A Space Odyssey - Cell culture version. A proposal for a system enabling the study of the impact of cosmic radiation on model cell lines

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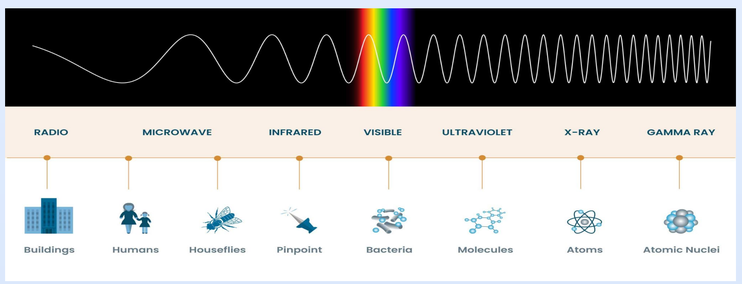
Introduction

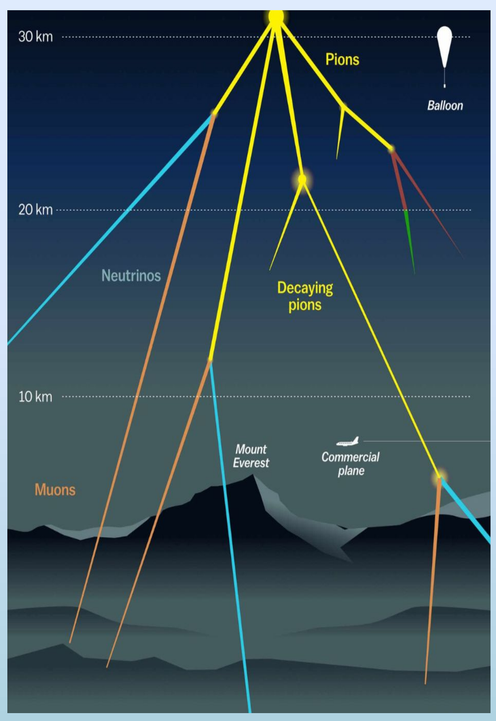
Since the 1950s, after the creation of the first cell line in the World - HeLa, in vitro research has been conducted on a massive scale, examining cellular responses to various factors, applied in chemo- and radiotherapy. One of the most frequently investigated physical factors affecting cellular responses is the influence of electromagnetic and particle radiations. Various types of electromagnetic radiation, with different wavelengths, were employed within these studies, ranging from visible light to UV as well as ionizing radiation. Ionizing radiation, characterized by the highest penetrability, leads to the most significant damage in cells, such as the formation of double-strand DNA breaks. Numerous publications have elucidated cellular responses following exposure to radiation. Consequently, the question arises: What happens when cells are exposed to cosmic radiation, which even is more complex and more dangerous than X-ray radiation? Will the cellular responses resemble those to X-ray radiation? Will cell survival be similar? Will there be an increased expression of cancer markers in healthy model cell lines?

Our study aims to address these questions by developing a system to support the maintenance of cell cultures. This system will enable live cells to be sent to the stratosphere, where they will be exposed to cosmic radiation. We present systems and technological proposals designed to address issues related to maintaining suitable conditions within the mission capsule.

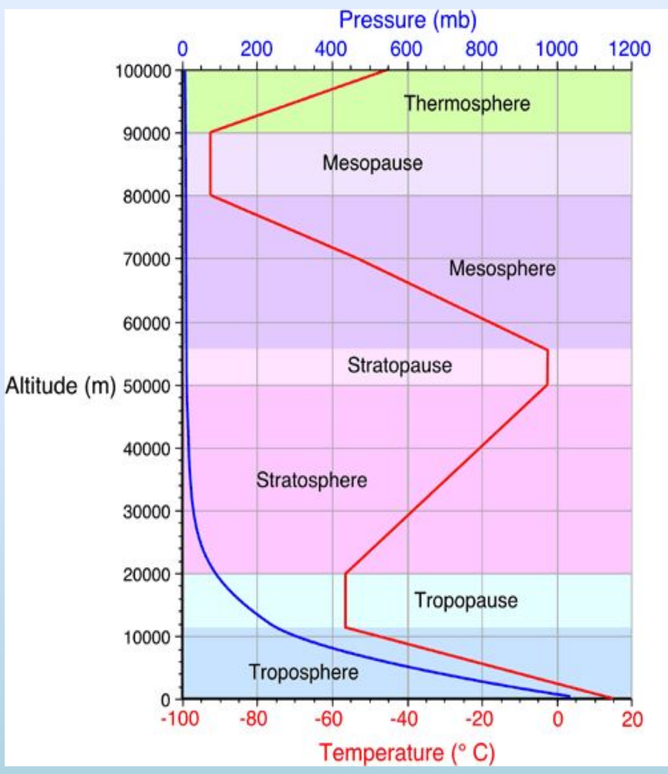


https://hubblesite.org/contents/articles/the-electromagnetic-spectrum

Cosmic Rays are type of high energy particles extraterrestrial in nature (as Cosmic rays classified are also particles created as a result of interaction between particles of extraterrestrial origin with particles of Earth's atmosphere). Composition wise as primary Cosmic Rays they are predominantly cores of common atoms striped of its electron (mostly protons and alpha particles), on contact with atmosphere they into Muons, Pions and neutrinos.



https://www.vox.com/the-highlight/2019/7/16/17690740/cosmic-rays-universe-theory-science



https://www.coolgeography.co.uk/A-level/AQA/Year%2013/Weather%20and%20climate/Structure/Atmospheric%20layers.htm

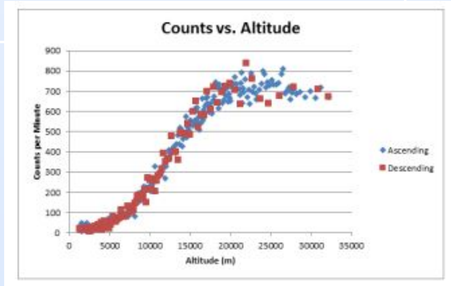


Figure 4: *Trend of particles (counts per minute) and altitude, this includes ascent and descent of balloon*

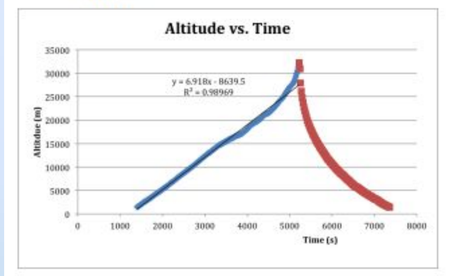


Figure 5: *Altitude vs. Time, blue is ascending and red is descending*

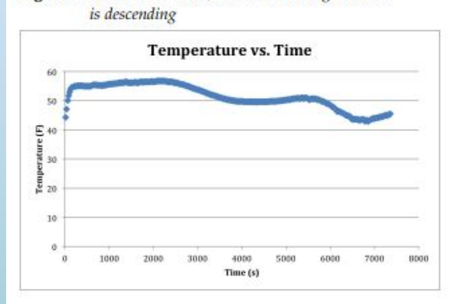


Figure 6: *Temperature inside the payload as compared to time*

https://www.colorado.edu/center/spacegrant/sites/default/files/attached-files/03_High_Altitude_Cosmic_Ray_Radiation_Detection.pdf

To investigate the impact of cosmic radiation, commercially available cell lines will be sent to the stratosphere in a specialized capsule. The cells will be stored in standard culture bottles and will also be seeded onto 96-well plates.

Four cell lines have been selected: two normal lines (NHDF fibroblasts and Beas2B bronchial epithelial cells) along with cancerous cell lines derived from the same tissue as the normal cells (specifically, Me45 and A549).

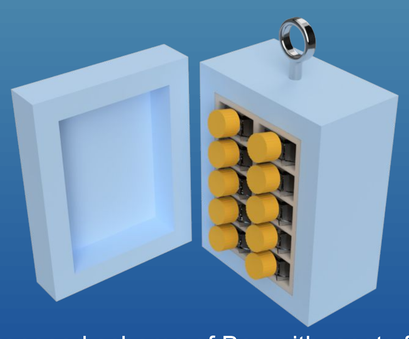
Mission Procedure:
- Preparing cell cultures
- Placing bottles and plates in mission capsule
- Start the mission
- Localization and capsule capture
- Collecting cells and tests performing

Plans for the experiments:
- cell viability
- cell death markers
- cell cycle
- mutations

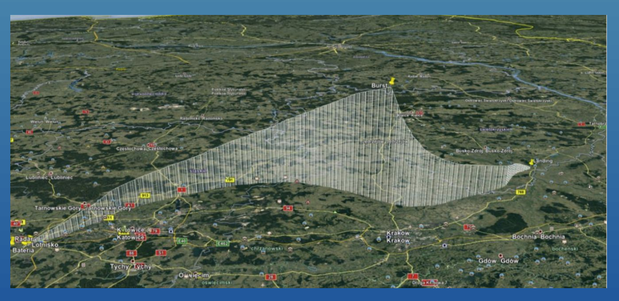
LABHAB capsule will be attached to HAB probe designed in a **CubeSat** standard. Two radiation detectors onboard the mission will independently measure the dose of radiation absorbed by the cells. Capsule will ensure that all cells stay within required temperature range and protect them from harsh outside environment where temperature may drop to **-60°C**. Planned max altitude of the flight is **35km**.

Assumptions for the capsule
- 3D printed thermal structure with array of heaters
- Multiple temperature sensors
- Capsule insulated on the outside
- Possibility of attaching the bottles vertically and horizontally
- Mass not higher than **1.5kg**

Example of Mission Box



Proposed scheme of Box with spots for cell culture bottles



Trajectory of HAB flight

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