iGEM Meeting Weeks 1&2

7/1/18-7/13/18

Brainstorming Ideas

Synthetic Biology vs. Cancer

Problem: In 2016, an estimated 1,685,210 new cases of cancer were diagnosed in the United States and 595,690 people died from the disease. -National Cancer Institute

Uncontrolled mass production of cells that can no longer maintain homeostasis and properly perform their function

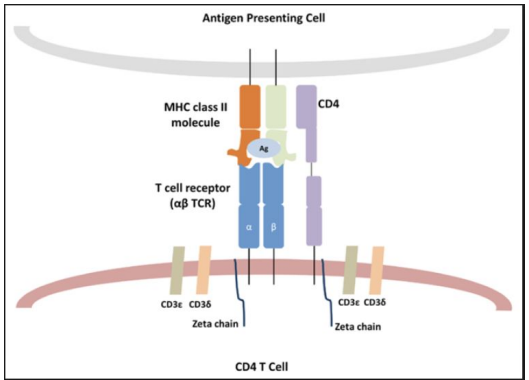
Body's normal regulation systems fail to identify and attack cancerous cells

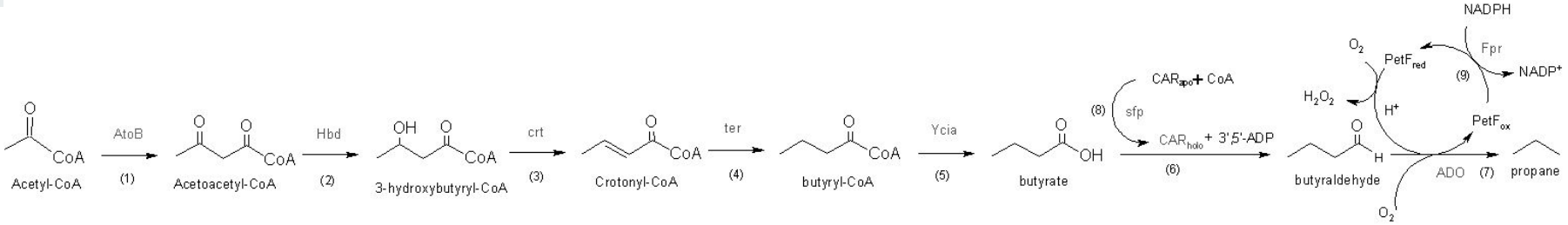
T-Cells must recognize antigens of tumors

How to combat?

Cancer Cell Identification Ideas

- Route 1: Use logic gates/circuits that make a cell exhibit behavior that allow T cells to recognize and destroy it more easily that is activated when a cell shows indication of being cancerous. (more preventative approach)
- *Route 2: Reverse of Route 1; Identify biomarkers of specific cancer cells already present and then modify T cells (with CRISPR/Cas9 or retrovirus insertion?) to search for and destroy only those cells. (more targeted approach)
    - Increase T cell affinity for specific antigens





Biofuel Production:

Problem: Climate change is argued to be one of the greatest challenges faced by mankind.

- The current climate change is mainly caused the consumption of fossil fuel stocks without returning the emitted gases into the natural carbon cycle.
- To fight climate change we have come up with a solution which would tackle the emissions made by the road transportation which make up 11% of the world's greenhouse gas emissions.

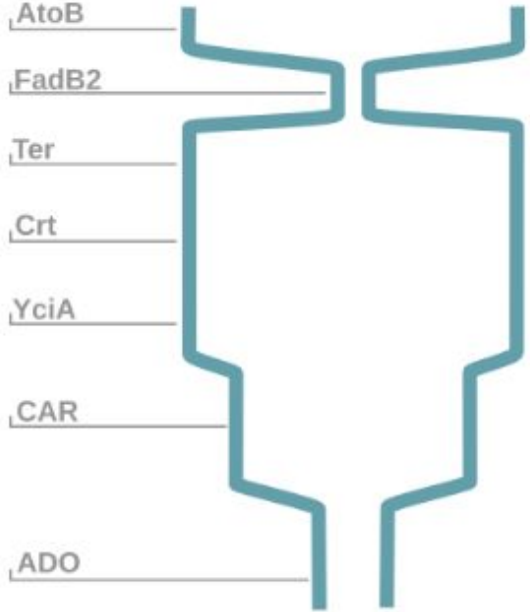
Why Synthetic Biology: Biofuels can be used to tackle this problem because natural organisms can produce fuels in a more efficient manner without as many harmful byproducts.

E. coli Producing Propane

Solution: Proposed project for this year's iGEM team is to delve into biofuels to attack this issue. Our group can add onto the work done by a 2015 team, Aalto-Helsinki, and their work on E. Coli producing renewable energy from cellulose. While their project was very comprehensive, I believe that we could delve deeper into mapping the pathway in order to:

- Identify bottlenecks and the rate limiting steps of the propane production pathway
- Create a more comprehensive model of the pathway

http://2015.igem.org/Team:Aalto-Helsinki



Illustrative picture of the Aalto-Helsinki results o the bottlenecks of their pathway for propane production

https://link.springer.com/chapter/10.1007/978-3-319-21088-9_4

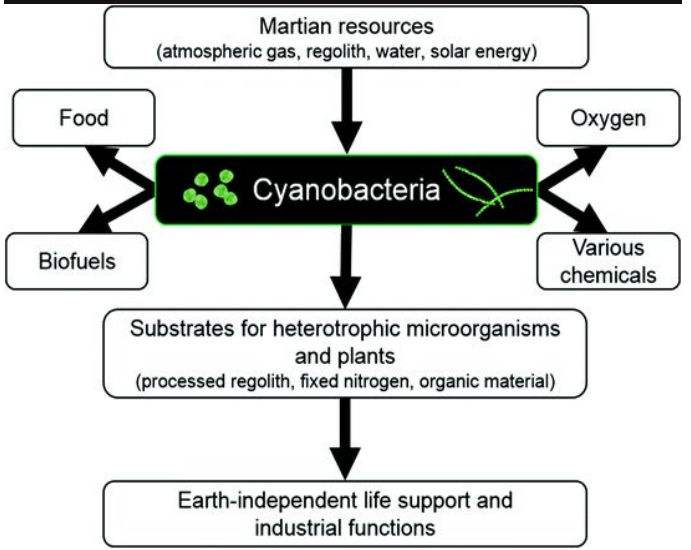
Astrobiology: Life in Space

Problem: The future of the human race may very well end up in space. As such, self-sustainability in terms of food, energy, and materials will become a priority.

Synthetic Biology: Genetically engineering microorganisms to survive and thrive in space will provide insight and value for the possibility of more complex life.

Solutions/Potential Projects:

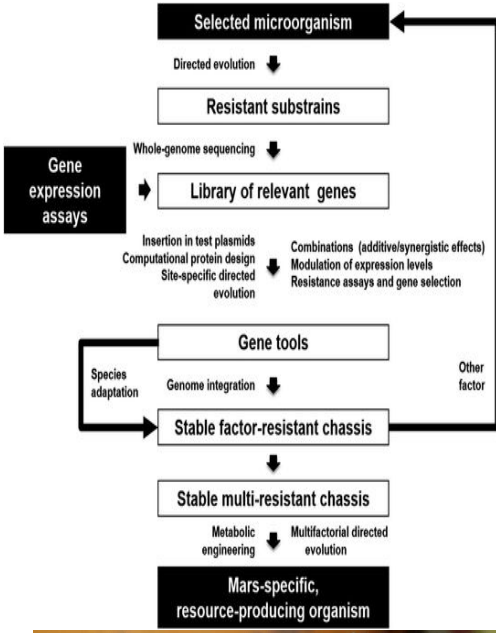
1) **Habitability:** Examining the environmental conditions on Mars and other select optimistic habitable zones, we can attempt to modify cyanobacteria and other microorganisms such that the previous / current evolution of life can be computationally mapped and analyzed.
    a) Could potentially build off 2012 Stanford-Brown “Hell Cell” experiments



https://www.liebertpub.com/doi/abs/10.1089/ast.2012.0829

Astrobiology: Life in Space (cont.)

2) **Sustainability:** Food of course is another main concern. We could potentially re-create Martian soil, and attempt to modify photosynthetic pathways in fast-growing crops to better harness the wind and nuclear energy in space. Moreover, under similar 'Martian' conditions, we could examine how to modify these crops such that they are more protein-rich.
3) **Mining:** Asteroids are filled with precious metals - however cost and feasibility regarding rockets are preventing further developments. Following terrestrial copper biomining techniques, we could modify metal-mining microbes to survive space-conditions, and extract particular metals.
4) **Building off 2017 Stanford-Brown Electricity:**
    a) Oriental Hornets are able to harvest solar energy and protect against UV radiation, generating electric potential. It would be interesting to further study these organisms, and attempt to create electrical circuits by modifying simple microorganisms after Hornet analysis, and see how this could be applied to space.

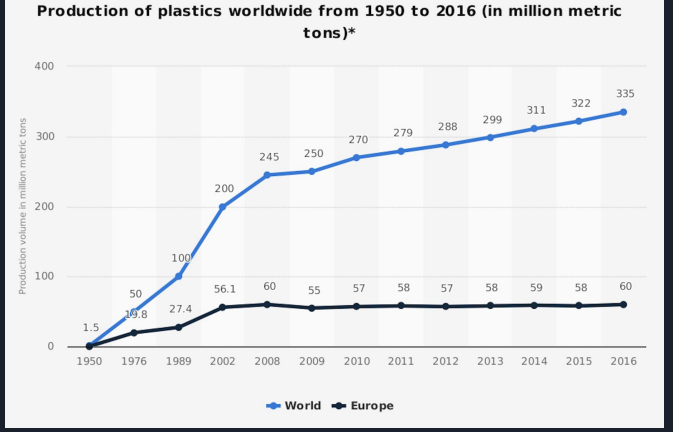


Questions

- Available summer lab space?
- Which project is most feasible?
- What's a reasonable timeline for our project?
- How much work needs to be done during spring and fall quarters?
- What lab/technical skills will our team need to gain before this summer?

Week Two Updated Brainstorming

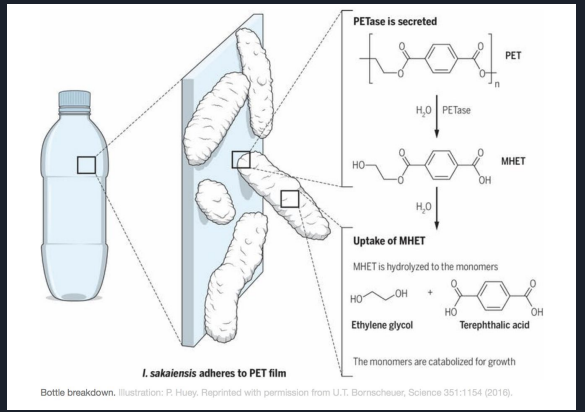
Plastic Decomposition



Ideonella sakaiensis=plastic munching bacteria

"The Kyoto researchers identified the gene in the bacteria's DNA that is responsible for the PET-digesting enzyme. They then were able to manufacture more of the enzyme and then demonstrate that PET could be broken down with the enzyme alone."

PET → 2 environmentally benign monomers=terephthalic acid and ethylene glycol



Published by Science out of Kyoto University
http://science.sciencemag.org/content/351/6278/1196/tab-article-info
Harvard 2016 iGEM:
http://igem.org/Team.cgi

Plastic Decomp Cont

Why synthetic biology?

-utilize the gene that allows bacteria to produce enzyme and place in into aquatic/more robust bacteria or organism or...

-SPACE?!

-Tons of plastic waste in space

-Create a bacteria with the capability to produce enzyme and live in space

Deliverable in addition to wet lab manipulation of bacteria/organism:

Fun, interactive game-
Space Bacteria trying to collect energy (plastic pieces) to function

Cyanobacteria: A basis for extraterrestrial life

Problem: The search for extraterrestrial life has long puzzled astronomers and biologists (Fermi Paradox, etc.) By learning how life could organically develop in spatial conditions, we can gain great insight about how humans could one day inhabit and thrive in space, as well as help to answer the question, “are we alone”?

Why Synthetic Biology: By directly observing living organisms, we can come to more specific and telling conclusions related to the formation of life in varying conditions.

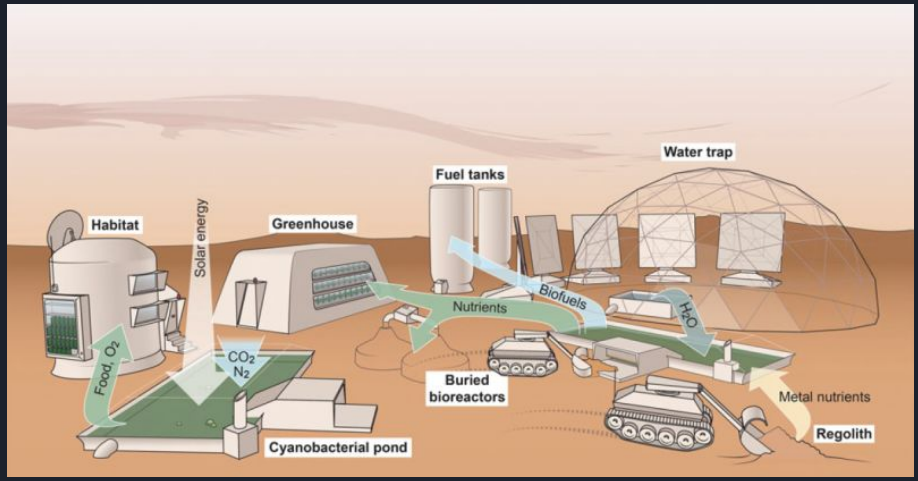
- https://gizmodo.com/the-key-to-colonizing-mars-could-be-these-tiny-green-mi-1731268670
- http://www.sciencetimes.com/articles/6407/20150516/nasa-hopes-to-rely-on-algae-and-bacteria-for-oxygen-production-on-mars.htm

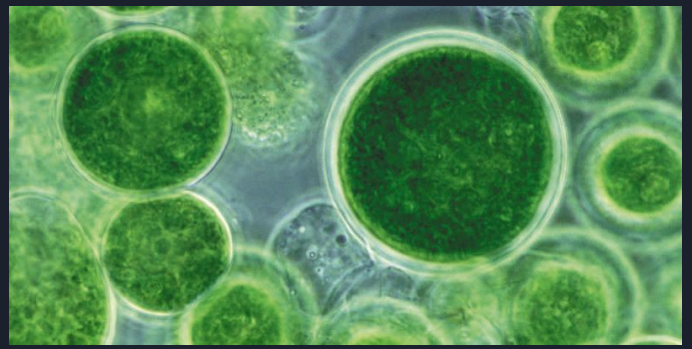
Cyanobacteria: A basis for extraterrestrial life

Solution:

Building off Stanford-Brown projects of past (namely 2011, 2017), we can work to achieve the following goals this summer:

- Genetically modify choice cyanobacteria and algae to survive and photosynthesize in extreme conditions (microgravity chamber, extreme temperatures, extreme pH, pressures, radiation)
- Create and analyze most efficient pathways for oxygen production
- Conduct electricity as well? (Oriental Hornet idea)
- Construct a model for cyanobacteria evolution and life cycles in extreme conditions





Final Brainstorming Idea

Team Updates

- Opentrons Application
  - Unfortunately our team was not selected to receive an OT-2 liquid handling robot, btu for the extent of the 2018 competition we could purchase one with a $2000 discount on the baseline model.
- Funding
  - Effective balance in iGEM account is $9442.88, so the members that did not receive SIGP we be able to be paid this summer
  - Plans to apply for additional sponsorship/funding from other companies and “Experiment” crowdfunding platform.

Water Detector

- Chromium detection
  - US Steel dumping hexavalent chromium, or Chromium(VI), a heavy metal found to be carcinogenic in humans and animals, into lake Michigan Water.
  - Large spills in both April and October of 2017 released hundreds of pounds of chromium into Lake Michigan—a substantial portion of it chromium(VI)—close to where people use the beach, swim, and surf and where the City of Chicago draws its drinking water.
  - The safety limit for Chromium(III) is relatively high and the spill was well below that limit, but they did not test for Chromium(VI).

Water Detection Continued

- Why Synthetic Biology
  - Local impact on Lake Michigan
    - Work with Evanston Water Department, Friends of the Chicago River
  - Cell-free expertise in Jewett/Lucks Labs
- Solution
  - Create a cell-free dried test strip to detect hexavalent Chromium (CrVI)
  - Enable Citizen Science for testing and tracking spills in the future
    - Potentially test water samples from all around Lake Michigan and the Chicago River, create map of Chromium hotspots

Chromate Resistant and Reducing B. Cereus

- He et al. discovered in a strain of Bacillus Cereus (SJ1) at least 8 genes that play a role in chromate resistance.
- Of these 8, 6 were constitutively active and the other two became activated only in the presence of chromate.
- One of these, chrI, was determined to be the regulator gene of the other, named chrA1, which was identified as a chromate transporter gene.

Chromate Biosensor Using chrIA

- We could add these two genes into a cell-free extract (such as the E. coli T7 S30 Extract System) preceded by a GFP gene, so that our biosensor would become green in the presence of chromate.
- We could also determine the minimum inhibitory concentration (MIC) of our system (the concentration of chromate at which the gene activity breaks down).
- We could also look into other heavy metal efflux genes to build a larger biosensor library.