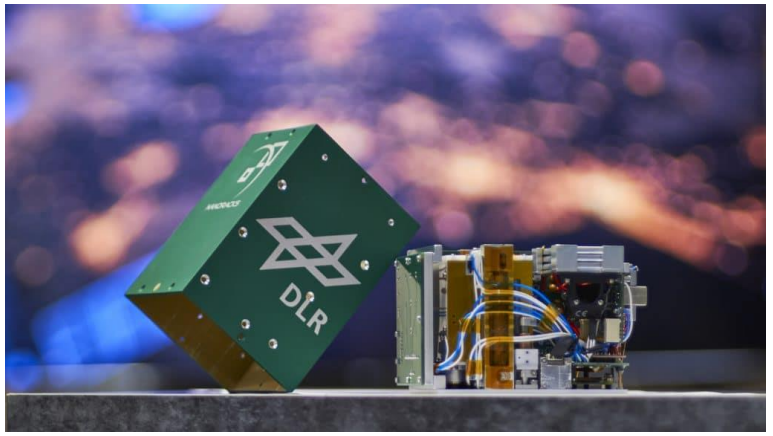
Generic Agricultural mini Lab

Work with a team of students to develop a generic agricultural Nanolab that can be adapted to many different agricultural experiments for the ISS. This generic platform will allow students or researchers to germinate seeds or grow small plants in zero-g. You will need to understand what kind of experiments need to be done so you are developing a box that will satisfy many researchers' needs.



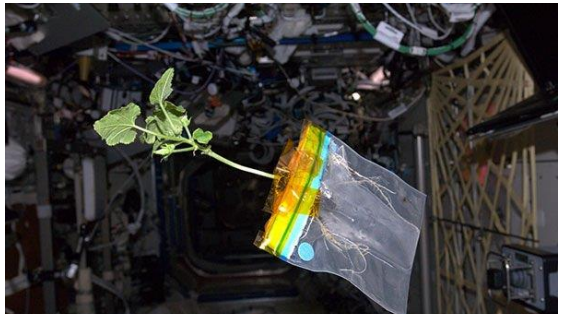
Agriculture in Space

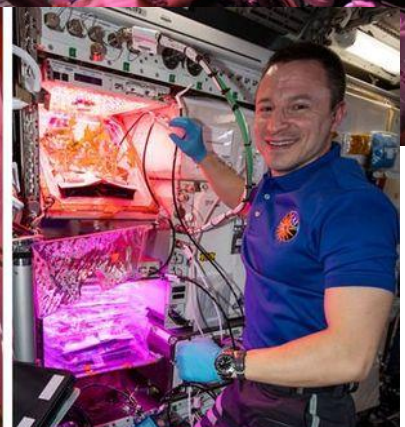
As people move further into space, we will need to become less dependent on the Earth for supplies. Coming up with a method for growing our own food in space will be an important part of that. Astronauts on the International Space Station have been helping scientists run experiments to see which kind of plants grow well in the zero-g environment and looking for ways to make food grow in ways that have never been done before. There have been many different methods that have been developed to grow a variety of plants from seeds. Some have been more successful than others. Some edible plants may grow well but take too long to develop a fruit or are slow to mature. Some plants that are edible may not grow well in zero-g but could be hybridized with non edible plants that do grow well in zero-g. There may also be some plants that are symbiotic (mutually dependent) with other plants, bacteria or fungus and could be paired up with these organisms to help plants grow better and faster.

There are huge numbers of experiments that need to be done to determine which plants can grow in space and be beneficial to people and space craft for long term use. To make this research easier, quicker and cheaper, NASA needs a small, generic laboratory module that can be altered slightly by the researcher to fit their specific experiment. Some of the variables will include amount and times of light and its colors, amount and timing of water, and the amount of air circulation all while using a minimal amount of power. Researchers on the ground will want pictures or video of their growth chamber. It is also possible that they are interested in testing a gel, agar or other water holding material. They may need information about how the water is evaporating or the local temperature of their seed bed. Your team's job would be to develop a NanoLab that is generic enough to support not just one experiment on germinating seeds but many experiments.

The main value of developing this generic agriculture experiment lab is that HUNCH will be able to provide this to any high school, college or industry.

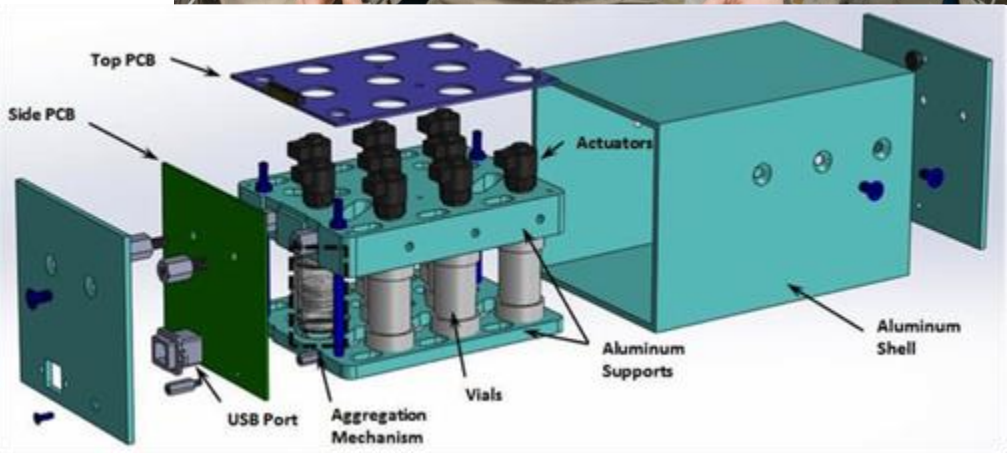
Once a design is approved, it will be much easier and faster to approve each of the experiments that want to use it for their experiment.





Nanolabs

- Nanolabs are small, autonomous, powered experiments that fit inside a specialized ISS Locker that are sent to the International Space Station for testing effects of microgravity on materials, processes, living organisms and many other experiments. These experiments are meant to be relatively cheap so many people and organizations can afford to develop an experiment for the space program. There are specific sizes and power requirements that the experiments have to meet. These are not new and many high schools, colleges and industries have participated in Nanolabs already.
- So far most of these Nanolabs have been specially designed for a very specific experiment. That will probably remain so for many future experiments. However, there are a lot of groups interested in doing an agricultural experiment in space but are daunted from doing an experiment because they have to first develop the Nanolab platform for the experiment.
- NanoRacks would like to partner with HUNCH students to develop a more generic Nanolab that would allow for a variety of agricultural experiments so people could concentrate more on the experiment they want to do rather than on the development of the Nanolab cube for their experiment.



Requirements for the Generic Agriculture Lab

Problem:

Many people would like to fly a plant growth experiment to the ISS but get discouraged that they have to design the container as well as the experiment. Could HUNCH make it easier for prospective researchers by designing a NanoLab that could work for many experiments instead of just one experiment?

Objective:

Design a generic NanoLab for growing seeds and/or small plants that could be used by any high school, university or researcher that wants to try out their experiment on the ISS. The purpose of this NanoLab is for it to be versatile enough so that anyone who wants to do a seed or small plant growth study in zero gravity can make small adjustments to the platform and send up their experiment without having to design the whole lab from the bottom up.

- Limited to 2 USB cables for power
- Everything must fit inside a 10cm x 10cm x 20cm aluminum container (external dimensions) the walls of the aluminum container are 3.18 mm thick. You will need to make the internal structure that supports the electronics, the plant growth chamber, camera, sensors, lights….
- Supply of water or other media such as gels or agar for seeds and plants
- If not using gel or ager --Packet of water with method for getting it to the roots
- Lighting for plant and growth area.
- At least one camera—still or video?---consideration of time intervals of how often pictures are needed at different times of the growth
- Location for seeds to germinate and grow
- Fan for air circulation?—this would only be for internal circulation not with air outside the container
- Arduino or Raspberry Pi for control of water, light, air, camera, timing, power, sensors,…
- Stay with Spark fun for components—HUNCH is partnering with Spark Fun so your team will get a discount on their products.
- This lab will need to be able to function for a 30 day mission.

Pictures of 2U NanoLab shell with dimensional call outs so students can mock it up for their prototype.

- I will update this page as soon as I get more detailed pictures.

A beginners guide to space agriculture

- https://spacecenter.org/try-this-at-home-part-1-grow-your-own-space-seeds/
- https://www.theverge.com/2018/9/21/17883780/nasa-veggie-plants-space-station-mars-moon-soil-food
- https://www.nasa.gov/mission_pages/station/research/news/b4h-3rd/hh-plant-growth-in-iss-global-impacts

- https://www.txstate-epdc.net/growing-plants-in-space/
- what happens when an experiment goes bad?
- https://www.youtube.com/watch?v=6CwtlxuyVxo&feature=emb_rel_end
- https://www.youtube.com/watch?v=9MfWARdoF-o
- https://www.youtube.com/watch?v=9JDAZBoLJUc
- https://www.youtube.com/watch?v=e6UARqycUfI&list=PL3t8hjfINetaFCTMPFTSEQMoLwnX2S0sq&index=15
- Please learn more than the links on this page.

Root Rot

- If water stays on the roots too long and uses up the oxygenated water, the roots will start to rot. If there isn't enough water, the roots can dry up and die. This has been a problem on several of the plant experiments on the ISS.
- Some experiments may try to add nutrients, chemicals or biological materials to the water to mitigate the problem.
- Some will want to experiment with the 'soil' or bedding material they use.
- Some of this could be a gel or agar that doesn't need additional water. This would save a lot of complication with moving water.
- Consider how you might be able to have pictures that show how the roots are growing also.
- Your team will need to come up with a good plan for how to control the amount of water that will be delivered to the plant bed.
  - Capillary action
  - Chia pet
  - Micro pumps
  - Zero-g coffee cup

https://www.youtube.com/watch?v=pk7LcugO3zg

Variables to consider

Researchers should be able to make the following changes:

- Decide on the material for the seeds to grow in
- Vary the type of light available –change the LEDs and wavelength of light used—either by controls of the LEDs or by changing out the LEDs to a specific color range they want
- Vary the amount of time the lights are on
- Vary the amount of air flow
- Vary the type of seeds they want to fly
- Amount of water that is provided to the seeds over time
- How often are pictures taken by the camera(s)
- Location of camera(s), (mirrors instead of more cameras?)

Nanolab requirements

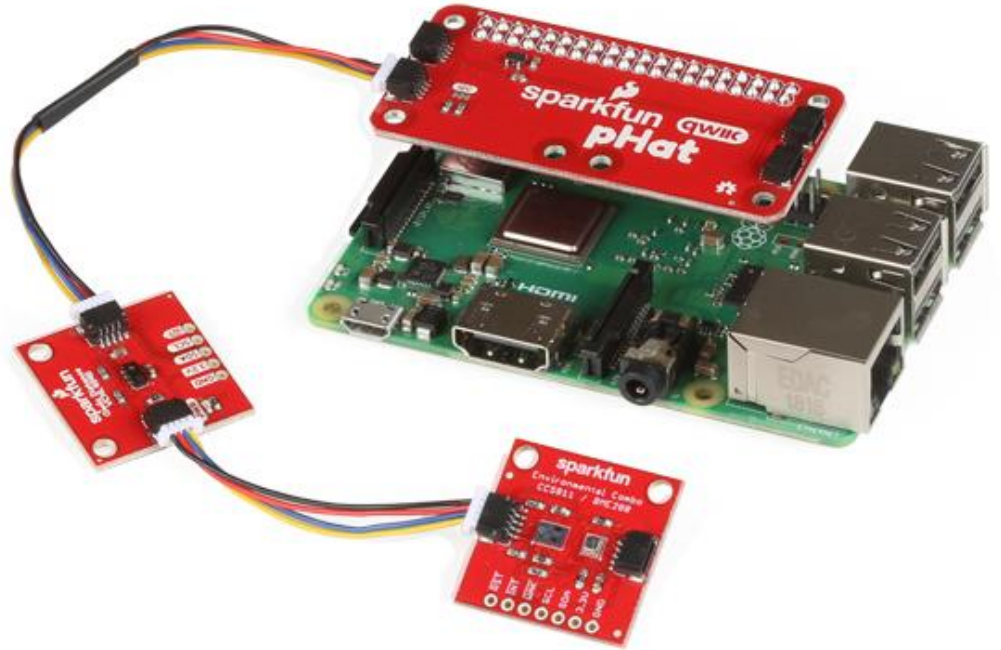
Your team will needs to be aware of the requirements of the NanoLab, Nanode (the locker that the NanoLab will sit in) as well as the requirements for the International Space Station. This sounds like a lot but all of the information is available on the NanoRacks web site. The aluminum box that all of your electronics, lights, camera, growth chamber, soil simulant, support structure… will be provided by Nano Racks allowing you to concentrate on fitting your materials into the box. This means you don't have to worry about how the box fits into the experiment holding rack.

- Most of this is pretty obvious: Your NanoLab can not be flammable, or off gas stinky or poisonous fumes, we don't want it to electrically short out anything or make a rattling or squeaky sound that bothers the astronauts.
- Use the links below to download and print out the Nanode Interface Document, Standard Materials and Processes, Flammability and Offgassing and Acoustic Noise Control and Analysis.
  - https://nanoracks.com/
  - https://nanoracks.com/products/nanolab/
  - This is a video that shows you some of the make up of the ARISE Nanolab.
  - https://www.youtube.com/watch?v=M72qjfMBalU
  - Example of an agriculture experiment that went to space.
  - https://nanoracks.com/the-chicks-are-going-to-the-iss/

Sparkfun Connection

- HUNCH recommends using SparkFun components because they have a wide range of easy to use electronic components and some of them have already flown to space on a variety of different experiments.
- To help you develop your electronics packages, SparkFun suggests using their Qwiic System that uses small cables and connectors to help avoid soldering and loose connections. They also have Python code that is already written that will help your team move forward with your ideas.
- HUNCH Ag NanoLab Kit http://sfe.io/w161155

- I am not suggesting that this list is the correct or only set of components you should use. This is a set of parts that will give you a good start on finding what you need. Please think deeper. We are not looking for the Ag NanoLab with the most expensive parts. We are looking for the most versatile Ag NanoLab that the most researchers could use and afford so more people can do an experiment on the International Space Station.



Pictures of Sparkfun components on ISS

Potential Areas of agricultural study in Space

Molecular Changes of plants in a microgravity environment

- Gene expression
- Radiation Influences on plant genes and plant microbes
- Changes in cellular biology involved in photosynthesis, respiration (opposite of photosynthesis uses carbohydrate and oxygen to produce energy for plant growth), transpiration (evaporation of water through plants) and guttation (pressure of water drops in xylem sap to move to the tips of leaves)
- Production of enzymes involved in the above chemical reactions
- Transgenic plants (genetically altered plants) vs wild type plants

Physiological Changes of plants in a microgravity environment

- Seed germination activity
- Plant phytobiome (microbes that live on plants) development
- Plant transpiration activity involving xylem and phloem
- Leaf, Stem, Pods, Seed, flowering, fruit, roots, nodules and tuber production
- Coloration (pigment formation), plant height, and inflorescences (arrangement of flowers) of plants

Developmental Changes of plants in a microgravity environment

- Influence of stress on plant development
- Influence of temperature, humidity, carbon dioxide, oxygen, nitrogen, and volatile organic gases such as ethylene on plant development
- Influence of wavelengths, direction, distance from plants, timing, day length, and intensity of light
- Influence of amounts and timing of watering and nutrient availability on plant development
- Influence of the interaction between all of the above developmental influences but especially of watering and lighting for plants since water needs to be preserved as much as possible

A few Examples of potential experiments that might be done:

- Does the optimal combination of light wavelengths change for different types of plants or different stages of plant development?
- Is it possible to 3D print plants from plant chips?
- Would plants respond to an artificial root system shunted to a plant that could deliver nutrients more efficiently and avoid root rot?
- Could grafting of plants allow for better plant development by combining a plant with an efficient root system with a quick leaf growing plant?
- How does the lack of gravity affect the root pressure in plants?
- Does Rhizobium, a nitrogen fixing bacteria, still produce nodules in leguminous plants in microgravity?
- What are some of the ways that researchers can find to conserve water in plant chambers?
- How to prevent hypoxia (lack of oxygen) in plants?
- How may lunar dust or other particular matter affect the physiological aspects of plant growth?
- What is the best practice to prevent root rot?
- How does radiation effect plants growth and genetics?
- Does microgravity influence the rate of growth of plants?
- How can plants be pollinated in space?
- Can plants grow in agar?
- How does microgravity environment effect root pressure of the water moving in the xylem up to the leaves of the plants? This pressure can be measured by a manometer.
- Do plants appear differently when grown in microgravity (size, color, leafiness etc.)
- Do plants grown in microgravity needs for water, nutrient or air change?
- Do plants rate of photosynthesis or respiration change in microgravity?
- How does ethylene production affect germination?
- How does ethylene production affect fruit spoilage?
- Is there a difference in the length of survival or life of plants in microgravity?
- Do plants age differently in microgravity?
- Do the seeds of plants grown in microgravity produce a difference in its plants? (Tomatosphere)
- Do we have to use water to grow Plants in microgravity? What about gels, agar, or slime?
- Does the degree of osmosis (the movement of water from roots through the root membrane to the xylem change in microgravity environment?
- Does Mendel's Laws hold true for pea plants grown and reproduced in a microgravity environment

Hydrofuge

- https://www.youtube.com/watch?v=OHWYUbA5eLI
- Lakewood high school in Lakewood, Colorado
- https://www.dreamup.org/an-interview-with-matt-brown-nasa-hunch-educator/