Intern: Pritika D., Biological Engineering Major
Topic: A biological perspective on life and space
Setting: Lehman Alternative Community School, Ithaca School District, middle school science classes

The following lesson goes along with a PowerPoint presentation developed by Pritika
Life and Space: A Biological Perspective

Slide 1:
- Introduce self

Slide 2: Biological Engineering
- Application of engineering skills to solve problems in biology and medicine

Slide 3: What is Life?
- Ask students what the definition of life is
- What do we need for life?
- Examples of living and not living
- Write out their answers out on the board
- Tell them that this question prompted me to study biological engineering

Slide 4: Life is a condition that distinguishes active organisms from inorganic matter. Living organisms grow, they respond in some way to their environment, reproduce, and adapt to their environment.
- Most living things are characterized by having carbon. Anything that has carbon in it is most likely an organic compound

Slide 5: Earth is a biosphere, which means it supports life as we know it.
- For example, the moon is not favorable for sustaining life because there is no water, organic topsoil, and atmosphere. We also need light.
- What is Earth's atmosphere? Mostly Nitrogen and Oxygen.

Slide 6: The Planets' Atmospheres
- Mercury – hydrogen, helium, oxygen, sodium, magnesium, calcium, potassium, and water vapor
- Venus – 95% carbon dioxide, 3.5% nitrogen
- Mars – 95% carbon dioxide, about 2.7% nitrogen, 1.6% argon
- Jupiter – mostly hydrogen, and some helium
- Saturn – 96.3% molecular hydrogen and 3.25% helium
- Uranus – Hydrogen and helium mostly, but there is also water, ammonia, and methane
- Neptune – 80% hydrogen, and then helium, some methane

- Investigate the composition of each planet's atmosphere
- What is the atmosphere of the Moon? Moon's gravity is 1.63 m/s2

Slide 7: Why do we care about Space?

- One of the great things about humanity is our desire for knowledge and our insatiable curiosity. Space is the final frontier.
- Satellites allow us to communicate instantaneously with people on different continents. Weather satellites help us understand our world better. For example, studying climates would be impossible without the data provided by satellites. Global Positioning System (GPS) allows us to pinpoint our location anywhere in the world.
- The need to reduce weight on rockets led to microchips and the modern computer.
- Safe efficient power sources
- Space could be a place where we could get more resources (mining)

Slide 8: How did life originate on Earth?

- Earth used to be just like the other planets and had no sustainability for life. There were a lot of inorganic compounds. It was primarily made of nitrogen.
- There were also large volcanic eruptions all over. The main compounds available were methane, ammonia, hydrogen, and water
- The atmosphere was exposed to energy in many different forms (like the Sun, lightning) and produced organic molecules.
- These organic molecules soon gave way to form simple one-celled prokaryotes.

Slide 9: Stanley Miller and the Miller-Urey Experiment

- Simulated how life originated abiotically
- He gathered water, methane, ammonia, and hydrogen. The liquid water was heated to induce evaporation, sparks were fired from the electrodes (lightning through the atmosphere and water vapor), and then the atmosphere was cooled again so the water could condense and trickle back. After a week, some of the carbon had formed into organic compounds including amino acids, sugars, lipids, and building blocks of nucleic acids.
- Why could this not happen on Earth now? Discuss.
- Titan (largest moon of Saturn) has shown clear evidence for the potential of life. The Moon and Mars are possible options.

Slide 10: What would Humans need to Survive in Space? What do we need to live?

- Food
- Water
- Waste Processing
    - Liquids sent to space, solids are stored, air is used instead of water in toilets and then filtered
- Oxygen:
    - What gas do humans and animals need to breathe in? Oxygen

- What do they breathe out? Carbon Dioxide
- What is photosynthesis? What gases are taken in and produced?
- Photosynthesis takes carbon dioxide and water. Produces oxygen. It converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight.

Slide 11: Questions

1. What gas do humans and animals need to breathe in? What is photosynthesis? What gases are taken in and produced?
2. How much do we depend on food? What foods last a long time? Why is this useful to know?
3. Think of all the things you do during a regular school day, from the minute you wake up until the time you go to sleep. List each activity that involves water. List each activity that requires electricity.
4. During summer, have you ever heard a public announcement that "water conservation measures are in effect"? What activities are affected by this announcement?
5. Imagine if a summer drought continued for years, then how could water be conserved for people? For animals? For crops? For businesses?
6. List ways to produce electricity. Where does energy come from?
7. It is likely that space in the Moon base will be limited. Protein sources like cattle and vegetable sources like corn require substantial space for production. What are other sources of protein that take less space? What fruits and vegetables could be produced in limited space?

Slide 12:

Design a development on Moon/Mars that is realistically possible. Brainstorm what you would need to create a self-contained habitat with all the life support systems necessary for the survival of people, animals, and plants.

1. Air Supply
2. Communications
3. Electricity
4. Food Production and Delivery
5. Recreation
6. Temperature Control
7. Transportation
8. Waste management
9. Water Supply

Students then did the hands-on 'Element Bottle' activity from the Beyond Einstein Explorers Program (name was changed to Afterschool Universe and this activity was removed from new leader guide). There is a set of six bottles filled with dried rice, lentils, beans, and peas that

represent different elements. Each bottle represents a different object in the Universe: The Sun, the Earth's atmosphere, the Universe, a meteorite, a super nova remnant, and a mystery bottle (human). There is a key and the challenge is to figure out what the mystery bottle is.

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The intern developed the following lesson outline for three class periods. She wasn't able to visit the class three times and therefore cut it back to one class period (available above as a script that accompanies a PowerPoint presentation).

Audience: Middle School
Schedule: ~3 class periods, spanned over ~3 weeks
Objectives:

- Gain interest in Biological Sciences (biology, chemistry)
- Gain interest in Engineering (math, physics, chemistry)
- Gain interest in Space (scientific support and travel)
- Be able to relate and individually explore

Students Will:

- Learn about many different areas of study that have the versatility to lead to various career paths (including space sciences)
    - Biological Engineering/Biological Sciences/Materials Science and Engineering
    - Medicine
    - Physics/Theoretical Mathematics
    - Mechanical Engineering
    - Civil Engineering
    - Computer Science
- Learn about different technologies that are being created to help with space exploration
    - Improved physio-chemical technologies
    - Water recovery
    - Waste recovery
    - Food production
    - Air
- Participate in interactive activities that investigate the advantages of space exploration and the importance of the technologies (above) for humans to survive in space

Vocabulary:

- Will be incorporated in classroom talks/lectures/slides
- Fun facts about the start of the Earth as we know it [example: Stanley's Miller's experiment: origin of life]
- Simple vocabulary learned in physical sciences and biology classes (very basic level)

Activities:

- Why do we care about space?
    - Start of life on Earth
    - Ozone layer
    - Curiosity
    - Learning about space can indirectly lead to other discoveries in other fields of science
    - Satellites, GPS, etc (impacting our world to make it drastically different)
    - "Final Frontier"
    - Future Investment (space may have useful resources)
- Biosphere Activity (main activity):
    - A good spring activity
    - Have students organize themselves in teams of 4 (botanist, agronomist, science specialist, zoologist)
    - Make biosphere (that must have soil, light, water, plants, and animals)
    - Observe biosphere
    - Compare this with making self-contained habitats on the Moon/Mars
    - Compare with activities (below)
- Design a development on Moon/Mars that is realistically possible:
- Investigate what chemicals are on each planet
- Water
    - How to preserve water?
    - How astronauts shower
- Air Supply System for Human Settlement and Exploration
- Model Food Processing:
    - How much do we depend on food?
    - What minerals do we need for living?
    - What foods last a long time?
    - What could we do to foods to make them last a long time (what degrades fruit, vegetables, etc.)
    - How can these techniques be applicable in our everyday lives?
    - How would scientists eat?
- Model Electrical Power Supply
- Temperature Control
- Waste
    - Liquids sent to space, solids are stored, air is used instead of water in toilets and then filtered
- Simulate an activity where they are in a space shuttle after they developed these systems
    - How long is a space mission?
    - What were the space missions in the past?