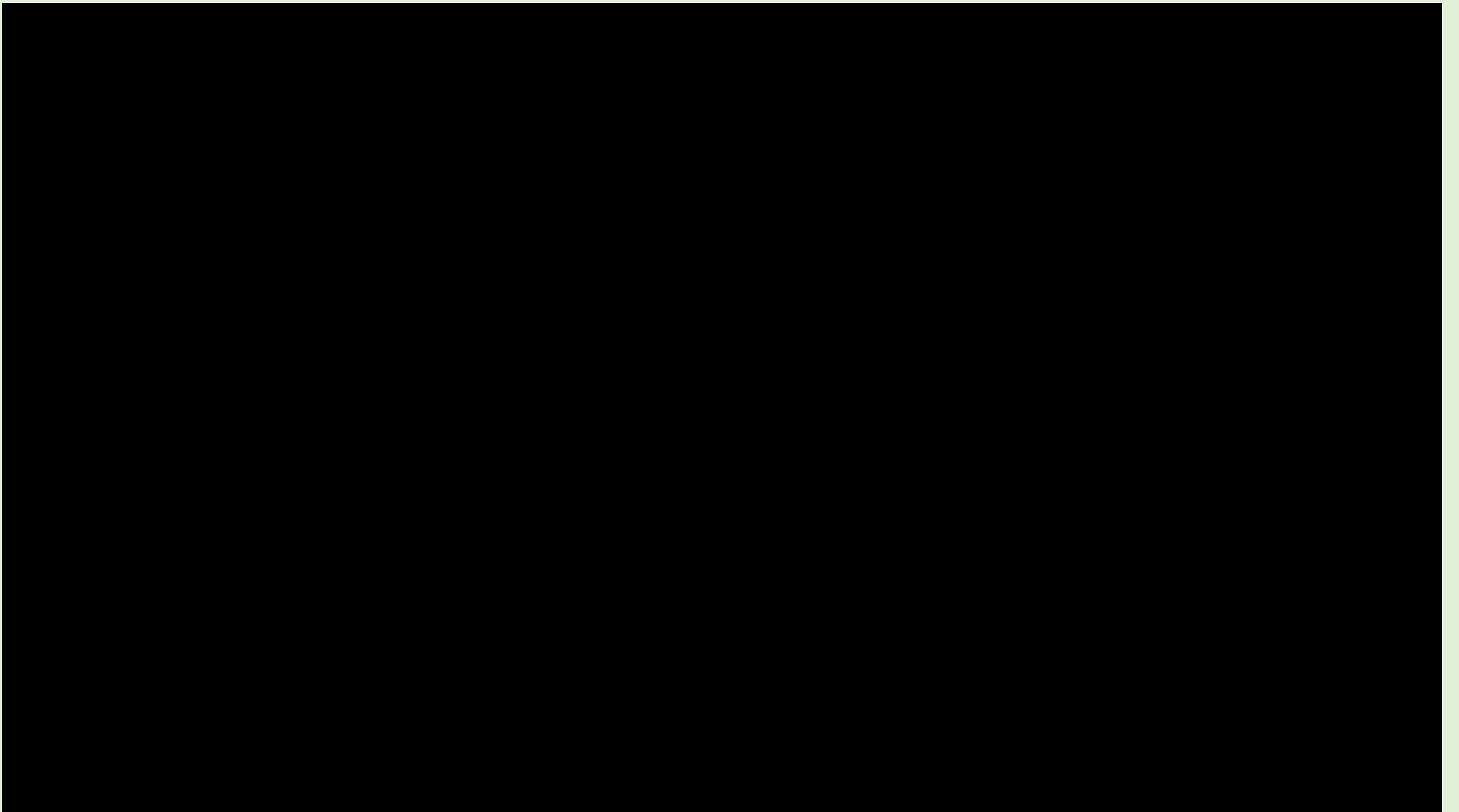
Growing plants in space can provide astronauts and colonists with needed vitamins and nutrients.

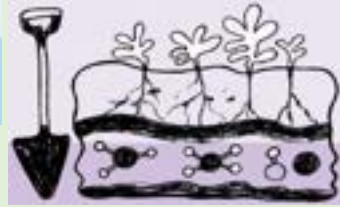
Plants also help metabolize CO₂ and produce Oxygen. They can improve the air quality of the habitats.

Plants may have psychological benefits.

Artemis III astronauts will grow plants on the moon.

The Lunar Effect on Agricultural Flora (LEAF) instrument.





Nourish the Future



Nourish the Future is a national education initiative developed *by* science teachers *for* science teachers. Our mission is to inspire a network of educators to foster critical thinking, connect students to modern agriculture, and provide sound science-based resources that meet teachers' and students' needs in the classroom.

Nourish the Future is generously sponsored by



developed by



SOIL & SUSTAINABILITY (HS)
Soil texture

Focus question What is soil texture? How is it determined?
Vocabulary Sand, silt, clay, gravel

Materials

- 100-ml graduated cylinder or clear, flat-bottomed jar with a lid
- Spoon
- Pipette (or plastic wash)
- Water

Procedure

Day 1: Collect soil and prepare soil columns

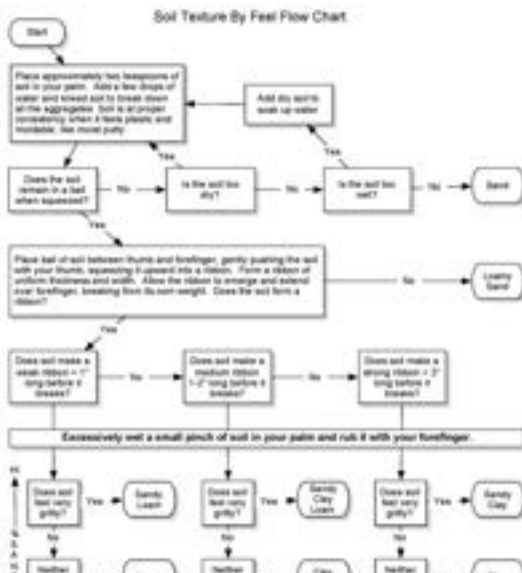
1. Follow teacher instructions to collect soil samples.
2. Lay soil out on a table top. Remove any sticks, roots, and debris from the soil.
3. Add 100 ml of soil and a pinch of dyes to a 100-ml graduated cylinder or jar.
4. Add water up to 100 ml in the cylinder or jar.
5. Cover the top of the cylinder with parallel half ball in the jar.
6. Follow the directions on the soil texture flowchart (on the following page) to determine the soil texture of your sample by feel.

Record your soil texture by feel.

Soil texture flow chart



NOURISH FUTURE



SOIL & SUSTAINABILITY LESSON 2
Soil nutrient testing

Focus question What nutrients are found in soil? What effects do the nutrients in soil have on plants?
Vocabulary pH, phosphorus, nitrogen, potassium

Materials

- 100 ml of soil
- Soil sieve or wire mesh colander
- LabSafe complete soil test kit

Procedure

1. For day 1, spread out the soil, break apart any soil clumps, and remove large sediments (gravel/rocks) and organic matter such as leaves, twigs, etc. Allow the soil to dry for several hours or overnight.
2. Push the dry soil through a soil sieve or colander to break up soil particles. Mix the dry soil to be used for testing.
3. For day 2, use the LabSafe complete soil test kits to determine the pH and the level of N, P and K in your soil samples. Create a data table to record your results.

pH test

1. Fill the test tube to line 4 with pH indicator. Squeeze bottle gently to control the amount dispensed.
2. Use 0.5g spoon to add 3 measures of soil sample.
3. Cap and mix gently for 1 minute.
4. Allow tube to stand for 10 minutes to allow soil to settle.
5. Match color reaction with pH color chart and record result.

Nitrogen test

1. Fill test tube to line 7 with nitrogen-extracting solution.
2. Use 0.5g spoon to add 2 measures of soil sample.
3. Cap and mix gently for 1 minute.
4. Remove cap and allow soil to settle.
5. Use a clean pipette to transfer the clear liquid to a second clean test tube. To avoid splashing of soil, squeeze bulb of pipette before inserting tip into liquid. Release bulb slowly to draw clear liquid into pipette. Do not pull up any soil.
6. Fill second test tube to line 3 with liquid.
7. Use 0.25g spoon to add 2 measures of nitrogen indicator powder to soil extract in second tube. Cap and gently mix. Wait for 5 minutes for pink color to develop above the powder.
8. Match test color with nitrogen color chart and record result.

NOURISH FUTURE

learn more at www.nourishfuture.org

SOIL & SUSTAINABILITY

Soil ecosystems

Focus question Is soil alive? What are the characteristics of living things?
Learning target Students observe soil ecosystems to determine how changing environmental conditions impact soil biodiversity.

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS2-6
Classroom connection: Students evaluate the claim that soil is alive through observation of freshly dug and dry soils. Students identify and describe evidence to support or refute the claim that soil is alive.

Science and engineering practices

Engaging in Argument from Evidence
Classroom connection: Students describe the strengths and weaknesses of the claim "soil is alive" by comparing the characteristics of living things to soil.

Disciplinary core ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
Classroom connection: Students observe different soil samples to identify living and nonliving characteristics in the soil samples.

Cross-cutting concepts

SOIL & SUSTAINABILITY (HS)

Mesofauna biodiversity investigation

Focus question Can human impact affect the biodiversity of soils? How can Simpson's Index of Diversity help to determine the species richness of disturbed soils?
Vocabulary Biodiversity, mesofauna, macrofauna, Simpson's Index of Biodiversity, species richness, species evenness, relative abundance

A healthy soil demonstrates high biodiversity with millions of **mesofauna** (microscopic invertebrates) and **macrofauna** (macro-invertebrates). Mesofauna are busy decomposing organic material and releasing key nutrients for plant use within the soil. Macrofauna play an important role in soil aggregation, porosity, and carbon accumulation within the soil. Healthy soils demonstrate high biodiversity. Human impact on soils due to construction, agricultural production, and lawn care can decrease soil biodiversity. Soil ecosystems can be altered as soil structure is changed and/or the loss of nutrients and/or erosion occurs.

Simpson's Index of Diversity is a tool used to measure the level of biodiversity present in each soil sample. It measures both the **species richness** (number of species per sample) and the **species evenness** (relative abundance of each individual species per sample) in a community. A community dominated by one or two species is considered to be less diverse than one in which several species have a similar abundance. The Simpson's Index of Diversity value (D) ranges between 0 and 1. In Simpson's Index of Diversity, 1 represents infinite diversity and 0, no diversity.

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Simpson's Index of Diversity
D = the total number of organisms of a particular species
N = the total number of organisms of all species

Example: Sample Calculation

Species	Number (n)	n(n-1)
A	2	2
B	8	56
C	1	0
D	1	0
E	3	6
Total	N = 15	$\sum n(n-1) = 64$

$$D = 1 - \frac{(64)}{(15)(14)}$$

Simpson's Index of Diversity = 0.7

NOURISH FUTURE

learn more at www.nourishfuture.org

SOIL & SUSTAINABILITY

Soil, microbes, and plants

Focus question What are the relationships between soil microorganisms such as nitrogen fixing bacteria and plants? How the introduction of nitrogen fixers into soil ecosystems impacted the populations of soil bacteria used?
Vocabulary Nitrogen, fertilizer, nitrogen fixation, nitrogen forms (ammonium NH₄⁺, ammonia NH₃, nitrite NO₂⁻, nitrate NO₃⁻, nitrogen gas N₂), assimilation, leaching, nitrification, yield

This investigator will ask you to evaluate the claim that **nitrogen** amendments in modern agricultural practices impact the stability of soil ecosystems. The three major nutrients found in soil are nitrogen (N), phosphorus (P), and potassium (K). Bacteria and other microorganisms in the soil allow for **nitrogen fixation** to happen (convert atmospheric nitrogen into usable nitrogen for the plants) and can increase nitrogen levels in the soil. This is an important part of the nitrogen cycle for plants and in many cases will limit the growth of producers.

Nitrogen makes up approximately 77% of our atmosphere. This form of nitrogen is of no value to plants and animals. Nitrogen gas (N₂) is captured from the air by species of bacteria and is made into **nitrites** (NO₂⁻). Nitrogen then enters the food web through the growth of producers. In addition to this, nitrogen can be returned to the soil when an animal urinates or when its **nitrogen** (as and decomposers go to work, in the form of **ammonia** (NH₃)). Other organisms in the soil can convert ammonia into usable nitrogen compounds that will re-enter the food web. When **ammonia** (NH₃) is added to the soil as a fertilizer or by bacteria converting atmospheric nitrogen, it can be converted into **nitrites** (NO₂⁻) and again into **nitrate** by different species of bacteria.

Nitrogen within a plant aids in its growth and development. Plants that lack nitrogen appear yellow, do not grow as well, and produce lower yields. When plants are given enough nitrogen, they are able to produce the proteins that help them to grow. One of the specific things nitrogen can do for a plant is help with the production of chlorophyll. The more chlorophyll a plant has, the more efficient it can be in conducting photosynthesis and the more food it can make. The **nitrate**, which they excrete through their roots. Root exudates are in the form of carbohydrates and proteins. Their presence in the soil makes up, attracts, and grows specific beneficial bacteria and fungi that exist on these exudates and the cellular materials sloughed off as the plant's root system grows. These interactions between microorganisms and plants help to maintain soil nutrient availability and ecosystem stability.

Some bacteria have been used or stopped going through nitrogen fixation altogether due to additional amounts of nitrogen added to the soil. Generally, if farmers want to get more nitrogen to the ground they need to rotate their crops. Farmers will make sure to plant crops (legumes) that will help return nitrogen levels after planting a crop that has removed a lot of nitrogen from the soil.

NOURISH FUTURE

learn more at www.nourishfuture.org

Regolith



“Moon dirt is very different than Earth’s soil. Moon dirt, or regolith, is created when micrometeoroids hit the surface of the moon, throwing debris out of impact craters and breaking the moon’s rocks into smaller pieces. This fine dust covers the surface of the moon. Regolith is a mixture of moon rock and micrometeoroid particles. The composition and texture of the lunar regolith varies from place to place depending on the rock types that have been broken.”

**NASA eClips
Educators Guide
NASA’s Our World
Dirt**



Regolith Nutrient Testing

Focus question: What nutrients are found in regolith?

Work with people at your table to conduct these regolith tests*:

pH Test

Extraction Test

Nitrogen Test

Phosphorus Test

Potassium Test

Component	Level (units)
pH	
N	
P	
K	

Safety

Wear goggles, gloves, and a mask when handling regolith.

***Directions for conducting each test are in the containers on your table.**

pH

1

Fill a test tube (0106) to the 10 mL line with distilled or deionized water.



2

Add 1 Soil pH TesTab (5503A).



3

Cap the tube.



4

Mix the contents by inverting 10 times.



5

Fill test tube cap with soil.



6

Pour the soil into the test tube. Mix the contents by inverting 10 times.



7

Stand test tube upright on a flat surface and let the soil settle out for 1 minute.



8

Hold the test tube against the white part of the soil pH color chart (5912-CC). Match the color of the liquid above the soil to a color on the chart. Record results as pH.



Conduct the pH test.

pH SOIL COLOR CHART

Colorímetro del pH del suelo | Charte de couleurs pour le pH du sol



Code 5912-CC
723

Use the color chart to determine your results.

Extraction

1

Fill the round extraction tube (0725) to the 30mL line with DISTILLED WATER.



2

Add two *Floc-Ex TestTabs (5504A). Cap the tube and mix until the tablets have disintegrated.



3

Remove the cap. Add one heaping teaspoon of soil.



4

Cap the tube and shake for one minute.



5

Let the tube stand until the soil settles out. The clear solution above the soil will be used for the Nitrate, Phosphorus, and Potassium tests.



Conduct this test first.

Nitrogen

1

Use the pipet (30444) to transfer the clear solution above the soil to a square test tube (0108) until it is filled to the shoulder.



2

Add one *Nitrate CTA TestTab (3703A). Immediately slide the tube into the Protective Sleeve (0108-PP).

NOTE: Nitrate Wide Range CTA Test Tabs (3703A) are sensitive to UV light. The Protective Sleeve (0108-PP) will protect the reaction from UV light. If testing indoors, there is no need to use the Protective Sleeve in this procedure.



3

Cap and mix by inverting for 2 minutes to disintegrate the tablet. Bits of material may remain in the sample.



4

Wait 5 minutes for the color to develop. Remove tube from Protective Sleeve. Compare the pink color of the solution to the Nitrogen Color Chart (1382).

L = 40 lb/ A/6" soil
M = 160 lb/ A/6" soil
H = 320 lb/ A/6" soil



Phosphorus

1

Use the pipet (30444) to transfer 25 drops of the clear solution above the soil to a square test tube (0108).



2

Fill the tube to the shoulder with DISTILLED WATER.



3

Add one Phosphorus TestTab (5422A). Cap and mix until the tablet disintegrates. Wait 5 minutes for the color to develop.



4

Compare the blue color of the solution to the Phosphorus Color Chart (1382).

L = 8 lb/ A/6" soil
M = 20 lb/ A/6" soil
H = 64 lb/ A/6" soil



Use the solution from the extraction for these tests.

Potassium

1

Use the pipet (30444) to transfer the clear solution above the soil to a square test tube (0108) until it is filled to the shoulder.



2

Add one *Potassium TestTab (5421A). Cap and mix until the tablet disintegrates.



3

Compare the cloudiness of the solution in the test tube to the Potassium Color Chart (1382). Hold the tube over the black boxes in the left column and compare it to the shaded boxes in the right column.

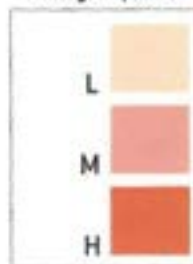


L = 40 lb/ A/6" soil
M = 80 lb/ A/6" soil
H = 160 lb/ A/6" soil

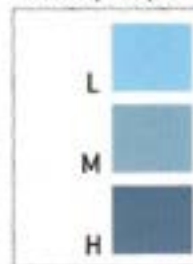
NPK SOIL COLOR CHART

ESCALA COLORIMETRICA | CHART OF COLORS

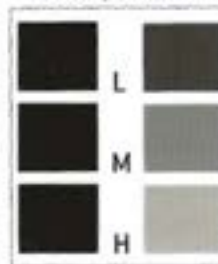
Nitrogen
Nitrógeno | Azote



Phosphorus
Fósforo | Phosphore



Potassium
Potasio | Potassium



Code 1382 / 1.05

Use the color chart to determine your results.

Regolith Nutrient Testing

Focus question: What nutrients are found in regolith?

Work with people at your table to conduct these regolith tests*:

pH Test

Extraction Test

Nitrogen Test

Phosphorus Test

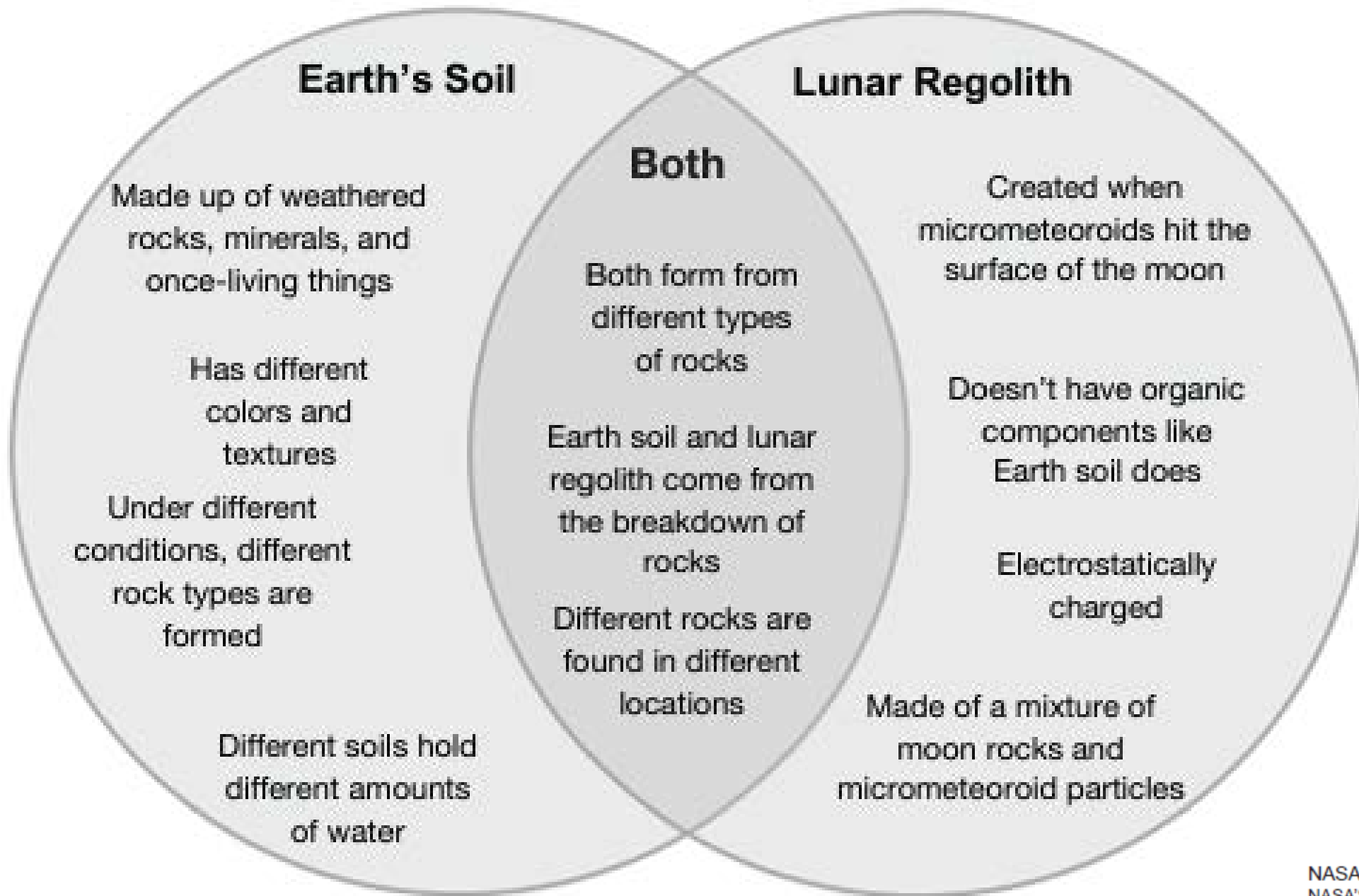
Potassium Test

Component	Level (units)
pH	
N	
P	
K	

Safety

Wear goggles, gloves, and a mask when handling regolith.

***Directions for conducting each test are in the containers on your table.**



Moon ABCs Fact Sheet

Property	Earth	Moon	Brain Busters
Equatorial diameter	12,756 km	3,476 km	How long would it take to drive around the Moon's equator at 80 km per hour?
Surface area	510 million square km	37.8 million square km	The Moon's surface area is similar to that of one of Earth's continents. Which one?
Mass	5.98×10^{24} kg	7.35×10^{22} kg	What percentage of Earth's mass is the Moon's mass?
Volume	---	---	Can you calculate the volumes of Earth and the Moon?
Density	5.52 grams per cubic cm	3.34 grams per cubic cm	Check this by calculating the density from the mass and volume.
Surface gravity	9.8 m/sec/sec	1.63 m/sec/sec	What fraction of Earth's gravity is the Moon's gravity?
Crust	Silicate rocks. Continents dominated by granites. Ocean crust dominated by basalt.	Silicate rocks. Highlands dominated by feldspar-rich rocks and maria by basalt.	What portion of each body is crust?
Mantle	Silicate rocks dominated by minerals containing iron and magnesium.	Similar to Earth.	Collect some silicate rocks and determine the density. Is the density greater or lesser than the Earth/Moon's density? Why?

ABC Mars Fact Sheet Student Page	Earth ABC's	Mars ABC's	ABC's Learning Tips
<u>Equatorial diameter</u>	12,756 km (7,926 miles)	6,786 km (4,217 miles)	At 50 mph, how long would it take to drive around the equator
<u>ABC Fact Length of Year</u>	Earth ABC's 365 ¼ days (24 hr length of day)	Mars ABC's 687 Earth Days (24 hr, 37 minutes length of day)	ABC's Learning Tips When would you celebrate your birthday on Mars? Would you mark the months by Earth time? The seasons?
<u>ABC Fact Distance from Sun (in millions)</u>	Earth ABC's 147.1-152.1 km (91.4-94.5 mi)	Mars ABC's 206.6-249.2 km (128.4-154.8 mi)	ABC's Learning Tips How big would the Sun look in the sky? The Earth?
<u>ABC Fact Axis Tilt</u>	Earth ABC's 23.5 degrees	Mars ABC's 25.2 degrees	ABC's Learning Tips Would there be shadows at noon?
<u>ABC Fact Crust</u>	Earth ABC's Silicates	Mars ABC's Silicates	ABC's Learning Tips What are silicates?
<u>ABC Fact Mantle</u>	Earth ABC's Iron, Nickel, silicates	Mars ABC's Silicates	ABC's Learning Tips



Grows Fast

Outregeous
Red Romaine Lettuce
NASA First Bite 2015



Buttery Leaves

Tokyo Bekana
Chinese Cabbage
NASA First Bite 2017



Black Peppery Flavor

Mizuna
Mustard
NASA First Bite 2017



Soft Leaves

Waldmann's Green
Lettuce
NASA First Bite 2017



Earthy Flavor

Red Russian
Kale
NASA First Bite 2018



Crisp Texture

Dragoon
Lettuce
NASA First Bite 2018



Spicy, Horseradish Taste

Wasabi
Mustard
NASA First Bite 2019



Crisp And Refreshing

Extra Dwarf
Pak Choi
NASA First Bite 2019



Spicy And Crunchy

Cherry Belle
Radish
NASA First Bite 2020



Savory Taste

Amara
Mustard
NASA First Bite 2021

From the first taste of Red Romaine Lettuce in fall 2015, astronauts have **GROWN** and **EATEN** a range of salad crops in orbit as NASA researches ways to keep crews healthy on future missions exploring the Moon and Mars. These plants are good sources of Vitamin C and Vitamin K, and they have traits that make them good candidates for feeding future space explorers.

Name: _____

Team: _____

Crop selection

Do the background research on the plants you might chose.

Name of crop:

What is its growth period?

|

How long does it take to germinate?

What are the nitrogen needs?

Identify whether it has high or low water needs.

How does temperature and humidity affect the growth?

What is the nutritional value of your crop?

Bibliography:



Complete Seed List Growing Beyond Earth 2015 - 2022

ID	Name	Family	Species	Variety
GBE 1	Red Romaine Lettuce	Asteraceae	<i>Lactuca sativa</i>	
GBE 2	Chinese Cabbage	Brassicaceae	<i>Brassica rapa</i> var. <i>chinensis</i>	Outredgeous
GBE 3	Redleaf amaranth	Amaranthaceae	<i>Amaranthus tricolor</i>	Tokyo Bekana
GBE 4	Red Orach	Amaranthaceae	<i>Atriplex hortensis</i> var. <i>rubra</i>	
GBE 5	Chard	Amaranthaceae	<i>Beta vulgaris</i>	
GBE 6	Beet	Amaranthaceae	<i>Beta vulgaris</i>	Bright Lights
GBE 7	Strawberry spinach	Amaranthaceae	<i>Blitum capitatum</i>	Babybeat
GBE 8	Saltwort	Amaranthaceae	<i>Salsola komarovii</i>	
GBE 9	Spinach	Amaranthaceae	<i>Spinacia oleracea</i>	
GBE 10	Bunching onions	Amaryllidaceae	<i>Allium fistulosum</i>	Red Kitten
GBE 11	Ashitaba	Apiaceae	<i>Angelica keiskei</i>	Parade
GBE 12	Samphire	Apiaceae	<i>Crithmum maritimum</i>	Koldzumi
GBE 13	Carrot	Apiaceae	<i>Daucus carota</i> var. <i>sativus</i>	
GBE 14	Escarole	Asteraceae	<i>Cichorium endivia</i>	Mokum
GBE 15	Shungiku	Asteraceae	<i>Glebionis coronaria</i>	
GBE 16	Leaf lettuce	Asteraceae	<i>Lactuca sativa</i>	
GBE 17	Red malabar spinach	Basellaceae	<i>Basella alba</i>	Starfighter
GBE 18	Upland cress	Brassicaceae	<i>Barbarea verna</i>	Rubra
GBE 19	Misome	Brassicaceae	<i>Brassica</i>	
GBE 20	Kale	Brassicaceae	<i>Brassica oleracea</i>	Misome
GBE 21	Kale	Brassicaceae	<i>Brassica oleracea</i>	Toscana
GBE 22	Kohlrabi	Brassicaceae	<i>Brassica oleracea</i> var. <i>gongylodes</i>	Starbor
GBE 23	Komatsuna	Brassicaceae	<i>Brassica rapa</i> var. <i>pervinidis</i>	Quickstar
GBE 24	Mizuna	Brassicaceae	<i>Brassica rapa</i> var. <i>japonica</i>	

Crop Planting

Get a baby bottle test tube.

Mix regolith with your chosen addends. Use at least 50% regolith.

Plant the seeds you selected.

Water your crop!



Plant the Moon and Plant Mars



Plant the Moon
CHALLENGE

<https://vimeo.com/923064480>

From the Plant the Moon Challenge Website:

“Participants in the Plant the Moon Challenge will join a global science experiment and research challenge to examine how vegetable crops can grow in lunar or Martian soil. Each team will receive real soil simulant from the University of Central Florida’s CLASS Exolith Lab! You will design and conduct a set of experiments using this simulant to grow crops for a future long-duration mission.”



Introducing Plant the Moon Jr.!



Plant the Moon
CHALLENGE

- High School/Undergraduate
- Student Directed
- Research Focused
- Team size: 1-5 students
- Kit size: 2.5 kg simulant
- No changes to submissions
- Best-in-Show and Experiential awards!



Plant the Moon
CHALLENGE JR.

- Elementary/Middle School
- Teacher Directed
- Fundamental Learning
- Team size: 1 classroom
- Kit size: 5 kg simulant
- Age-appropriate submission items
- Generalized Best-in-Show awards



Plant the Moon
CHALLENGE

- Task 1: Team Demographic Survey
- Task 2: Initial Experimental Design
- Task 3: Initial Planting Video
- Task 4: Midpoint Grow Update
- Task 5: Project Reports
- Task 6: Final Video
- Task 7: Final Survey

No major changes in PTMC submissions or materials.



Plant the Moon
CHALLENGE **JR.**

- Task 1: Team Demographic Survey
- Task 2: Initial Experimental Design
- Task 3: Team Badge
- Task 4: Project Summary
- Task 5: Final Survey

Age-appropriate submissions and materials for PTMC Jr.



Plant the Moon
Plant Mars
CHALLENGE

PTMC Project Guide



Plant the Moon
Plant Mars
CHALLENGE

Coach's Guide



Plant the Moon
Plant Mars
CHALLENGE

Fundamental Experiment



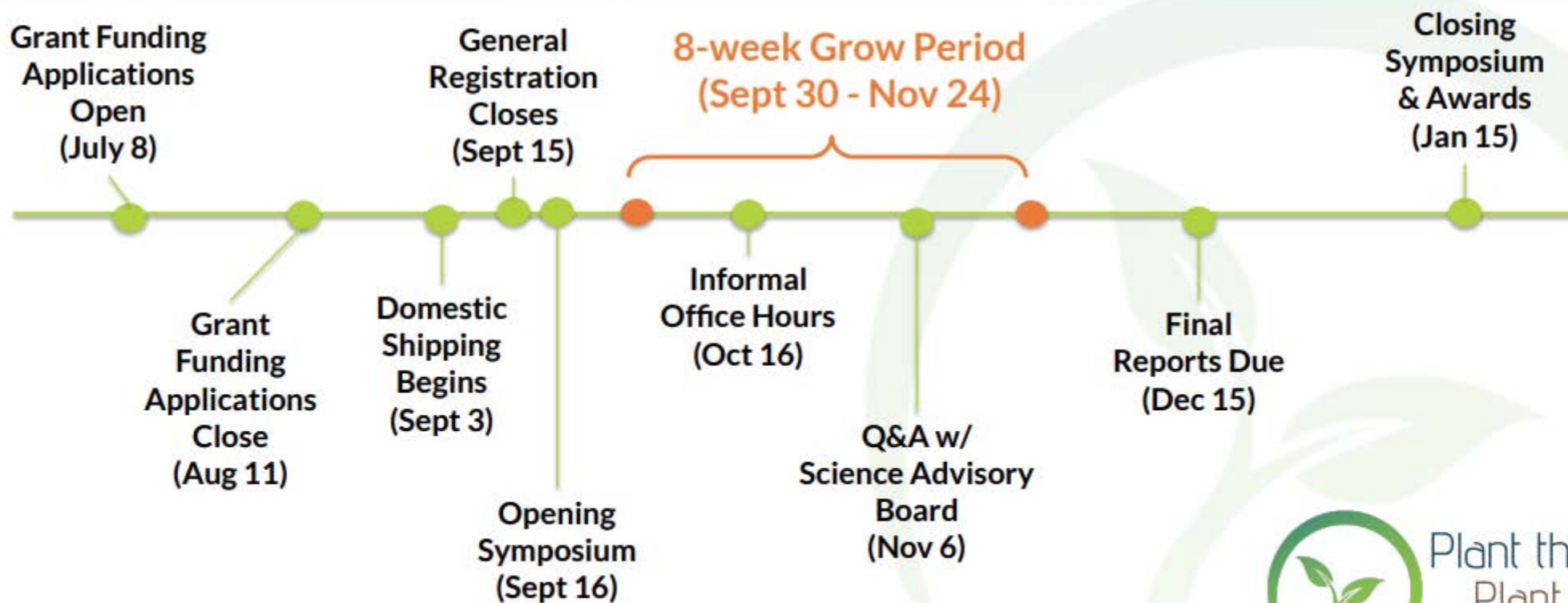
Plant the Moon
Plant Mars
CHALLENGE

Extension Activities

Overview

PTMC Fall 2024 Milestones

July	Aug	Sept	Oct	Nov	Dec	Jan	
Registration			Design Period	Grow Period		Report Period	Evaluation Period



All divisions have the same registration process/deadline, grow period, and live events.



Plant the Moon
Plant Mars
CHALLENGE




**Plant the Moon
 Plant Mars
 CHALLENGE**

**Congratulations to your
 Best in Show team!**

Most Innovative Experiment

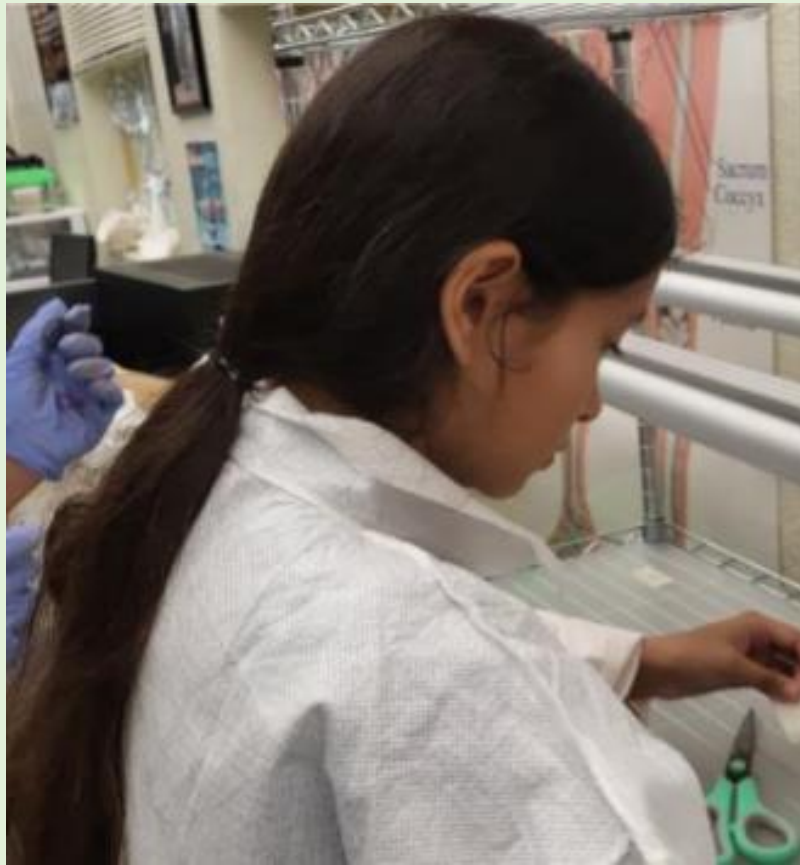
Team #11421
 Walkie Talkies
 Vero Beach, Florida

Team Members:
 Darren McKinnon Connor Sloss
 Linda Sanchez Samaira Soom
 Cole Setik

Team Coach:
 Melissa Sleeper

SAB Commentary by:
 Dr. Shawana Tabassum

 **Plant the Moon
 Plant Mars**



Best Evaluation of Results

Team #11429
InSight
Vero Beach, Florida

SAB Commentary by:
Dr. Rafael Loureiro


Team Members:
Virginia Barradas Lane Davis
Trenton Bell Madeline Hawkey
Kathryn Bender

Team Coach:
Melissa Sleeper

 **Plant the Moon**
Plant Mars
CHALLENGE

Challenge Division: Middle School Team Name: HT Boks A'choy ~~A'choy~~ Team ID#17378

Crops are a sustainable option to provide this source, and it would be most efficient to use the local resource of the Moon: its lunar regolith.

This project is to investigate what amendments help plants grow in lunar regolith. In order for NASA to achieve its goal to build a sustainable life for humans on other planets in our solar system, we selected Bok choy, due to its vitamin and mineral content that can potentially enhance bone health and heart health. In outer space, the low gravity nature that causes weightlessness during flight also results in deficiencies such as in calcium and vitamin K, which can decrease the overall bone health of astronauts, a major complication ran into during missions. On that note, Bok choy is known to be high in calcium and vitamin K plus other high vitamin and mineral content to be incredibly beneficial to use as a source of food provided for missions.

Bok choy is a type of cabbage that is part of the Brassica or cruciferous family. It takes 7-10 days to germinate. After seeding, Bok choy can be harvested after 40 to 50 days. It prefers soil rich in potassium, nitrogen, and phosphorus, which may be provided through compost and organic fertilizer. Bok choy has moderate watering needs.

As previously mentioned, Bok choy has many nutrients that are important for strong, healthy bones. It is high in calcium, phosphorus, iron, magnesium, and vitamin K. Some studies have found that it may reduce the risk of cancer, heart disease, and cognitive impairment. It can be served cooked or raw.

Azotobacter vinelandii is an obligate aerobe that supports nitrate fixation. We chose this microorganism in order to combat the natural deficiencies of nitrogen in lunar regolith. Soil tests conducted on a sample of lunar regolith indicated there was less than a trace of nitrogen in the regolith. This experiment investigates how *Azotobacter vinelandii* will affect the growth of Bok choy in the lunar regolith, leading to the research question: *Will Azotobacter vinelandii affect the growth of Bok Choy in lunar regolith?*

Hypothesis:

If we introduce *Azotobacter vinelandii* (mixed with soil) to Bok Choy in lunar regolith, the crop will grow stronger and taller because *Azotobacter vinelandii* is a nitrogen-fixing bacteria that adds nitrogen to the soil, and due to the deficient nitrogen levels in soil on the lunar regolith the bacteria will enhance the nitrogen. Accordingly, in order for it to adequately grow, Bok Choy needs a significant amount of nitrogen in its soil that will be efficiently provided with the *Azotobacter vinelandii* amendment.

Independent

each fully

Control:

Type of

Type of

Liquid

Water

Control:

Material

1. Bok

2. PI

3. C



HT Boks A'choy

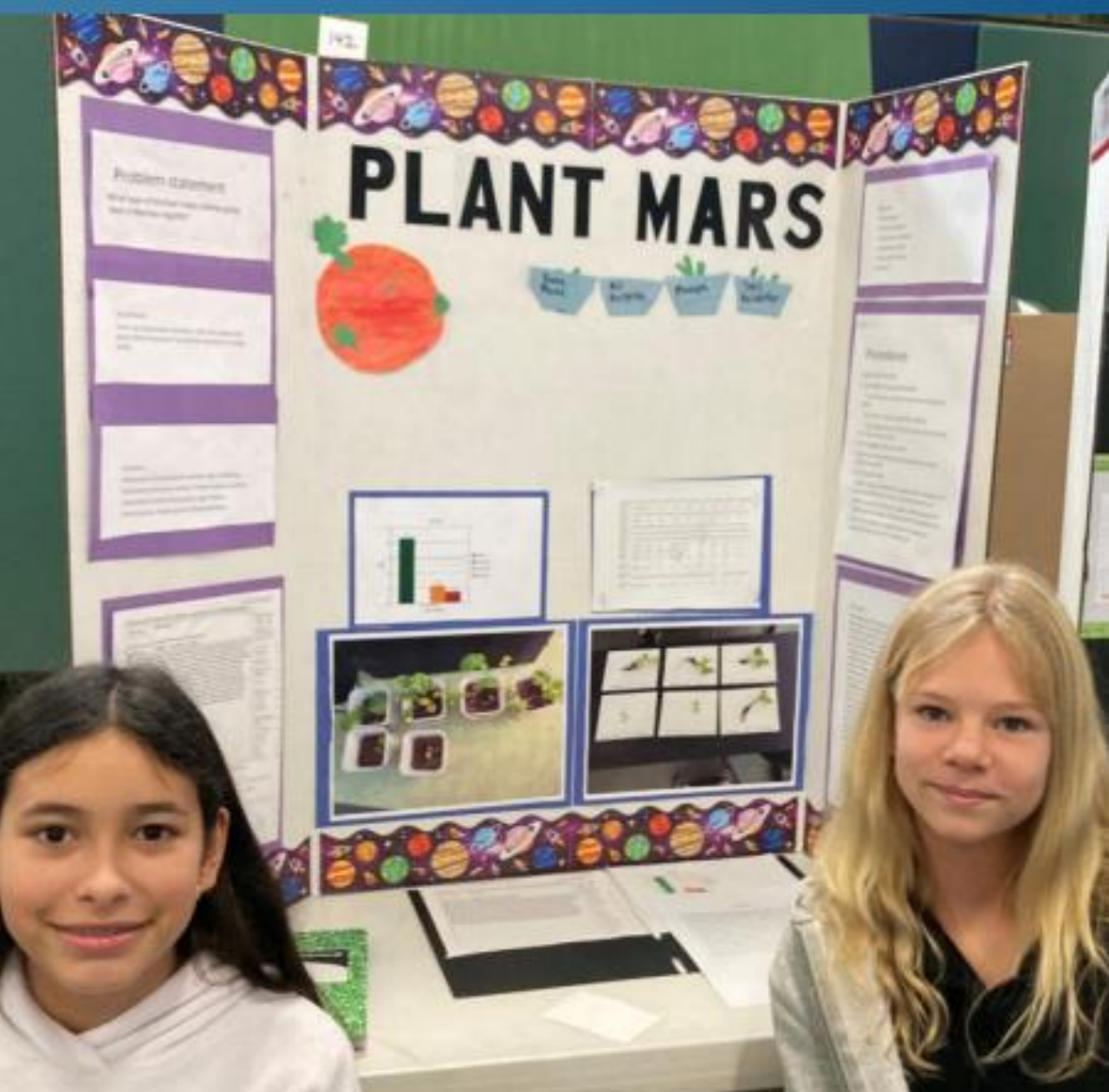
Team # 17378

Plant the Moon

Holy Trinity Episcopal Academy

Melbourne, Florida

Middle School



Science Fair Projects



Resources and Opportunities from



<https://nasaclips.arc.nasa.gov/>

National Institute of Aerospace



Sharon Bowers

STEM Education Specialist



Joan Harper-Neely

STEM Education Specialist



Betsy McAllister

Educator in Residence

Hampton City Schools



Students Teaching Students



Martian Greenhouse

A poster for 'Martian Greenhouse 4.0' with a dark blue background. On the right side, there is a partial view of the planet Mars. The text 'HELP GROW THE NEXT GENERATION' is written in white and green. Below it, 'Martian Greenhouse 4.0' is written in white with a white line graphic. At the bottom, there is contact information and logos for AIAA and a green leaf icon.

**HELP
GROW
THE NEXT
GENERATION**

Martian Greenhouse 4.0

Contact emily@emilymatula.space

emily@emilymatula.space

From the Martian Greenhouse Web Site:

Martian Greenhouse 3.0 Request for Proposal (Sample RFP)

Overview: The Martian Greenhouse Project 3.0 team, in collaboration with AIAA (American Institute of Aeronautics and Astronautics) and the Aldrin Family Foundation, is seeking systems designed to produce food for human habitation on Mars. These prototype systems will need to be self-sufficient and fit within a relatively small space. The greenhouse will provide habitat for the growth of a variety or varieties of edible plants.

I. Design of Structure

1. Student teams are asked to design a self-contained greenhouse module with a volume no larger than 1 meter³. This volume includes all supporting equipment.
2. Teams will create a set of procedures and plans that may be shared that allow others to duplicate their design.

II. Growth of Plants

1. Teams will provide a rationale for their selection of a crop or crops to be produced.
2. Teams will submit procedures and a time-line for planting, maintenance and harvest of their crop(s).
3. Teams will provide a recipe for preparation of their crop(s) as a food source.

III. Use of Water

1. Teams will identify the amount of water that will be consumed by the system and create a water budget for their greenhouse design.
2. Teams will address systems to limit use of water.

IV. Use of Energy

1. Teams will identify the amount of energy that will be consumed by the system and create an energy budget for their greenhouse design.
2. Teams will account for lighting and generation of power.

V. Efficiency of the System

1. Teams will calculate and submit a chart defining the efficiency of their system by comparing total use of energy and water to the total calories of food produced.

VI. Submissions

1. Teams have the option of submitting one of the following packages:
 1. Technical drawings and a descriptive paper.
 2. Technical drawings, a descriptive paper, and a conceptual model.
 3. Technical drawings, a descriptive paper, and a functioning prototype.
2. Teams will create and post a brief video to YouTube that describes the process, products and learning by the team.

The RFP is designed with the idea of appealing to students with a wide range of interests and to make use of management strategies. Projects will not be judged against each other. The idea is to allow everyone a chance to compete with themselves against set functional standards.

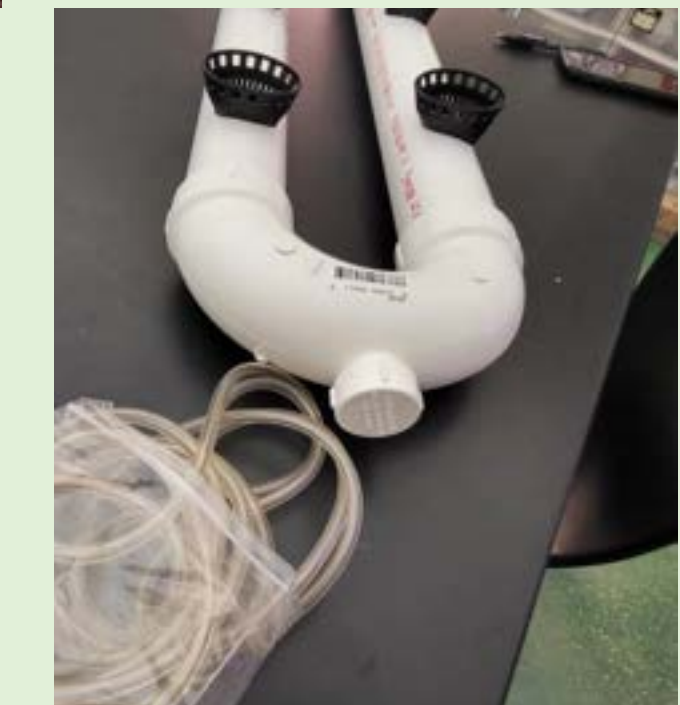
Jim Christensen, Aldrin Family Foundation, 2021

Martian Greenhouse – The Project Cycle





Martian Greenhouse



25th Annual International Mars Society Conference



Martian Greenhouse 3.0

3.0

Team Members: Cade, Will, Cole, and Tommy

Additional help: Alexis and Lane

Our Goal

Our team's goal is to improve life on Earth and make life and agriculture on Mars possible. We want to collaborate with schools around the world to see how they approach farming on Mars. Finally, we want to develop engineering and social skills.





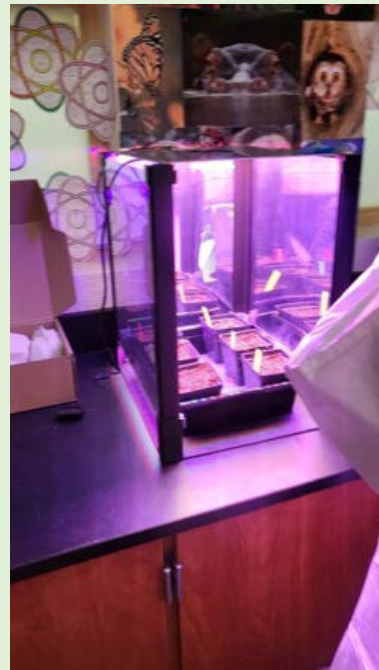
GROWING BEYOND EARTH™

A PARTNERSHIP BETWEEN FAIRCHILD TROPICAL BOTANIC GARDEN & NASA

<https://fairchildgarden.org/growing-beyond-earth-welcome/>

From the GBE Website:

- **By participating in GBE, your students will:**
- **collect and contribute important data that NASA plant scientists will use to determine the best crops to grow in space**
- **work directly with plant scientists at NASA's Kennedy Space Center**
- **develop and conduct original experiments to address the many challenges of growing plants in space**
- **analyze data and communicate results with NASA scientists, researchers, and administrators during the Virtual Student Research Symposium**
- **collaborate with students nationwide**
- **chat with astro-botanists nationwide**





GBE Project Pictures



Individual research possibilities second semester.

Tomatosphere

TOMATOSPHERE™

2. The seeds travel to space in the belly of a dragon—SpaceX's Dragon spaceship, which transports the seeds to the International Space Station.

3. The tomato seeds spend about four weeks in space.

Why grow tomatoes in space?

Future crews on long space missions will not be able to take all their food with them—they will need to grow plants, which will add oxygen and water and remove carbon dioxide from the environment. Why tomatoes? They are easy to grow, versatile, nutritious and tasty and make a great space salsa!

4. Back on Earth, the seeds are sent to over 20,000 classrooms across Canada and the United States. Students then grow the space seeds and compare them with regular seeds. They will only find out which seeds went to space when they complete the experiment.

1. 1.2 million tomato seeds are prepared to be sent to space.

Take a bite out of science with Tomatosphere™!

Since it began in 2001, Tomatosphere™ has reached over 3 million students.



ExoLab



“Through a network of science laboratories students can join others around the world in a live mission aboard the International Space Station.”

Introduction to ExoLab-11



ExoLab

Magnitude.io
Powered by Colony

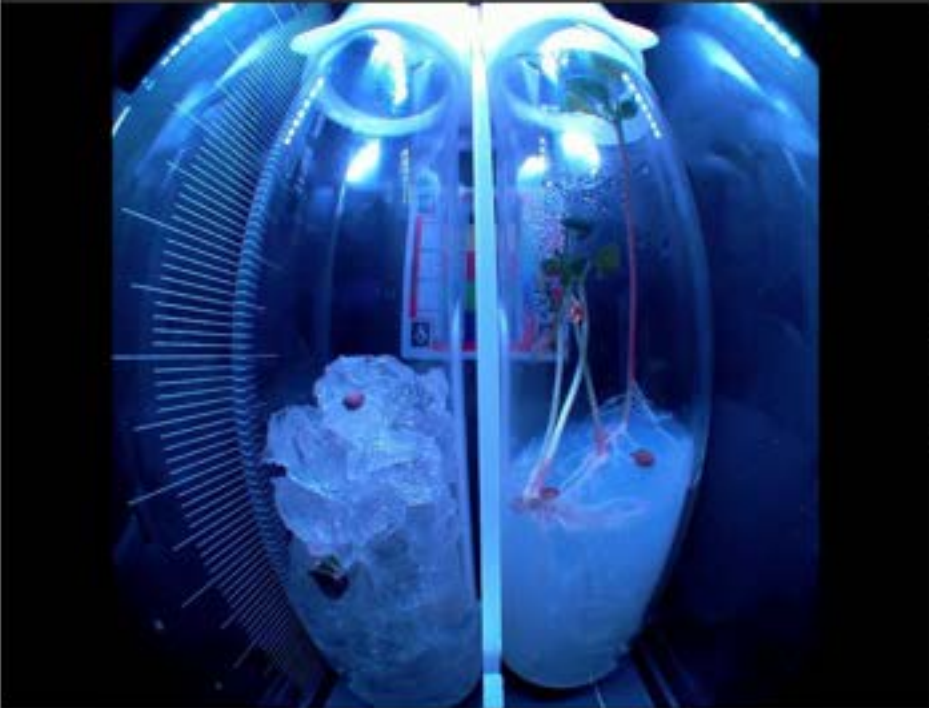
Melissa Sleeper
teacher

CHARTS

May 26, 2024 19:55:15 UTC


May 30, 2024 20:20:01 May 08, 2024 16:02:32 May 07, 2024 15:39:03 May 10, 2024 01:07:06 May 12, 2024 10:40:06 May 14, 2024 20:12:36 May 17, 2024 06:45:06 May 18, 2024 15:17:41 May 22, 2024 00:50:12 May 24, 2024 10:02:44 May 26, 2024 19:55:15

Growth of Radish Plant



DAY:	25
EARTH TIME UTC:	19:27:35
TEMP:	27.0 °C
HUMIDITY:	47.5 %
CO2:	455.0 ppm
Light:	58.1 μmol/m ² /s
LATITUDE:	-
LONGITUDE:	-
ALTITUDE:	-

ExoLab-10 Alfalfa



Units: 1 mm/dly
Camera: 1
Timestamp: 2024-05-27 19:54:57

DAY:	25
SPACE TIME UTC:	03:54:57
TEMP:	-
HUMIDITY:	-
CO2:	-
Light:	-
LATITUDE:	14.53
LONGITUDE:	45.71
ALTITUDE:	414340.32 m

Tube 1: M. Saliva
Tube 2: M. Saliva

Resources:

Nourish the Future

<https://nourishthefuture.org/>

Plant the Moon and Plant Mars

<https://plantthemoon.com/>

NASA eClips

<https://nasaclips.arc.nasa.gov/>

Martian Greenhouse

martiangreenhouseproject@gmail.com

<https://sites.google.com/view/martiangreenhouse/home?authuser=0>

Growing Beyond Earth

<https://fairchildgarden.org/growing-beyond-earth-welcome/>

Tomatosphere

<https://www.firsttheseedfoundation.org/program/tomatosphere/>

Magnitude.io ExoLab-11

<https://magnitude.io/>

Contact Information:

Lina Dupuy

**Plant the Moon Challenge, State Coordinator
Florida Space Grant Consortium**

Lina.Dupuy@ucf.edu

Melissa Sleeper

**NASA/JPL Solar System Ambassador
Nourish the Future, Teacher Leader
Holy Trinity Episcopal Academy**

msleeper@htes.org