NASA - Raw notes

Project: iGEM 2018
Authors: Jessica Laury
Date: 2018-06-17

SUNDAY, 6/17/18

http://blogs.plos.org/synbio/2015/11/08/mars-will-come-to-fear-my-botany-powers/ - On desk top called SynbioSpaceEx
We need to use synbio to make the microorganisms compatible with harsher environments and relieve them of their dependence on earth pre cursor molecules.
http://rsif.royalsocietypublishing.org/content/12/102/20140715

NASA -
Core Competencies

1. Base Line Understanding - Where are we now with SynBio - who are our major players/tools
    a. CRISPR, Cas9
    b. PCR
    c. Gibson/Golden Gate Assembly
    d. Plasmids
    e. SOL
        I. BIO5 Students will investigate and understand common mechanisms of inheritance and protein synthesis.
            1. Exploration of the impact of DNA technologies
            2. Events involved in the construction of proteins - **where do we fit in**
    f. **SYNBIO**
        I. What can't we do
        II. What can we do
2. Creating ecosystems on other planets, focus on crops & food
    a.

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Table 2 Environmental parameters on Mars and Earth surfaces

Parameter		Mars	Earth
Surface gravity		0.38*g*	1.00*g*
Mean surface temperature		−60 °C	+15 °C
Surface temperature range		−145 to +20 °C	−90 to +60 °C
Mean PAR photon flux		8.6×10^{19} photons m^{-2} s^{-1}	2.0×10^{20} photons m^{-2} s^{-1}
UV radiation spectral range		>190 nm	>300 nm
Atmospheric pressure		5–11 hPa	1013 hPa (mean at sea level)
Atmospheric composition (average)	N_2	0.189 hPa, 2.7 %	780 hPa, 78 %
	O_2	0.009 hPa, 0.13 %	210 hPa, 21 %
	CO_2	6.67 hPa, 95.3 %	0.38 hPa, 0.038 %
	Ar	0.112 hPa, 1.6 %	10.13 hPa, 1 %

Adapted from Kanervo et al. (2005) and Graham (2004), and reproduced from Verseux et al. (2015) with permission from the editor of the International Journal of Astrobiology

    a. Converting Mars soil into enriched plant ready soil
    b. What does it take to create a balanced and highly productive ecosystem
    c. What adaptations will plants need to survive on other planets? This might not just be pure survival but efficiency of sparse space resources for example how do we get plants to be productive with less water? Work already being done with stomata...I think it's interesting.
    d. SOL
        I. BIO2. Students will investigate and understand the chemical and biochemical principles essential for life.
            1. Water Chemistry and its impact on life processes.

2. The capture, storage, transformation and flow of energy through the processes of photosynthesis and respiration.

II. BIO4 - Students will investigate and understand life functions of Archaea, Bacteria and Eukarya.
   1. Comparison of their metabolic activities
   2. Maintenance of homeostasis
   3. How the structure and functions vary among and within the Eukarya kingdoms of protists, fungi, plants, and animals

III. BIO 8 - Students will investigate and understand dynamic equilibria within populations, communities and ecosystems
   1. Interactions within and among populations including carrying capacities, limiting factors and growth curves
   2. Nutrient Cycling with energy flow through an ecosystem
   3. Succession patterns in ecosystems

IV. ES3 - Students will investigate and understand the characteristics of earth and the solar system - Position of earth in the solar system, sun-Earth-moon relationships: Seasons, tides, and eclipses - **if we could control these on another planet how would we do this and what would it mean? Longer growing seasons? No freezes? According to the mars article we would have shorter growing seasons because we would only be getting 40% of the sunlight we get on earth, and we will need to be growing things under a lot of sand to prevent radiation.**

e. **SYNBIO**

I. We have to grow things with less light

II. We have to grow things that will not take up heavy metals (we don't want to eat those, but they are in the soil)

III. Growing plants with a small amount of nitrogen - Look at Ginkgo Bioworks and Bayer for building nitrogen fixing bacteria. Also look at Pivot Vio for boosting nitrogen fixing abilities.

IV. What will we use as pollinators?

V. What will we use as nutrient cyclers? Bacteria to break down organic matter an N-fixation. Fungi to improve nutrient take up. Worms to break down organic matter. (Artificial ecosystem needs and functions)

VI. SynBioBeta Conference focus on synthetic protein rich animal products (we can't take the animals with us) lab grown meat - Memphis meats and Finless food companies.

VII. Microsynbiotix is genetically engineering algae to make edible vaccines to protect farmed fish.

VIII. We need to create organisms which can get by without organic carbon. https://www.researchgate.net/publication/281494184_Synthetic_Biology_for_Space_Exploration_Promises_and_Societal_Implications
   1. We need autotrophs like cyanobacteria
   2. We have in the past lysed cyanobacteria and then let yeast use it, but we ultimately want the cyanobacteria to secrete the organic food into the extracellular medium. Stanford-Brown iGEM did it in 2001x
   3. Growing things at lower pressure is also possible with SynBio

IX. However, even though some edible cyanobacterial species such as Arthrospira spp. have excellent nutraceutical properties (e.g., Henrikson 2009), they can currently not be used as a staple food due to their unpleasant and unvaried taste, lack of vitamin C and possibly essential oils, and low carbohydrate/protein ratios. These limitations could be addressed using synthetic biology (Way et al. 2011). First, taste, smell and color molecules have already been, or could be, expressed in bacteria. Then, modifying the sugar, protein and lipid ratios, as well as introducing essential molecules (e.g., vitamin C) could be achieved using metabolic engineering and, more generally, nutraceutical properties could be improved by genetic engineering. Preliminary work has been done in this direction; for instance, mutant strains of A. platensis have been selected that contained higher contents than the wild-type in essential amino acids, phycobiliproteins and carotenoids, among other nutrients (Brown 2008b). Cyanobacteria could also be used for food complementation without being directly eaten: they can be engineered to secrete nutritional compounds, so used culture media could be harvested without lysing cells and added to food (Way et al. 2011). Besides, as mentioned above, the possibility of engineering cyanobacteria to produce and secrete sugars has already been demonstrated. The use of plants could thus be restrained to applications where no large amounts are needed and where they could be grown within habitats (thus relieving the need for large-scale areas under highly controlled parameters): ornament and horticulture—which have beneficial psychological impact on crew members (Allen1991)—and occasional provision of comfort food.

Synthetic Biology for Space Exploration:... (PDF Download Available). Available from: https://www.researchgate.net/publication/281494184_Synthetic_Biology_for_Space_Exploration_Promises_and_Societal_Implications [accessed Jun 25 2018].

1. How do we manage waste?
    a. Minimize waste creation
    b. Converting waste into useful products (reduce reuse) Already working on a turn poop into material project.
    c. Waste isn't just fecal matter, but trash from packaging, we can't ship that back to earth so how do we make it useful? Do we try and get it to degrade(this is risky because it could degrade too soon making it not shelf stable if it were food packaging, it could make the materials weaker etc)
    d. SOL
        I. BIO2 - The function of enzymes
        II. ES8 - The students will investigate and understand how freshwater resources are influenced by geological processes and the activities of humans.
            1. Relationships between groundwater zones, including saturated and unsaturated zones, the water table and identification of sources of fresh water including rivers, springs, and aquifers with reference to the hydrologic cycle. (**How does earth clean our water? Can we adapt these for use in space? What do we need?)**
    e. **SYNBIO**
        I. We will have to recycle, how will we get the germs out of fecal matter, why are we less concerned about urea?
2. How do we keep people healthy in space?
    a. Diagnostic tools that are small, fast and accurate
    b. Diagnostic tools that can be adapted to multiple situations so that you don't have to bring hundreds of boxes of diagnostic material.
    c. Treatments for illnesses that are stable and last a long time, take up very limited space, but are replicable (i.e. like a stock solution that we can clone it would be best if these treatments were infinite) - Ready made medical treatments
    d. Can we create self sustaining ecosystems of helpful bacteria on plates cycling indefinitely.
    e. How do we create surfaces that won't allow for bacteria or virus to grow or live on for extended periods of time?
        I. What are the dangers of a completely steril environment? A lack of immunity.
    f. SOL
        I. BIO4 - Then student will investigate and understand life function of Archaea, Bacteria and Eukarya. Key Concept -
            1. How viruses compare with other organisms.
            2. Evidence supporting the germ theory of infectious disease - **How might this be impacted with people living in close proximity, in a contained space - spread might be faster. How do we create materials that are disease resistant?**
        II. BIO 4 - **NOT IN TESTING**

1. Human health issues, human anatomy, body systems

g. **SYNBIO**
   - I. Synthetic Genomics and the BioXP can we "print out" medicines?
   - II. Look to Life Technologies and vaccine development
   - III. We can make microorganisms produce the drug precursors we need, or perhaps the drug itself. We have already done this with anti-malarial drugs.

3. How can we build things in space to assist with unforeseen and novel challenges (i.e.. things we didn't think to pack for?)
   - a. 3D printing in space could be helpful but what challenges might there be?
   - b. How will we maintain a full "stock" of printing materials/building materials
   - c. How might tools work differently in space? How can we adjust them.
   - d. How do we take tools that don't take up a lot of space but serve versatile functions.
   - e. What materials do your students think we need to pack.
   - f. What about plastics
   - g. **SYNBIO**
     - I. https://www.bio.org/articles/current-uses-synthetic-biology - Metabolix with an alternate to plastics. Using microbial fermentation to produce the polymer PHA. We turn natural sugars into PHA, the pellet recovered is made to make Mirel Bioplastics by Telles products - will need to look at this company.
     - II. https://twistbioscience.com/company/blog/colonize-mars-use-synthetic-biology - We need to use 3D printers to print supplies, homes etc. We can't carry concrete to space but we can take bacteria that could produce a plastic we can use in place of concrete.
     - III. We can use bacteria to bio-extract metals on earth, we could theoretically use them to extract metals from martian soils and to also sort those metals once extracted.
4. How do we keep people hydrated?
   - a. What water reclamation methods can we put into practice?
   - b. How do we pack for that journey - 150-300 days of travel is a lot to pack for.
   - c. SOLs
     - I. ES 8 again - The students will understand how freshwater resources are influenced by geologic processes and the activities of humans
       1. Dependence on freshwater resources and the effects of human usage on water quality and ID of the major watershed systems (how do we find our water, how do we clean it? How does the water cycle clean our water for us - Desalination)
   - d. **SYNBIO**
     - I. There is water on the planet, it is full of perchlorate - easily filtered.
5. How do we collect energy resources on other planets? If we can't use fossil fuels?
   - a. SOLs
     - I. ES6 - The students will investigate and understand the differences between renewable and nonrenewable resources
       1. Fossil fuels, minerals, rocks, water and vegetation
       2. Advantages and disadvantages of various energy sources
       3. **Can we talk biofuels?**
   - b. **SYNBIO**
     - I. LS9 turning sugars into two diesel alternatives https://www.bio.org/articles/current-uses-synthetic-biology - Simple process - how did they do it?
     - II.
6. Math modeling and communication
   - a. What coding languages should students be learning? (What is NASA using?)
   - b. **SYNBIO**
     - I. Vaccine developers are going to try and cut down on travel time by sending Viral DNA via email. Craig Venter's company Synthetic Genomics and the BioXP. Create a virus from a digital data set so that you can get all great minds working on it quickly.
7. How can we regulate gases in closed systems?

a. How do we keep O2 levels high enough, CO2 levels appropriate etc. If we aren't using tanks
b. Can we create bacteria who produce O2? Should we look to algae?
c. SOL
    I. ES 11 - The students will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes and human activities on its composition an dynamics
        1. Scientific evidence for atmospheric composition changes over geologic time
        2. Current theories related to the effects of early life on the chemical make up of the atmosphere and
        3. Atmospheric regulation mechanisms including the effects of density differences and energy transfer
d. **SYNBIO**
    I. Lets start with basic compounds we think we can work with - solid and gaseous - C, H, O, N, P, S all there and in smaller amounts Mg, Fe, Ca, Na, K, Mn, Cr, Ni, Mo, Cu, Zn. and carbon dioxide and methane. Nitrogen and carbon also found in ice caps. fixed nitrogen also found.but we don't know if we can use that yet. We also have water. https://www.researchgate.net/publication/281494184_Synthetic_Biology_for_Space_Exploration_Promises_and_Societal_Implications

8. Ethics - Look at the building with biology topics.
9. How will we make soap, both for our bodies and for clothing?
    a.

The NASA problem and how Syn Bio can fix it.