Farming on Mars Soil

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Lesson Details

Subject Area(s): Biology, Chemistry, Earth Science, Space Science

Focus Grade Level: Collaborative project across multiple grades (7,8,9,10,11,12)

Grade Level Range: Secondary General

Research Background

ASU Bio design labs has (hopefully) concluded that bacteria are able to reduce toxic chemical levels in Mars-like rock to levels that plants can survive, but not low enough to grow edible produce. Other sources claim that certain inedible trees, plants and other autotrophic species can sequester or process these toxins, as long as the concentration is low enough.

Lesson Summary

Students will devise a way to measure soil nutrient uptake in Mars-like earths sourced around Apache Junction, for plants that are known to sequester or process toxins that Mars rocks have (Perchlorate, Iron, free metals, etc.) They will use these measurements to assess the practicality of a two-step soil mending process to start Mars agriculture (bacteria for toxins, inedible plants and trees for soil mending).

This is a follow up experiment to build on the toxicity reduction labs being run by ASU, and collaboration with the ASU researchers will be a key part in helping the students design the conditions of their trials.

Materials and Equipment

This is in two parts, one for home starter kits that can be reused and adapted, and the other for a school Greenhouse for courses, larger projects or collaborations.

At Home starter kits

1. Synthetic Martian soil $40 for reference sample, students can supply from Phoenix area collection sites)

2. Poplar tree seeds ($10 plus shipping per packet)

3. Arduino system based irrigation $40

4. Arduino sensor pack to track toxins, oxygen etc ($80 for full kit)

4. Tupperware tub with clear lid $40

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5. Any plant seeds that dont need soil to grow. That is edible as well (students select from local stores)

Amazon List of all items (some are duplicate for bulk pricing) $225 including duplicate bulk items

Summary/Reasoning:

Once the perchlorate level is significantly lower through ASU bacteria labs, plant the Poplar tree seeds(which will reduce the perchlorate even more). Finally Plant the other food seeds to start a viable food source, and create oxygen for the enclosed environment.

Hub Greenhouse Setup:

Willow or Eastern Cottonwood trees, common beans, nitrogen fixing plants, or other test plants as chosen by students ($10, to be procured by student)

Portable Greenhouse $200

Sealing Tape for Greenhouse $20

Base tarp for greenhouse $20

Pots and trays (local) $20

Arduino or other sensors, depending on student design $35-50 each

Dry and liquid sample bottles, for sending to ASU to run chemical analysis? $20 for a pack

Mars-like soil samples from Saddleback Basalt (obtained by field trip to Saddleback Mountain or nearby) https://www.themartiangarden.com/tech-specs

Soil Test Kits, $30 each

Irrigation distribution kit $40

Plant nursery lighting $50-100

Amazon List for all items (some duplicates for bulk pricing) $540 for everything.

Summary/Reasoning:

This hub location will serve as a longer-term design, batch test and team lab location for Mars farming research. As discoveries are made, this list and site will develop and this materials list will change, but this is the intended starting place. This would be for a separate course, school-wide project, or other out-of-class group.

ATTACHMENTS

https://sites.google.com/lumosarts.com/independentstudy/home https://myresearchcred.wpcomstaging.com/wp-login.php?action=register

EDUCATIONAL STANDARDS

The approach here is the students will be pretested to eliminate most of these standards like on an Edgenuity pre-assessment, and based on the remaining topics for them to learn, will choose from these possible standards to design their project, using these topics as their driving questions.

NGSS Standards:

PS1A: Structure and Properties of Matter

PS1B: Chemical Reactions

PS2B: Types of Interactions

PS3D: Energy in Chemical Processes and Everyday Life

PS4C: Information Technologies and Instrumentation

LS1A:Structure and Function

LS1B: Growth and Development of Organisms

LS1C: Organization for Matter and Energy Flow in Organisms

LS1D: Information Processing

LS2A: Interdependent Relationships in Ecosystems

LS2B: Cycles of Matter and Energy Transfer in Ecosystems

LS2C: Ecosystems Dynamics, Functioning and Resilience

LS3A: Inheritance of Traits

LS3B: Variation of Traits

LS4B: Natural Selection

LS4D: Biodiversity and Humans

ESS1B: Earth and the Solar System

ESS1C: The History of Planet Earth

ESS2A: Earth Materials and Systems

ESS2C: The role of Water in Earth's Surface Processes

ESS2D: Weather and Climate

ESS2E: Biogeology

ESS3A: Natural Resources

ESS3B: Natural Hazards

ESS3C: Human Impacts on Earth Systems

ESS3D: Global Climate Change

ETS1A: Defining and Delimiting an Engineering Problem

ETS1B: Developing Possible Solutions

ETS1C: Optimizing the Design Solution

Learning Objectives

SWBAT: Design a functional, closed biome where toxin reduction is monitored.

SWBAT: Determine useful chemicals to monitor, and methods to monitor them with leave-in-place sensors.

SWBAT: Gather and interpret data related to nutrient cycling in a closed biome.

SWBAT: Gather and assemble a mars-like dirt sample for testing, and verify how similar it is to real Mars dirt.

Vocabulary

vocab word/phrase (lower case)	*Definition punctuated like a complete sentence even if it's only a phrase.*
Perchlorate	Perchlorate is a negatively charged molecule made of one chlorine atom and four oxygen atoms. Perchlorate can occur naturally or be man-made.
Toxin	an antigenic poison or venom of plant or animal origin, especially one produced by or derived from microorganisms and causing disease when present at low concentration in the body.
Mending	Mulch the soil with bark, wood chips or some other type of mulch that decomposes slowly. Over time, the sun and rain break down the mulch, which will also improve your soil. Growing a cover crop from seed can also help. Try clover, winter rye or legumes to build up healthy soil.
Agriculture	agriculture. noun. ag·ri·cul·ture ˈag-ri-ˌkəl-chər. : the science or occupation of cultivating the soil, producing crops, and raising livestock : farming.
Hydroponics	the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil.
Sequestering	isolate or hide away.
Degrading	break down or deteriorate chemically.

Nutrient Cycle	The nutrient cycle is a system where energy and matter are transferred between living organisms and non-living parts of the environment. This occurs as animals and plants consume nutrients found in the soil, and these nutrients are then released back into the environment via death and decomposition.
Ecosystem	a biological community of interacting organisms and their physical environment.

Lesson Procedure

Introduction/Motivation

Show video of ASU Mars research, or collaborative website where other students have completed similar projects.

If you've done similar projects in prior years, classes, or units, review the results of those projects to build design guidelines.

Learning Activities/Strategies

Run a pre assessment (can be standards based, or custom), to week out standards that students already know.

Build teams based on similar missed questions, and select the most advanced student in each team as the team leader.

Any student that passed all standards on their pre assessment can choose a project of interest, or join a team they prefer.

Have each team collaborate to design an experiment out of the standards that were missed, to solve the Mars toxic soil question. They may use the collaborative website as a guide, or in discussion with you. Their main goal is to set up a Mars Microcolony in a sealed box that addresses the standard or topic they missed, and solves an open question or problem from a prior peer project. (ex.: a group is working on the water cycle because they missed ESS2C: The role of Water in Earth's Surface Processes. So they choose to design a Mars Colony Box that can self-water based on temperature cycles and distillation technique.)

Team Leaders then assign all roles, including builder, designer, recorder, measurer, report writer, etc. Team leaders should have NO ROLE other than team leader. This means the team leader's only task is to make sure the rest of the team performs well, and their grade will be based on the performance of the team.

The team then sets deadlines and presents them back to you.

You monitor all teams through their deadlines via check-ins with the team leaders every class period.

The report is due at the end of the deadlines set by the teams, and their report should include the standards they were attempting to meet in their references section.

If you're extending the project into a Research Program style classroom, you can implement a standards-as-points system like I have here.

Closure

Well done on your projects. It just so happens [if you had time to set it up] that I have set up a video presentation day with one of the researchers at ASU to hear about your project. This researcher has been working on [name project] and is interested to see how your project builds on that.

Students can then opt in or opt out of presenting to the ASU researcher on the scheduled zoom call.

Assessment

Formative Assessment

My school's education system is based on the Edgenuity online course system, so I will generally be using that as the pre assessment and skills check.

For continuing assessment, I will generally be meeting back with the team leaders and addressing the whole class or whole teams as needed to verify progress and check for understanding.

Summative Assessment

The student presentation, Mars box display and written paper can all be used in their summative assessment.

Contributors

Individuals

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References

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