**Executive Summary**

Ground breaking discovery was made on the international space station on September 2023. For the first scientists have successfully bio printed knee meniscus tissue. Knee meniscus tissue does not regenerate if heavily damaged. This is what causes people to get knee replacement surgery. This technology will allow doctors to simply replace your meniscus tissue with an exact bio printed copy that is made up of your own cells. Cardiovascular tissue is next in line for research. This will not only prevent heart surgery, it will allow doctors to replace, repair, or fortify any part of the heart that is not performing optimally. The biggest barrier to getting this into hospitals is cost. Harvesting water from space is an interesting solution that is being researched by NASA and major universities. This presentation will show the unique proposals that have been made by NASA and a cost analysis of the options.

**Motivation**

Biomanufacturing is the process of 3D printing with human cells. This is nearly impossible to achieve on earth as we are printing on the cellular level. Due to the force of gravity lattices are required to support each layer of cells as tissue is being printed. The microgravity of space allows researchers to bypass this process entirely. The BioFabrication Facility on the International Space Station [announced in September 2023](https://redwirespace.com/newsroom/redwire-biofabrication-facility-successfully-prints-first-human-knee-meniscus-on-iss-paving-the-way-for-advanced-in-space-bioprinting-capabilities-to-benefit-human-health/) that is had successfully 3D printed human knee meniscus tissue in lower earth orbit. This process gathers cells from the patient and uses them the same way that a generic 3D printer uses plastic filament.

**Data Question**

* How much water can be found on the asteroids in the NEO data from the NASA API. What is the min/max/mean of how much water can be found on each asteroid?
* How much does it cost to collect water in space? Value needs to be in per liter.
* How much does space travel cost from escaping lower earth orbit to reaching the asteroid? Value needs to be in dollars per mile and dollars per day for life support systems.
* How much does it cost to lift a liter of water from earth into outer orbit? Value needs to be in dollars per liter.

**Minimum Viable Product (MVP)**

**Description:**

* Presentation that shows why we should harvest water from space.
* Show cost comparison in dollars between bringing water from earth compared to harvesting it in space.
* Show how much water can be found on the asteroids that are in near earth orbit.
* Visual highlighting either a specific asteroid or a category of asteroids that we should harvest water from. A calculate where in its orbit path you should harvest water from it based on distance from earth/cost of travel and amount of water that can be harvested from it along with the dollar amount that it will be purchased for.
* Show that there is a viable model for profitability along with current financial commitments from government/private sector to make this a reality.

**How will analysis be presented?:**

* All data/facts presented will have a visual/blurb showing the source of information to assert that the data is credible and accurate.
* The analysis will be a cost to benefit visual.
* This presentation will heavily rely on visuals for two reasons. Because this is so data and space jargon heavy, the audience should be able to draw conclusions from the pictures and what I’m saying alone. The data/numbers will only be there to prove what I am saying is factual/accurate.
* (Stretch Goal) A slide will have a video of a specific asteroid and earth’s orbit path around the sun (picture shown below this is a video that can be played on NASA’s website for any of the asteroids in the API file) and a simple visual next to it and that has the price of fuel/life support systems next to it. As the asteroid gets closer and closer to earth the price will increase and visa versa.

A diagram of the sun

Description automatically generated

* (Super Duper Optimus Prime Victory Over the Decepticons Stretch Goal) Gather the data (or whatever is needed) from the video of the orbit paths above and find a way to edit it so that it is not so boring. The visual will have icons/visuals representing the sun, planets, and asteroid with the stars in the background.

**Intended audience:**

General public from high school age and up. It is expected that everyone in the audience either graduated high school or is in high school.

**Schedule (through <date of demo day>)**

1. Get the Data (11/15) DATA GATHERED PENDING REVIEW
2. Clean & Explore the Data (11/22)
3. Create Presentation of your Analysis (12/13)

* Should be a presentation, but could include a Jupyter Notebook or dashboard in Excel, Tableau, or PowerBI

1. Internal demos (12/13)
2. Demo Day!! (<date of demo day>)

**Data Sources**

\*\*\* All data/information sourced from WIKI will be traced back to the original research/article that is cited for the information. If not cited directly to a credible source it will not be used. All topics have multiple sources of data/information so I will have the data I need. All of the info I gathered was specifically stated by WIKI that the info was derived from research papers/articles. I just didn’t go looking for the source yet. \*\*\*

1. Asteroid classifications for water: <https://en.wikipedia.org/wiki/Asteroidal_water>
2. Asteroid mining general info: <https://en.wikipedia.org/wiki/Asteroid_mining>
3. Asteroid orbit path: <https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=3366282&view=VOP>
4. Info showing that aeton asteroids have up to 20% water: <https://en.wikipedia.org/wiki/Aten_asteroid>
5. Water molecules detected on the surface of asteroids for the first time:

<https://www.cnn.com/2024/02/16/world/asteroid-water-molecule-detection-scn/index.html#:~:text=The%20Faint%20Object%20infraRed%20CAmera,million%20miles%20from%20the%20sun>.

1. Medical research that can only be done in spce:

<https://www.nasa.gov/missions/station/space-station-leads-to-breakthroughs-in-human-health-on-earth/>

1. Propellant Depot research by Nasa: Cost and functions of a fuel depot:

<https://en.wikipedia.org/wiki/Orbital_propellant_depot>

1. Current cost of water from earth to space:

<https://www.ars.usda.gov/ARSUserFiles/ott/New%20Website/Partnerships/SBIR%20-%20TT/Pancopia%20NASA%20Success%20Story.pdf>

1. Cost analysis of brining water to LOE:

In capstone folder/attached to email.

1. Cost analysis of different load/mission categories. This shows how much cargo and crew transportation costs.

In capstone folder/attached to email.

1. Medical research that can be done in microgravity:

<https://pmc.ncbi.nlm.nih.gov/articles/PMC8758939/>

1. University of Florida symposium and research on in-space medical research:

<https://pharmacy.ufl.edu/biomanufacturing-in-space-symposium/>

1. ISS successfully 3D prints knee meniscus:

<https://www.nasa.gov/missions/station/iss-research/3d-bioprinting/>

**Known Issues and Challenges**

* **Challenge**: Due to the high complexity of the subject matter it will be difficult to present it in a way that is palatable to everyone in the audience.
  + **Resolution**: My presentation will mimic high school science videos or documentaries about space made by Discovery Channel. This will provide a framework for presenting this material in a way that is easy to understand, interesting, and thorough.
* **Challenge**: I am a big space nerd and use many of the acronyms, terms, jargon in conversation. There have been several times where I don’t explain the jargon and I either lose the person’s attention or confuse them.
  + **Solution**: The presentation will be built layer by layer. I am going to start from Earth and work my way out.
  + Example Outline:
    - Scientists on the International Space Station have made a discovery that will make knee and heart transplants a thing of the past.
    - Overview of research, discovery, implications.
    - How much does it cost to do this research?
    - Why does it cost so much?
    - What is being done about it the high cost?
    - Why is water such a big contributor to the high cost?
    - Why is water so important to NASA that they pay this much to get it to the ISS?
    - How much does it cost to get to space?
    - What can we do to reduce cost?
    - Show that harvesting water is an interesting and serious solution.
    - Show cost analysis vs lifting water from earth to space.
* **Challenge**: The audience may just think this is BS and not take it seriously. There is a segment of the population that does not take NASA seriously at all and thinks it is a waste of time.
  + **Solution:** I cannot control somebody’s opinion on NASA, but I can present evidence that these are not fairy tale board room ideas. These are ideas that have billions of dollars invested into it from the public/private sectors and laboratories have been built in major universities to research/advance this field.