The Martian

Tyler Pollak | Fall 2024

Field(s) of Interest: Astronomy, Terraforming, Climate Engineering

Brief Overview (1-3 sentences):
Mentees will explore ideas related to creating a settlement on Mars. Mentees will be given a chance to devise their own plans for a Martian Settlement, as well as make straw rockets, water filtration devices, and cloud in a bottle.

Agenda:

- Introduction/Module 0 (10 min)
- Module 1: Starships Were Meant to Fly (20 min)
- Module 2: So Fresh, So Clean (15 min)
- Module 3: On Cloud 9 (10 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:

- ➔ Basic Human Needs
  - ◆ Food
  - ◆ Water
  - ◆ Oxygen
  - ◆ Warmth/Shelter
- ➔ Habitable Zone
- ➔ Terraform
- ➔ Starship
- ➔ Martian Settlement
- ➔ Spacesuit
- ➔ Filtration
- ➔ Contaminant
- ➔ Electrolysis
- ➔ Atmosphere
- ➔ Clouds
- ➔ Greenhouse Gas
- ➔ Water Cycle

Background For Mentors

Module 0

- **Basic Human Needs**
  - **Food**
  - **Water**
  - **Oxygen**
  - **Warmth/Shelter**
- **Habitable Zone**
- **Terraform**

Mars is the fourth planet from the sun in our solar system. It is a mountainous, desolate planet whose soil is rich in iron oxide giving it its red color. Mars is 1.5 astronomical units away from the sun (50% further than the Earth), meaning it falls within the **habitable zone**, which is the region surrounding a star in which water can exist in the liquid phase on the surface of a planet. Some other notable conditions on Mars are that its atmosphere is 100 times less dense than that of Earth's, its average temperatures are below zero, and while there is water on Mars, it exists in the form of ice.

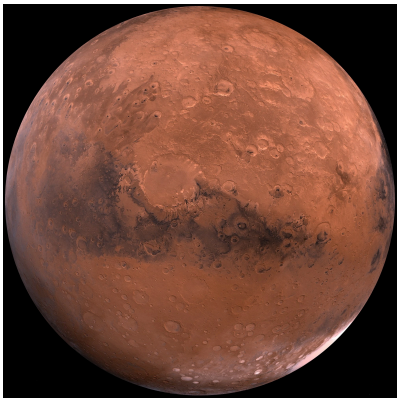

Figure 1: Planet Mars

While Mars currently is not habitable, its location in the solar system as well as the presence of water make it a suitable planet for **terraforming.** That is, to use scientific processes to turn the planet more earth-like in order to better sustain life. According to NASA, in order to sustain life, four **Basic Human Needs** must be met: Food, Water, Oxygen, and Shelter (Warmth). The most essential need on Mars would be **shelter**, this is because the extreme temperatures and lack of pressure would get to humans the fastest. The next most pressing need is the lack of **oxygen**, as humans can go 10-15 minutes without it. Subsequently, the lack of clean **water** and then the lack of **food** are why Mars in its current state is uninhabitable.

Module 1

- **Starship**
- **Spacesuit**
- **Martian Settlement**

The first step towards terraforming Mars is to get there and set up a camp to immediately fulfill humans' basic needs**.** In order to do this, humans must set up a **Martian Settlement**, or a permanent human habitat on Mars that is capable of sustaining human life. It will take a long time for Mars to be self sustaining for humans, so this settlement must be able to provide food, water, and oxygen along with warmth.

Figure 2: Example of What a martian Settlement May Look Like

Lots of technology and machinery may be brought along in order to aid human development on Mars, such as **spacesuits,** which are garments that can withstand the harsh conditions of space while regulating temperature and pressure, as well as rovers, solar panels, greenhouses etc. In order to transport all of this equipment to Mars, a futuristic **Starship**, a spaceship capable of interplanetary travel while carrying large payloads, must be developed and used. Even then, the large amounts of resources brought to Mars must be planned meticulously.

Module 2

- **Filtration**
- **Contaminant**
- **Electrolysis**

Now that we have set up a settlement to sustain life for the immediate future, we need to start using the resources on Mars. Mars has a large supply of water that exists in the form of ice. This ice is full of **contaminants,** such as perchlorates and other toxic polluting substances that make the water on Mars undrinkable. In order to make this drinkable, the water must undergo a **filtration** process. This is a process by which water passes through a medium that separates it from its contaminants. In this module, this will be done using a porous medium, where water is able to pass through the small holes but the larger contaminants are not able to.

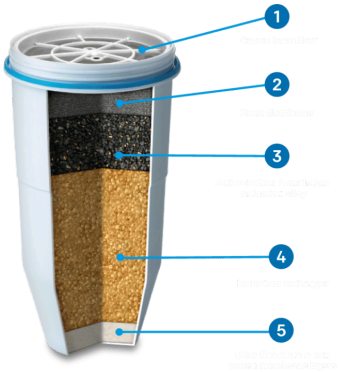

Figure 3: Inside of a Typical Water Filter

Water is not just important for drinking. Clean water is needed for growing food in the Martian Settlement, and for long term oxygen. By a process called **Electrolysis**, water can be split up into hydrogen gas as well as oxygen gas, providing a sustainable way to maintain breathable air.

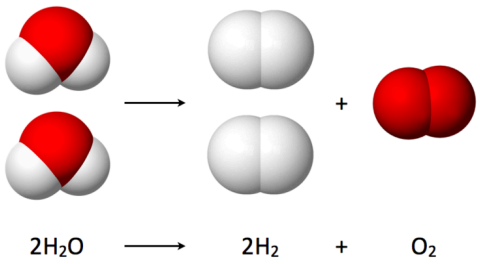

Figure 4: Electrolysis Chemical Reaction

Module 3: ● **Atmosphere** ● **Greenhouse Gas** ● **Clouds** ● **Water Cycle**	The largest issue for humans' long-term colonization of Mars is its lack of **atmosphere.** An atmosphere is a collection of gases that surround a planet providing utility such as trapping in heat and blocking out harsh UV rays and debris from space. The lack of atmosphere contributes to the harsh temperatures, unlivable pressure, and constant exposure to harmful radiation from the sun. The Martian atmosphere is 1/100th the density of the Earth's, and its makeup is 95% carbon dioxide. There are many ways to go about restoring an atmosphere on Mars, but the most agreed upon one is to release **greenhouse gases** via industrial processes. Greenhouse gases are ones that absorb heat in the form of infrared radiation and emit it back towards the planet, trapping heat and warming the planet. The eventual warming of the planet will lead to the large ice caps on Mars beginning to melt. When this happens, a **water cycle** will begin. This is a process in which water on the surface evaporates into the atmosphere, cools down and condenses to form **clouds**, and then precipitates down to the surface. The cloud in a bottle activity is used to represent this process. The rubbing alcohol is akin to the greenhouse gases added to the atmosphere. When the bottle is twisted, the pressure increases, increasing the local temperature of the fluids, causing evaporation. When the pressure is quickly released, the local temperature rapidly falls, causing the gases to condense creating a cloud for a brief moment.

Introduction

Why is this lesson important to teach? What is interesting or applicable about this lesson? Work with your MD partner to *provide mentors with various options to introduce your lesson here*. If you would like to put a demo here to open the lesson, then label this section as Module 0 and create a module page like the others.

Concepts to Introduce ● Introduce the idea of basic human needs ● Introduce the idea of terraforming ○ Let mentees be creative as they think about how humans can use technology to change a foreign world to meet our needs.	**Questions to Pique Interest** ● If you were stranded on a deserted island what would you need to survive? ● What makes Earth a place suitable for life? ● What are ways a foreign planet? ● Why would humans want to terraform another planet?
Scientists, Current and Past Events ● With climate change becoming more of a threat humans may look to expanding to other planets. Space technology still has a long way to develop, but there are many creative ways to go about creating a settlement, and some may be easier than we think. ● https://www.science.org/content/article/terraforming-mars-could-be-easier-scientists-thought	**Careers and Applications** ● Positions at NASA ● Astronauts ● Atmosphere Chemist ● Planetary Engineer

Module 0: Mission Briefing

This module will help introduce the mentees to the lesson, exploring the different challenges that inhabiting Mars would present and their relative urgency

Teaching Goals	**Materials**

List and explain/define the 1-3 main concepts you want to focus on *for this specific module*. For example...
1. **Basic Human Needs:** The list of necessities that humans need in order to survive.
   a. **Water:** The basis of fluids in living organisms
   b. **Oxygen:** A life supporting gas that makes up a sizable portion of the Earth's atmosphere
   c. **Food:** A nutritious substance
   d. **Shelter:** A space suitable to live in that may offer protection from harsh conditions.
2. **Habitable Zone:** The region around a star where conditions are suitable for liquid water to exist on the surface of a planet
3. **Terraform:** To transform the conditions of a planet so as to make it resemble Earth and be able to sustain human life.
	● Mars Pictures

Different Methods for Teaching

1. **Create a story! –** A great way to get mentees excited about the lesson is to turn it into a story. Ex: Tell mentees that they are in charge of planning a mission to Mars and then talk through the challenges that this mission would pose.
2. Start the conversation by asking mentees what things they absolutely need to survive, building off of their answers. Using this as a base, you can introduce the **Habitable Zone** by talking about how liquid water is essential for all organisms that we know which would be essential to sustain life and how **Terraforming** is needed to transform Mars' currently inhospitable conditions
3. Have some mentors pass around the pictures while the other mentor is teaching, this can help save time for other modules
4. Using the pictures provided to have the mentees think about the differences between Mars & Earth, and why Earth is currently suitable for life but Mars isn't.

Procedure

1. Explain to mentees the basic needs for human beings to survive.
2. Explain to the mentees the conditions on planet Mars. The degree of explanation may depend on the level of the class, but some key points to mention include:
    a. Mars' surface is made up of a red soil that is dry, toxic, and not suitable for plant growth.
    b. Mars does not have sufficient oxygen in the air to sustain human breathing
    c. Mars's average surface temperature is -10℉
    d. Mars does have water, but it is all in the form of ice and is contaminated.
    e. Mars is within the habitable zone, however, the current conditions are not suitable for humans. Mars requires terraforming for humans to live outside of settlements.
3. Pass around pictures of Mars
4. Write out the following parameters of survival: Oxygen, Warmth/Shelter, Water, and Food on a whiteboard.
5. Have the mentees guess how important each parameter is based on how long they would survive on Mars without it
6. Reveal the true amount of time humans could survive without each. Ranking is as follows:
    a. Shelter/Warmth: 2 minutes
    b. Oxygen: 10 minutes
    c. Water: 3 days
    d. Food: 1 month

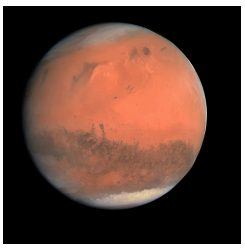

Figure 5: *Picture of Mars*

Figure 5: *Picture of Earth*

Figure 7: *Picture of Mars' surface*

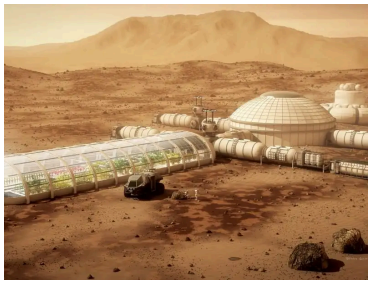

Figure 8: *What a potential Martian Settlement could look like*

Classroom Notes

If mentees are losing interest, move on to the other modules/activities, no need to linger on this module

Module 1: Starships Were Meant to Fly

In this module kids will individually build a rocket to get them to Mars and then in groups come up with a list of all the supplies they will bring to start off their settlement.

Teaching Goals

List and explain/define the 1-3 main concepts you want to focus on *for this specific module*. For example...

1. **Starship:** A large spacecraft designed for traveling long distances capable of carrying large payloads
2. **Spacesuit:** A garment that protects an astronaut from the harsh conditions of space whilst providing the basic human needs
3. **Martian Settlement:** A permanent human habitat on Mars capable of sustaining human life

Materials

- Straw
- Construction Paper
- Scissors
- Tape
- Pencils
- Paperclips

Different Methods for Teaching

1. **Continue the story –** We've finished planning our mission to Mars and now we need to get there!
2. Using references to movies or pop culture might help mentees understand the situation. One could compare making a settlement on Mars to starting a new Minecraft world.
3. For sites with mentees who can't read, mentees can draw pictures of what survival essentials they would bring instead (but don't let this take over the activity!)

Procedure

1. Help each mentee make their own straw rocket:
    a. Using construction paper make a cylinder slightly wider than that of a straw
    b. Pinch and tape off one end
    c. Cut out a rocket shape of their choice.
    d. Tape the rocket shape onto the construction paper, place this over the end of a straw.
    e. Add two paper clips to connect the end of the rocket to the paper cylinder for better flying.
2. In groups, mentees come up with a 'packing list' of what supplies and equipment they

Figure 9: *Step 1: Cut out paper and roll around straw, tape.*

Figure 10: *Step 2: Pinch and tape one end of cylinder*

would bring to comprise their martian settlement.

3. Have the mentees write out their list **on the rocket** to demonstrate the limited carrying capacity
4. As a class, go over what the mentees decided to bring, and give some ideas to add
5. Some important equipment to include (but not limited to) :
    a. Solar panels, Greenhouse, Soil/Seeds, Fertilizer, Spacesuits, Rovers, Oxygen tanks etc.

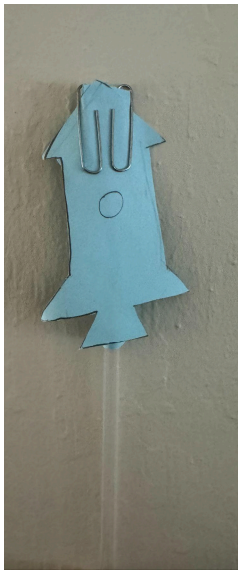

Figure 11: Step 3: *Cut out rocket shape and tape to cylinder, add paper clips as counterweight*

Classroom Notes

Mentees may need help with making the cylinders for the straw rockets. Feel free to take more time on this module as the next ones are not nearly as time-consuming.

Module 2: So Fresh, So Clean

In this Module, mentees will put together a water filter to remove contaminants from the water.

Teaching Goals

List and explain/define the 1-3 main concepts you want to focus on *for this specific module*. For example...

1. **Contaminant:** A poisonous or polluting impurity in water.
2. **Filtration:** The process of separating a substance from its impurities using a filtering medium.
3. **Electrolysis:** The decomposition of water into oxygen and hydrogen using an electric current.

Materials

- Precut water bottles (1 per group)
- Rubber bands
- Cotton Balls
- Napkins
- Dirty Water

Different Methods for Teaching

Give a couple of different teaching techniques that you think would be the most effective way for mentors to teach this module/the different teaching goals. For example...

1. **Continue the story –** Now that the mentees have landed on Mars, they need to make sure they have clean water to drink, relate this back to Module 0!
2. **Connect the water filters to masks**! Just like how masks can filter pollutants in the air, the water filter will keep the contaminants out of the water
3. The contraptions might not completely filter the water. Use this to explain to mentees that different contaminants may need different filters to be removed

Procedure

1. Pass out pre-cut bottles, as well as napkins, rubber bands, and cotton balls to groups of mentees
2. Have the mentees experiment with designs to best filter dirty water
3. When a mentees group is ready, have a mentor pour ~ ¼ of dirty water into the filter
    a. The water will usually take several minutes to filter
    b. During this time mentees may play with their rockets or draw their ideal martian settlement
4. Ensure to **make the connection** between the **dirty water** coming from **contaminated ice on Mars**
5. Once done, save the water for next module,

Figure 12: *Makeshift water filter*

Figure 13: *Napkin may be placed inside filter, or rubber banded onto outside*

clean up by throwing out cotton balls/napkins used for filter	

Classroom Notes

The filtration takes a few minutes and will be dirty if spilled, make sure mentees don't knock over filters and have something to do during this time. They may want to play around with the straw rockets or you could have them draw a martian settlement.

Module 3: On Cloud Nine

Mentees will view a cloud in a bottle demo to represent the use of chemicals to create a martian atmosphere and begin a water cycle.

Teaching Goals

List and explain/define the 1-3 main concepts you want to focus on *for this specific module*. For example...

1. **Atmosphere:** A mixture of gases surrounding a planet that trap heat and block out harmful space debris & UV rays
2. **Clouds:** A mass of condensed water vapor and other particles that enables precipitation
3. **Greenhouse Gas:** A gas that absorbs and traps heat within the atmosphere
4. **Water Cycle:** The cyclic movement of water between the surface and the atmosphere

Materials

- Empty water bottle
- Rubbing Alcohol
- Pipette
- Water

Different Methods for Teaching

1. **Finishing the story** – Let mentees know that the astronauts have now established a thriving (enclosed) settlement on Mars and they are now looking to form conditions suitable for life throughout the planet. Use this to segue into how important the atmosphere is for establishing ideal conditions for life, as it provides oxygen, traps heat, and mitigates the risk of the sun's intense UV rays.

Procedure

1. In larger groups, or as a class, combine water from the filtration device and pour into the unused bottle so that each one is ~¼ full.
    a. Depending on the size of the class there may be several bottles for the demo
2. Have a mentor use a pipette to coat the inner walls of the bottle with rubbing alcohol
    a. Two pipettes full should be sufficient
3. Connect the idea of **adding alcohol into the bottle** to **adding gases into the atmosphere**
4. Put the cap on the bottle and twist the bottle as much as you can, then release it back to normal
5. A cloud of water vapor should appear

Figure 14: *Successful cloud in a bottle*

6. Be sure to connect the idea of **adding gases into the atmosphere** to **changing the climate of Mars** **7.** Ask the mentees why causing climate change via greenhouse gases can make Mars more habitable for humans, but may be more harmful on Earth	

Classroom Notes

If there is no time for module two it can be skipped but you will need to get water at site to fill up the water bottles. Cloud in a bottle will still work even if the water is pretty dirty. The amount of rubbing alcohol is not as important as the total surface area covered by it, make sure when a mentor pipettes the rubbing alcohol out it is spread around. The demo can be run several times but will be less effective on subsequent runs.