Environmental Science Institute
THE UNIVERSITY OF TEXAS AT AUSTIN

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How to Survive on Mars

Lesson plan for grades 6-7
Length of lesson: 1 hr, 15 minutes
Adapted by: Mamie Huang, Environmental Science Institute, 05/15/14
Authored by: Natalie Wyll and Jenna Nelson & Marisa, Christa, and Carmen

SOURCES AND RESOURCES:

- Mission to Mars: Human Factors
  http://www.edb.utexas.edu/visionawards/petrosino/index.php?usr=nwyll&id=s:home_nwyll
- Mission to Mars: To survive on a trip to Mars
  http://www.edb.utexas.edu/visionawards/petrosino/index.php?usr=healthymars&id=s:home_healthymars
- Video: How to put a human on Mars
  http://youtu.be/GwK-NkTo9HE
- Glenn Lightsey at ESI's *Hot Science – Cool Talks*
  http://www.esi.utexas.edu/hot-science-cool-talks/376-space-exploration-from-science-fiction-to-the-texas-spacecraft-laboratory
- Mars Compared to Earth
  http://www.universetoday.com/22603/mars-compared-to-earth/
- Video: How to put a human on Mars
  http://youtu.be/GwK-NkTo9HE
- Environment: Here Comes the Sun
  http://www.clavius.org/envsun.html
- Mars Facts (with a table at the bottom comparing Venus, Earth, and Mars)
  http://quest.nasa.gov/aero/planetary/mars.html
- NASA: Plants in Space and many other lesson plan ideas and useful resources
  http://www.nasa.gov/audience/foreducators/spacelife/topics/plants/index.html#.U4-zV7td98b
- NASA: Plants in Space video
  http://www.nasa.gov/mp4/516917main_NE00021511_at28_SLSL.mp4

POTENTIAL CONCEPTS TEKS ADDRESSED THROUGH THIS LESSON:

§112.18. Science, Grade 6: 2A
§112.18. Science, Grade 6: 2B
§112.18. Science, Grade 6: 11C
§112.19. Science, Grade 7: 9A, 9B

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PERFORMANCE OBJECTIVES

Students will be able to:

- List the different human needs to enable life in space
- Contrast characteristics of Earth and Mars
- Explain how the spaceship needs to provide all the living needs Mars does not provide
- Elaborate on how the problem of gravity is solved in making a space landing

MATERIALS (per student):

- Books about Mars and Earth (optional)
- Internet access and computers/laptops/iPads/tablets

(per group):

- Poster paper
- Colored pencils
- Markers

CONCEPTS:

Basic needs: all life needs air, water, food, and shelter in order to survive

Gravity: a force that attracts any two (or more) bodies of mass towards each other

Centripetal force: a force that acts on a body moving in a circular path and is directed toward the center around which the body is moving

Radiation: the emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles that cause ionization; radiation is energy that can be transmitted as heat, light, electricity, etc. At wavelengths other than those in the visible spectrum, radiation waves can be extremely damaging to living organisms

Technology: the application of scientific knowledge for practical purposes, especially in industry and machinery and equipment development

BACKGROUND:

Dr. Glenn Lightsey is the Fellow of the W. R. Woolrich Professor in Engineering in the Department of Aerospace Engineering and Engineering Mechanics at The University of Texas at Austin. He is the Founder and Director of the Satellite Design Lab at UT-Austin, which designs, builds, and operates satellites with undergraduate and graduate students. His research program focuses on the technology of small satellites, including: guidance, navigation, and control systems; attitude determination and control; formation flying, satellite swarms, and satellite networks; cooperative control; proximity operations and unmanned spacecraft rendezvous; space based Global Positioning System receivers; radionavigation; visual navigation; propulsion; satellite operations; and space systems engineering.

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The lesson explores what it takes for there to be somewhat long-term survival in Mars, getting students to think not only about the basic necessities of life but also about the limitations and availability of different kinds of technology and equipment we have today. The basis of this lesson comes from an older PowerPoint draft of Glenn Lightsey's for his *Hot Science – Cool Talks* presentation. In this older draft, he would have discussed how various components of being able to live out in Mars would necessitate various other tools being sent out into space prior to human arrival on Mars. Some points that would be addressed is how different it is for us, currently, to travel to the moon verses traveling to any planet: how there must be a large supply of consumables and energy for humans to be able to live and work/study productively on Mars and how going out into space brings much more health concerns to the forefront that otherwise are minimal concerns on a short trip to Moon.

PREPARATION:

Have the "How to put a human on Mars" video [http://youtu.be/GwK-NkTo9HE] loaded up.

ENGAGE:

Teacher: What is the Curiosity?
Students: It's what killed the cat; it's when we're curious about something; it's when we want to know more about something; it's the rover that went to Mars.

Depending on how the students respond, the teacher can give students more hints, e.g.
"The Curiosity has something to do with the year of 2012 in early August,"
"The Curiosity has done something that no man has done before,"
"The Curiosity has done something that many Hollywood movies and science fiction movies and novels have fanaticized about,"
"The Curiosity roams on land," etc.

Once the students hit on the Curiosity being a Mars rover, the teacher can ask more questions over what they know about it, if they watched any of the movies on YouTube or on the news over it, how old they were when the Curiosity landed, etc.

Teacher: Why do you think scientists sent a rover to Mars? What is a rover? What does it do?
The teacher can direct the students to talk in 3-person groups or pairs and later ask students, "If you think you have a good idea why, please share."

Teacher: It wasn't only the scientists that were excited about the Mars rover landing. One YouTube video alone that I checked had 866,000+ views! This means that many normal people like you and me were also very excited and watched along. How come people were so worried about Curiosity having a safe landing?

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Hopefully students catch on to how people have long hoped for life to be found on other planets, e.g. Martians, in particular. The teacher can guide their thinking through reminding them, "The Curiosity has done something that many Hollywood movies and science fiction movies and novels have fanaticized about."

Teacher: Even before the Curiosity rover landed on Mars, humans have wondered about the possibility of visiting or even living on Mars. Now that we have a rover on Mars, people have been becoming more hopeful about one day sending astronauts to go on a mission to Mars. What would it take to survive? This video shows us a small glimpse of what it would take.

Show the "How to put a human on Mars" video [http://youtu.be/GwK-NkTo9HE]

Post the Driving Question on the DocCam or write it on the board:
Driving Question: What do astronauts need to survive a mission to Mars?

Take a few answers from the students and then have them brainstorm and write down as many ideas as they can think of on a sheet of paper. Then have students share with a partner their list. Come back together and have a class share out, with one student volunteer writing all the ideas on the board.

Next, have students consider what allows them to live on the Earth. Give them about 2-3 minutes to consider this and write down their thoughts. It should be the case that students realize the same necessities are brought up.

Lastly, have students consider how Mars matches up against these human life necessities. Students are free to use books, the Internet, and old notes to determine how Earth and Mars match up against each other.

Students will have a share out. Students ought to come to the conclusion that since Mars does not provide a livable environment, a livable environment must be made within the astronauts' own spaceship. The key points that ought to be talked about are as follows, from most likely to be noted to least likely to be noted:

- Basic necessities: water, food, air: all of these components must come from what the astronaut has brought along in his/her spaceship.
- Temperature: the freezing cold temperature of Mars is not only cold for people but may also negatively affect technological instruments and batteries. Students may also take a look at how the Curiosity is built in order to withstand the freezing cold temperatures and other aspects of the Mars climate.
- Winds: the windstorms bring up large amounts of dust. Whatever instrumentation humans bring may need additional protection
- Gravity
- Radiation
- Power and propulsion

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EXPLORE:

Give students the challenge of providing a report or poster of what astronauts must have in order for each astronaut to survive. The constraints are as follows:

- 5 astronauts
- 30-90 days on the Mars surface
- 560-620 days in space
- Up to 650 days in total in space and on Mars

The safety and wellbeing of each of these five astronauts is in the hands of the students. Students must research to explore how students are able to meet each of the needs to survive out in space and on Mars. What are astronauts able to do out in space? What must already be set in place prior to their arrival?

Something interesting for the teacher to note is whether or not students consider how Curiosity continues to roam on Mars' surface. Another interesting point for the teacher to note is whether or not students think of the Moon as the one place humans have traveled to in outer space.

EXPLAIN:

The following are some key differences between Earth and Mars:

- Availability of water: Mars has areas of frozen water in its craters
- Size (this affects gravity): Mars is 53% the diameter of Earth and 10% the mass of Earth
- Gravity: Mars is only 38% of the gravity of Earth
- Temperature: on Mars, it is -153°C (-225°F) to 20°C (70°F); on Earth, in Antarctica, the coldest recorded temperature is -89.2°C and the hottest recorded temperature is 70.7°C.
- Atmosphere: since Mars' atmosphere is 95% carbon dioxide, its air is poisonous for us to breathe
- Winds: Sometimes Mars gets dust storms that cover the entire planet and may take months to subside.

Below are some answers students may come up with:

1) Basic needs:
    a) Air: use of oxygen canisters, filtrations systems, or plants to convert the carbon dioxide being breathed out into oxygen

Teacher: How do plants "create" oxygen?
Student: Photosynthesis; they breathe in carbon dioxide and breathe out oxygen.
Teacher: What does a plant need to grow?
Student: Light, water, and nutrients (soil)

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Teacher: Will a plant have all of this in space?
Student: Yes/no; scientists have to figure out a way to mimic the sun.

b) Water: reclamation and purification systems
c) Food: stored or grown

2) Gravity
   a) Earth's 1g gravity is necessary for balance, heart, muscle, and bone systems
   b) Contrasting Earth (9.8 m/s^2) and Mars' (3.0 m/s^2) gravities
   c) Solution: a rotating structure such as a disc can use centripetal force to create a 1g force in the center, such as in these fair rides:

3) Radiation
   a) Space is full of radiation that Earth's magnetics field protects us from, e.g .UV radiation
   b) A high exposure to this radiation can result in radiation related illnesses, e.g. cancer, radiation sickness. Refer to http://us.arevablog.com/wp-content/uploads/radiation.png.

   The Mars Curiosity Rover has measured 1 Sievart (1 Sv = 100 rem) radiation over its 3 years in Mars, which is a survivable career dose. But a solar flare may produce as much a 1 Sv per hour. 2 hours in a solar flare would result in an exposure of 2 Sv, which leads to sometimes-fatal severe radiation poisoning

   "NASA says that [a] solar event is the single biggest danger astronauts would have to face on a mission to Mars. So why wouldn't it also have been a grave danger to go on lunar missions? That's because a mission to the moon lasting at most 2 weeks has good odds of avoiding solar events. [But] a mission to Mars lasting two or more years has very little chance of avoiding a major solar event." (http://www.clavius.org/envsun.html)

   Maybe a spacecraft generating a magnetic field could be sent up into space close to Mars when a human mission is sent in order to shield some of the radiation the astronauts would be getting.

4) Power and propulsion
   a) 1 MW = 10^6. Only nuclear power would provide enough energy for a manned Mars mission.
   b) However, so far we are not allowed to send nuclear reactors up into space.

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c) Since the atmosphere is 95% carbon dioxide and 0% oxygen, the ship's propulsion system cannot use oxygen from the atmosphere of Mars for landing nor liftoff. Unlike on earth, there is now no system for using energy, e.g. there are no floating outlets/plugs

ELABORATE:

The teacher can create an interactive web graphic organizer in order so that students can add and fill in details about each of the needs humans have to be able to survive the trip to Mars. The students can vote on which groups have the best ideas and would most likely have astronauts that would be able to survive the challenge. The time of sharing can be similar to an open forum where any student can challenge the presenting group on their design flaws, e.g. what would not be feasible long-term, in space, cost-wise, etc.

EVALUATE:

Although technology has greatly improved, there is still much that must be done in order for astronauts to safely travel to Mars for long spans of time (as shown in the answers above).

Closing comments:

The NASA website has many resources for more in-depth studies over some of these various problems and even proposed solutions. For example, the following is a video showing how plants can be used for food and oxygen in space and what scientists do to minimize dust:
http://www.nasa.gov/mp4/516917main_NE00021511_at28_SLSL.mp4

The NASA website can be used if the teacher wants to do more in-depth studies into various aspects of space. This written lesson plan mainly serves as a general overview of the many problems scientists must solve in creating the necessary environment for astronauts to survive out in space.