Mission Dine In Extraterrestrial Terrain (D.I.E.T): Effects of the Near-Space Environment on *Chlorella vulgaris*

Team Hungry Martians
Giovanni Berrios, Natalia Marin Reyes, Gazi Morshed
Community College of Aurora
Mission Overview

- Research ways to provide a nutritional food source for space explorers.
- Requires minimal maintenance and can survive on different terrains such as the surface of Mars.
- Small and renewable which will lower transportation costs.
- Viability of *Chlorella vulgaris* in a low pressure, low temperature, higher UV ray environment.
Brief Background

- Multiple studies done on algae adaptation and survival abilities.
  - Exposing algae to artificial space-like weather.
  - Observing changes due to the breaking of the ozone layer.

- UVA and UVB Radiation influences microalgae growth and photosynthetic rate.
  - Decrease in photosynthetic production of oxygen.
Why *Chlorella vulgaris*?

- 60% protein.
- 19 different amino acids.
- More than 20 different bio-available vitamins.
- Rich in unsaturated fatty acids.
- It is already a common food supplement in east Asia.
- Easy to grow and culture.
Mission Goals

- All three samples will survive and be able to grow after flight.
- Sample in dark chamber will showcase healthier cells and higher growth rates compared to the window samples.
- Look for, if any, physical damage on algae cells.
- UV sensor data and pictures will provide insight on the physical changes and the exposure *C. vulgaris* will go through during flight.
Experiment Overview

- Payload flew three 50mL culture vials containing 10mL of pre-cultured *C. vulgaris* each.
- One vial was placed in a dark chamber accompanied by a UV sensor.
- The other two vials were placed in a window accompanied by a UV sensor.
- One of the window vials was exposed to outside pressure with special cap.
- A digital camera was taking pictures of the window vials to give a macroscopic insight in any physical changes that happen to the algae.
Payload Overview

Heater
Camera
Arduino
UV Sensor (Right)
UV + Temperature Sensor (Left)
Vials
Sensors Used

- Temperature Sensor (TMP36)
  - ±2°C accuracy over temperature.
  - Operating Range: −40°C to +125°C.

- 2 x UV-Sensors (ML8511 Breakout)
  - Analog voltage.
  - Low power consumption.
  - Intensity in mW/cm².
## UV sensor test data points

<table>
<thead>
<tr>
<th></th>
<th>Output (voltage)</th>
<th>Intensity (mW/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inside</strong></td>
<td>1.00</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>1.01</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>Outside without sun</strong></td>
<td>1.20</td>
<td>1.77</td>
</tr>
<tr>
<td></td>
<td>1.22</td>
<td>1.91</td>
</tr>
<tr>
<td><strong>Outside with sun</strong></td>
<td>2.73</td>
<td>3.26</td>
</tr>
<tr>
<td></td>
<td>2.85</td>
<td>3.77</td>
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<td></td>
<td>2.91</td>
<td>4.00</td>
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<tr>
<td></td>
<td>3.32</td>
<td>5.74</td>
</tr>
</tbody>
</table>
Flight Overview

No flight data was obtained.
Flight Overview

- Successful Launch
- Payload returned Whole
- No leakage in pressure sensitive vial
- Arduino/Heater on at recovery
- Camera Off on Recovery
Recreating the flight

- Run the actual SD card.
- Shake the Arduino intensely.
- Loose SD card.
- Taking SD card out with turning off Arduino.
- Short circuit.
- Run Arduino for five hours.
What might have happened

- Buffer memory full.
- Sudden increase in current flow.
- Single Event Effect.
Algae Growth

- Initial growth in 50 ml vial
- Transferred to 200 ml container at 100ml
- Grown in 3 stages
  - 50 ml, 100 ml, 200 ml
- Day + Night Cycle
Algae Morphology

Pre-Flight
- Bright Green
- No Clear Cells

Post-Flight
- High Increase in Clear Cells

High UV Exposure
- Control 2

Low UV Exposure
What we learned

- Algae may be viable but further testing needed
  - Edibility
  - Calorimetry
  - Prolonged Exposure Testing
  - Extensive Cell Analysis
- How to grow and culture algae
Future Approaches

- Improved Design
  - Access Hatch
- Specialized Sensors/Tools
  - Barometric Sensors
  - Multi Chambered Vials
- Increase Extensivity of Ground Testing
  - Combined Approach
Questions?
References
