Day 3 - Our Topics & Closed Systems

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Wether we are on Earth or Mars humans have the same basic needs - food, waste management, shelter, water, clean air, transportation/fuel, medicine and diagnostic tools (seeing if you are sick). But what we do on Earth to solve these problems isn't going to work in space. To cope with these needs in space we are going to need to think beyond the conventional, we have to start thinking of solutions to biological needs in a synthetic biology way.

One major thing to consider is that on Mars we won't have the ability to "mail order" what we need, or ship our waste to a landfill. We will be living in a closed system, so we need to be really good at reducing, reusing and RECYCLING what we bring into the system.

Lets cover some of the conventional ways we deal with our human needs - some of them do utilize synthetic biology.

- Food
    - We grow a lot of our food just in the soil, we have edited the genome of many of our foods, see corn, tomatoes, wheat so that they have higher yields, are resistant to pesticides, can withstand drought.
        - Plants in space might not have to worry about insects, but they will need to worry about limited water, limited sunlight, possible radiation exposure and a lack of nutrients like nitrogen, phosphorus etc. readily available in the soil.
    - Our animal production, we have GMO animals who put on weight faster and reach maturity faster.
        - In space, we would need to think about the needs of these animals, the space, oxygen, food and water they require and the waste and gases that they produce that we might not want to introduce into our closed system.
- Waste Management
- Shelter
- Water
- Clean Air - but mostly oxygen
    - We don't really think about air all that often, we think about reducing our carbon emissions but our air is regulated for us for the most part. Plankton for the most part produce our oxygen, with some help from trees, grass and other plants.
        - In space we would need to create an oxygen recycling system which cleaned our air of high levels of Carbon Dioxide(we don't want to get rid of all of it, it is important for regulating our blood pH levels), and atmospheric nitrogen while adding oxygen into our system.
- Transportation and Fuel
- Medicine
- Diagnostic Tools

There are currently two models for these closed systems

Activities

K-5
Create a closed ecosystem in a bottle, typically a plant, dirt, a little water and a bug. Can be done with aquatic enviornments as well. Talk about how to adapt different components of the ecosystem with synbio to shift the enviornments to one that works with Mars.

6-8

Have each student (or pair) select a component of a human ecosystem (listed above). Have them outline how it is managed on Earth (sometimes looking how other countries handle these problems can provide additional creative stimulus for the second half of the activity. Once students have briefly outlined the earthly solutions to these problems, and potentially noticed some flaws with the sustainability of some of these practices, have them design a system which would be adaptable to space. This could be as simple as adapting the system we use on earth with additional machinery, or synthetic organisms, and as complex as starting from scratch to create a new solution to an old problem. If you have large classes, let students pitch their ideas to one another for critiques. If you have ample time let students present their ideas in a mock "investors meeting" and provide suggestions and questions to one another. Promote critical thinking and creative problem solving!

9-12

Discuss the importance of a closed system for the preservation of resources, also discuss that no recycling system recovers 100% of the liquid/material/water used.

Have students research and brainstorm a closed system which addresses one or more of the above challenges. Have students investigate current technologies which can be used. Have students identify the opportunities for resource loss/waste, and brainstorm ways to improve efficiency. Is there a better system or organism to be used? Can synthetic biology improve the efficiency? How? Are mechanical systems being currently used where living systems could be implemented (often these when perfected can be the most sustainable and efficient systems). Once students have created a modified/improved system have students discuss the risks involved with using mechanical systems in space (if they are broken how can they be fixed? what backups can be put in place), use this opportunity to also discuss the risks associated with using synthetic systems. What are the risks of failure when thinking about living organisms as resource providers.

NASA likes to use "redundancy" in their systems so that resources can be conserved and so that back up systems are available without creating more complex systems. Simple, redundant, efficient are all goals. Have students share out what they selected as their focus system - what systems can utilize some of the same tools? Have student collaborate one what systems they can bring together. For example, we eat plant based foods, those same plants provide oxygen. But I'm sure your students can come up with even more creative dual use systems.