Investigation of Life Sustainability in the Upper Atmosphere and the Earth's Surface

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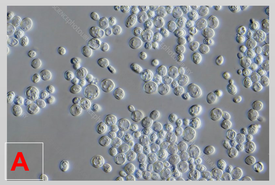
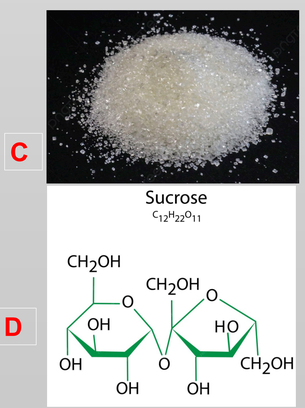
Abstract

The upper atmosphere is an unhospitable environment for survival. Altitudes exceed over 100 km, pressure reaching as low as 10^-11 atm, and temperature below -100oC, making it extremely difficult for living organisms to survive. This study investigates a eukaryotic microorganism called "yeast" from the genus ***Saccharomyces cerevisiae***. Approximately 1,500 species are known to exist. The single-celled fungi has significant importance on Earth. S. cerevisiae is an important organism in modern cell biology research and is a thoroughly studied eukaryotic microorganism. Cultures are used to understand the biology of the eukaryotic cell and ultimately human biology. Knowing this, yeast is the microorganism selected for this research looking at viability in varying conditions and sustainability of life. Parameters; temperature, pressure, and altitude are collected from the Earth's surface to the upper atmosphere to investigate the viability of ***S.cerevisiae.***



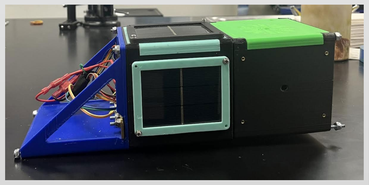
S.Cerevisiae **1000x 1-5 um (A and B)**



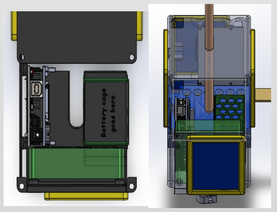
Sucrose (sugar) 10x (C and D)

Payload Design

- CubeStat structure (2 CubeStats)
- Modular design of CubeSat
- Data logger to store collected atmospheric data
- Heating elements to maintain internal temperature
- One dedicated CubeSat for biological experiments



Actual Payload

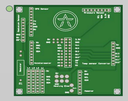


CAD Drawings

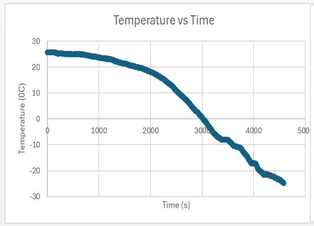
Payload Electronics

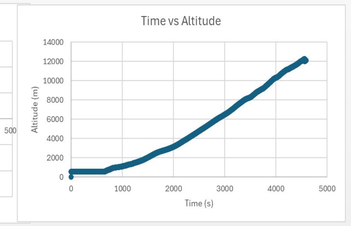
- Solar Panel: 43237-2
- Temp sensor: LM35DZ
- Altitude sensor
- Micro: Arduino Uno
- Data Logger: 3-01-1038-1

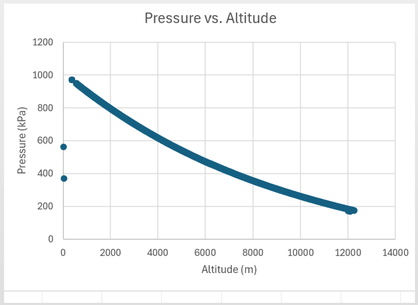
- Current Sensor:INA260
- Pressure Sensor: MPRLS0025PA00001A
- Temperature Sensor
- Custom PCB
- Magnetometer: QMC5883LC
- Camera (internal): GoPro Hero

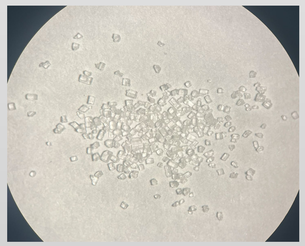


Results (note >1000 data points were recorded)

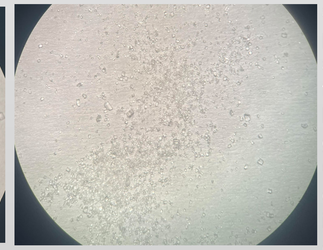








Sucrose – Launched



Sucrose – Not Launched

Objectives

- Collect passive data (pressure, temperature, altitude)
- Measure and store multiple data points
- Expose biological specimens to radiation and extreme conditions
- Investigate the viability and sustainability of an eukaryotic organism for the prediction of life in the upper atmosphere at extreme conditions

Conclusion

This project was a success as passive and biological data was obtained. The data collected during this flight supported several semesters of research in terms of sensor accuracy that have been collected at PCC, ANSR, and our peers. This CubeSat design has proven to be extremely rugged, light-weight, and space efficient. The payload is made entirely of 3D printed PLA filament. PLA is thought of as an inferior material for this application; however, we have seen that PLA is sufficient for this application as the CubeSat design was successful during this launch due to the construction parameters, design, and force points. Due to its modular design, this is an inexpensive and effective method to modify, adjust, and create custom experiments. The data that was successfully collected in the upper atmosphere is important in helping our understanding of climate in varying conditions.

The **S.Cerevisiae** (yeast) did visual change in its size. It was found that the extreme conditions made a slight change in reactivity. Using normal preparation (yeast, sugar, water) it was found that the yeast that remained at STP reacted with a 13 mm "growth" while the yeast that was put under extreme atmospheric conditions reacted wth19 mm growth rate. (reaction vessels= 1cm vials). The unexpected results (see figures to left) were the growth of the sucrose crystals. It is suspected this is caused by the temperature and change in pressure. A lower temperature favors a slower crystallization allowing for large more defined sucrose crystals. A stable temperature encourages a uniform growth of the crystals. It is known that a decrease in temperature causes a system to generate energy in an attempt to elevate the temperature (Le Chatelir's Principle). The formation of chemical bonds releases energy which allows more original crystals in an attempt to increase temperature which gives an explanation as to why crystals form when temperature decreases. The other factor is humidity. This variable was not studied here, but in future experiments will be included to see the effect of humidity on crystalline structure of sucrose. Experimental data on varying temperature, pressure, and humidity on the effects of ***S. Cerevisiae*** and sucrose can be applied to other biological substances and organisms.

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