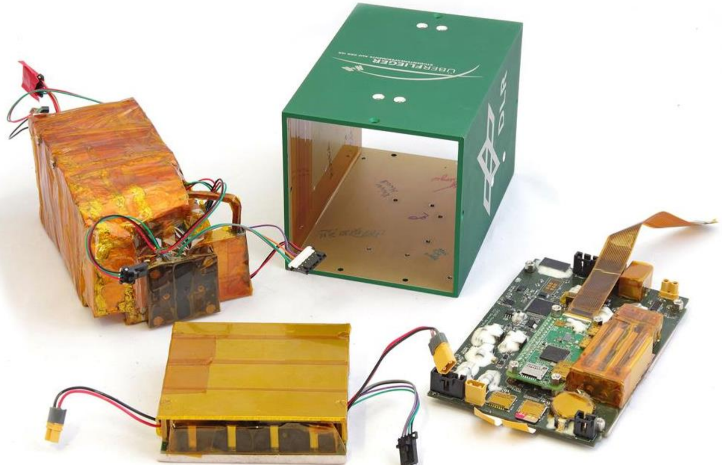
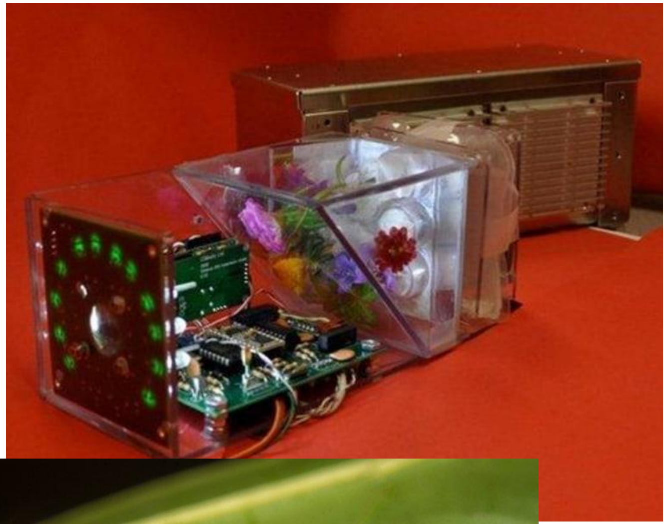
Generic Insect NanoLab

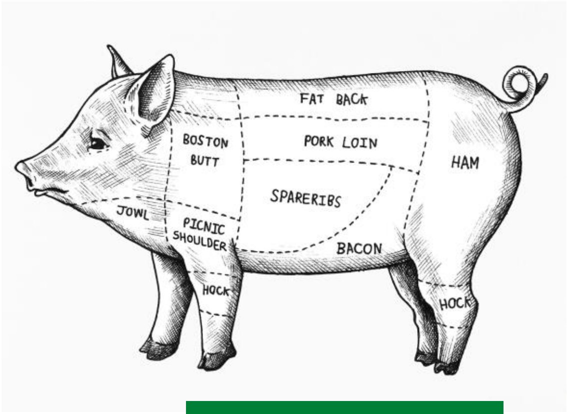
Problem:

NASA and other researchers are interested in watching the lifecycle of different insects in microgravity. This is interesting because various types of insects, arachnids, arthropods have much shorter lifespans than people but share valuable DNA and traits with humans that can be answered faster with their shorter lifespans, like the effects of radiation or deficits in immunity. The other interesting idea is that some bugs could be grown in a fairly small area as a protein and food source for astronauts on a long mission. The purpose of this project is to develop an enclosure that will allow scientists to grow insects and observe their lifecycle in the microgravity environment and learn what kind of structures and conditions are important for some insects to grow. Although eating bugs is something Americans have not been comfortable with, the long term goal beyond this insect growth NanoLab is so those insects may be made into a good, fresh food source when people travel for long periods of time in space.

Going to the moon, Mars and beyond are going to mean that we are traveling from Earth for a long time and we won’t be able to bring fresh food with us for very long. We will need to develop methods for cultivating some of our food along the way. Growing plants is being explored by many companies and scientific organizations. Last year NASA HUNCH had students developing NanoLabs for growing plants, mushrooms and even fermenting foods and liquids in micro-g. People also have a need for protein in their diet. Although some proteins can be obtained through beans, nuts and some vegetables, animal proteins are an important component of most people’s diet partly for our need for B-12



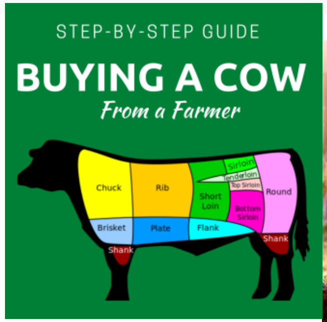




Obviously, cows, pigs and chickens would present a significant problem to grow, feed and take care of in a confined space craft. Although growing rabbits, rats, mice, guinea pigs can be a staple on many tables around the globe, even those are still big enough that growing a large enough number over the course of a long mission to feed a crew of 4 to 6 people would take up a lot of feed, time and space for the amount of edible food that would be obtained from butchering.

There are some scientists who are looking into growing meat without an animal both on the ground and in orbit. I am certain this is a great idea with many difficulties along the way and hopefully they will all be solved. However, it is important to look into a variety of solutions to our protein needs.

Bugs are eaten by around 2 billion people around the world as an important part of their diet. They are high in protein, fat, vitamins and minerals. Depending on the bugs chosen they can be as nutritious as eating the equivalent amount of beef but they can be grown on 1/10th the amount of food and water as required to grow the equivalent amount of beef. This has made the cultivation of bugs an evolving industry on Earth and a potential food source as we reach for the stars.



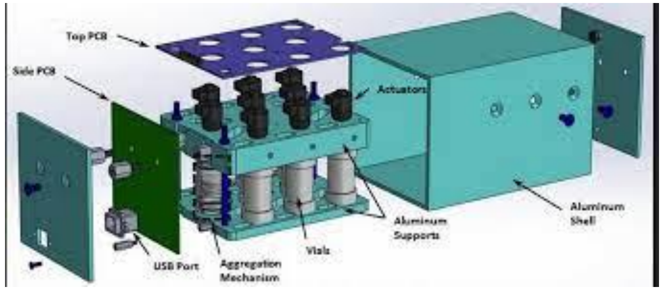
- Several companies have centered on meal worms and some have been working on making crickets part of our diet. HUNCH does not have a requirement for the type of bug that is grown We may find that a bug that seems to grow easily on Earth may be difficult in the micro-g environment for some reason—can't hold on to its food when floating around, jumping too much, can't handle the increased radiation,…
- Before we send bugs up to space as a food source, we need to know how they would live and reproduce in space.
- Do they behave differently because of microgravity
- Can they handle the radiation exposure?
- For obvious reasons (potential escapees) we will not send up bugs that are known for biting or stinging like wasps, hornets, ants, …

Objective:

- Design and build a Nanolab for growing 5 or more of one kind of insect (or two kinds of insect if they are symbiotic) for 30 days in micro-g You are trying to develop the inside of the box that could be used for many experiments done by other people not just your idea.

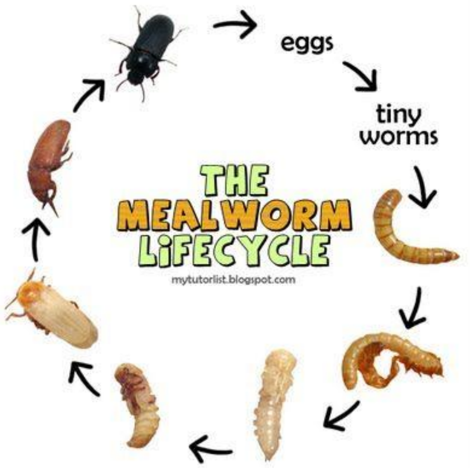
Requirements:

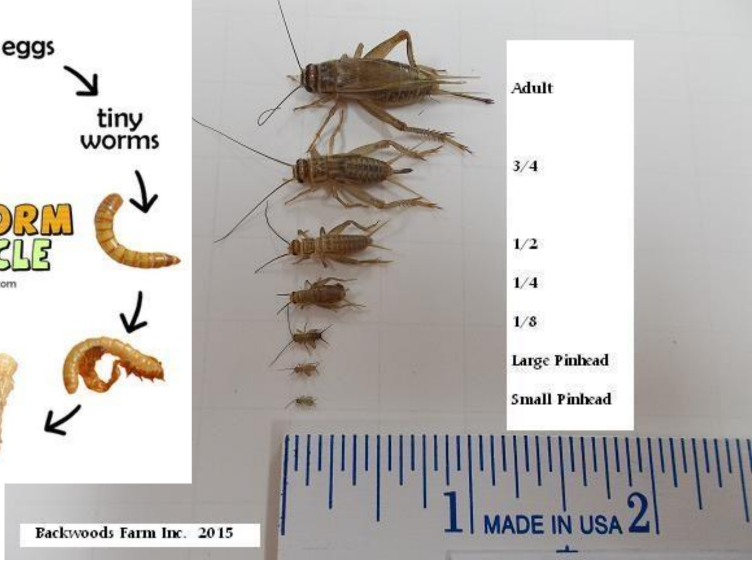
- Develop structures that allow insects to grow, feed and mature from different stages of the insects' lifespan. This structure should also allow for good lighting and camera views of the developing insects. Chamber that houses insects must have adequate space for sustaining at least one more generation of your insect.
- Chamber must also have source of nutrients (food) and water. Water must be contained to prevent contacting and electrical hardware and wiring. Keep in mind that investigators will want to record data inside growth chamber and video activity during the experiment.
- Must fit within a 10cm x 10cm x 20cm NanoLab.
- Accurately Account for the volume and a variety of locations for the hardware (cabling, camera, sensors, raspberry pi,…) to be installed in the box.
- Design should show flexibility in placement of hardware so different investigators can place items like camera, and sensors where they choose.
- Design must demonstrate ability to keep all hardware and electrical connections stable during vibrations of rocket launch, and reentry to Earth from the Space Station. It is not your job to outfit your prototype with all the correct electronics, just to account for the space they take up. It is always valuable to show as much of your concept as possible, even if it is different hardware.
- Keep the insects off the electrical contacts and places that might kill them.
- The long term goal is for observing how insects would live out its life cycle in micro-gravity so that in the future the structures and data gathered could influence how that insect could be grown as a fresh source of food for long duration space missions. We are not interested in stinging or biting insects at this time.
- Sensors to consider are temperature, humidity, carbon dioxide. Ask your biology teacher if there are other variables that would be important to measure.

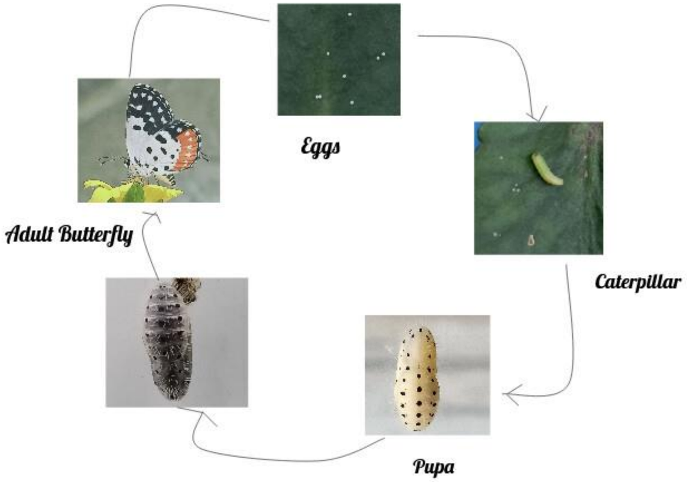


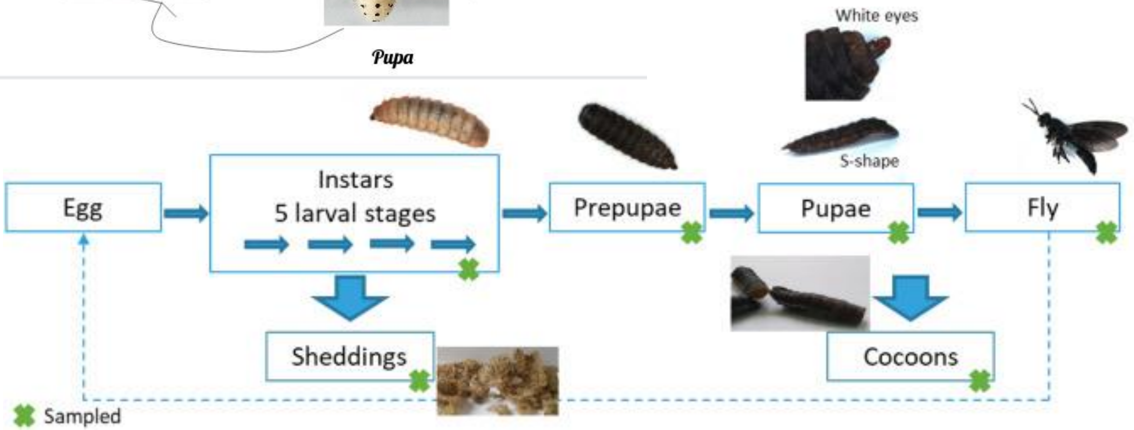
Things to consider:

- What stage of the insect's lifecycle would you send up?
- What kind of food do they need to eat?
- Do they need water besides what is in the food?
- At what stage of life should they be eaten?
- Do they like light?
- What kind of humidity does the bug need?
- Is there a reason to contain the bugs while they are eating?
- What temperature range do they grow in?
- How long is their lifecycle?
- How much oxygen do they need?
- How long will they live in the volume of a closed volume of a NanoLab?
- What kind of a structure do they need to crawl on?
- Can the food they are eating also be the structure they are crawling on?
- How do you keep the waste products from floating everywhere?
- Although you are not going to be able to exchange air outside of the NanoLab, there may be value to having a forced airflow with a fan and filter to separate out fine particulate. It may be valuable for the insects as well as visibility for the camera.









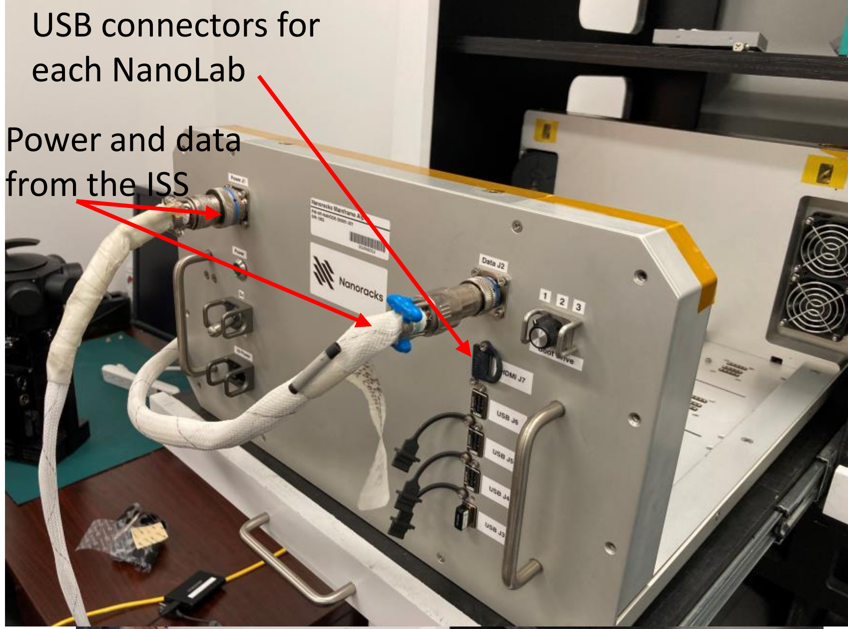
Tips:

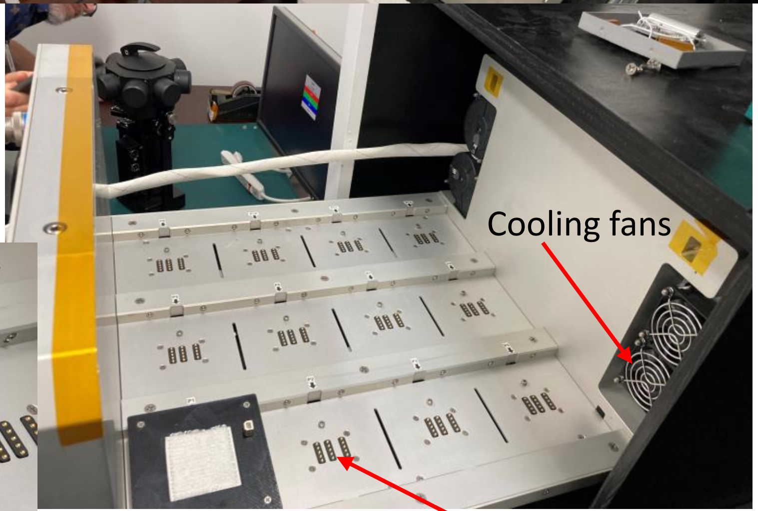
- Study up on the bug you want to grow.
- It would be a good idea to grow some of the bugs you think would go to space and observe their life cycle. This will give you ideas of how you might grow them in micro gravity.
    - Example—meal worms typically are fed loose leaves or grains, that won't be very possible in micro-g.
        - Can they be fed on some kind of grains on a stick or could the grains/leaves be held in a cloth bag?
        - Do they generate a lot of particles when they eat that might cause a problem?
    - When molting their skin, some insects require gravity for hanging and removing their old skin. Are there structures they would need for latching onto?
- Once we learn if bugs can be grown in space, we will also have to figure out how to separate out the bugs that are ready to be eaten from left over food, the bugs that are too young or too old.

NanoLabs

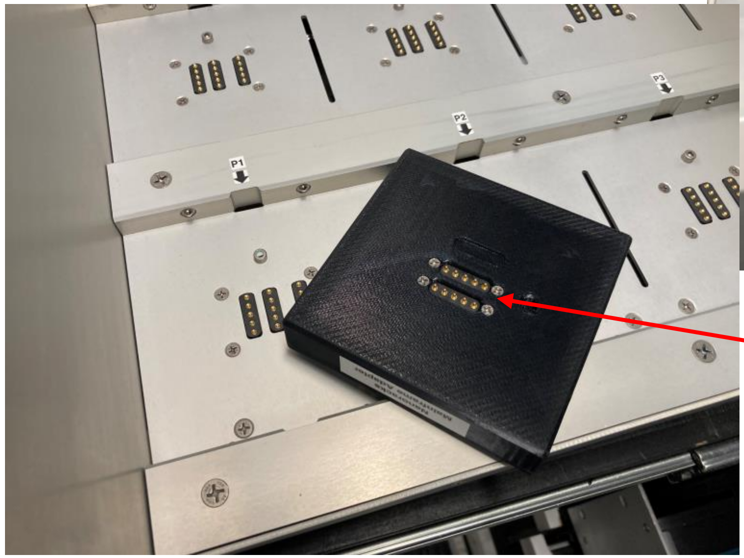
- Nanolabs are small, autonomous, powered experiments that fit inside a specialized ISS Locker that are sent to the International Space Station for testing effects of microgravity on materials, processes, living organisms and many other experiments. These experiments are meant to be relatively cheap 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 experiment in space but are daunted from doing it because they have to first develop the Nanolab platform for their experiment. This development can take a long time especially if you don't understand all the requirements related to zero-g and the ISS.
- NanoRacks would like to partner with HUNCH students to develop a more generic Nanolab that would allow for a variety of 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.

This is a Nanoracks drawer that fits inside an ISS Locker that will contain and control several NanoLabs. Power and data go to and from the drawer through the front of the drawer. Each NanoLab connects to that power and data by way of the pins in the bottom of the drawer. Cooling to all of the boxes is through the fans at the back of the drawer.



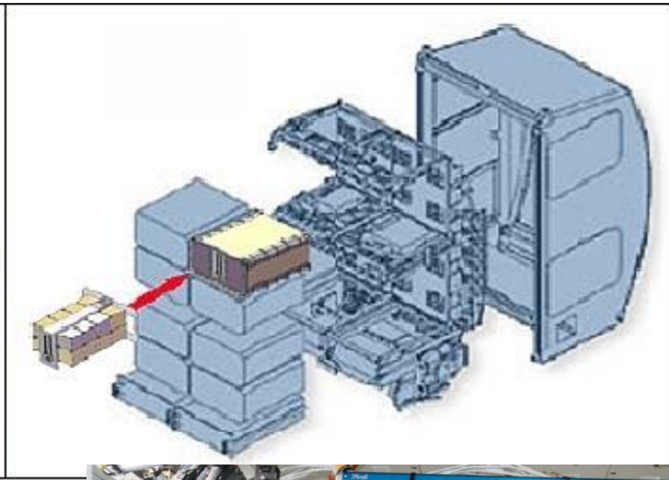


Power and Data connections to the NanoLab from the drawer.

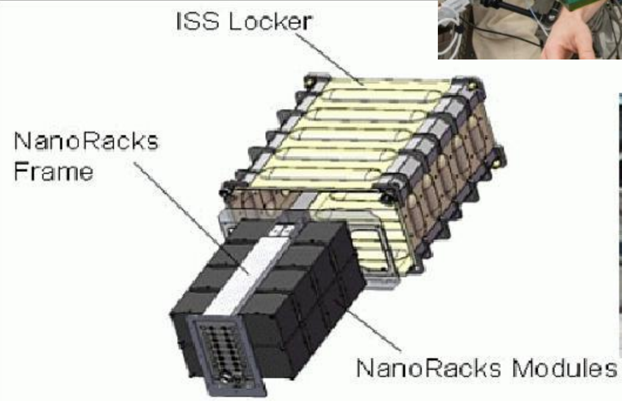


This is the endcap of a NanoLab with 2 of the 3 power and data connector pins

Important General information about all Nano Labs



- All Nano Labs (modules) will be installed into a NanoRacks frame —up to 16 Nano Labs to an ISS Locker. This ISS Locker will travel up to the ISS on a supply vehicle and will be removed from the supply vehicle by an astronaut and placed in one of the EXPRESS racks on the ISS where it will be turned on by the astronauts. All of the Nano Labs inside the Experiment box will run autonomously for about 30 days. After that time, the astronauts will remove the Experiment box with all of the Nano Labs inside and place the Experiment box into a vehicle where it will be returned safely to the ground or be burned up in the atmosphere. You should expect that your Nano Lab will never be touched by the astronauts. All of the actions inside the Nano Lab will happen with out human hands. All of the data must come from the Nano Lab and into Space Station computers without human hands.
- All Nano Labs have to be sealed to prevent any contents of one experiment from contaminating another experiment or the living space for the astronauts. This also means there is little if any air exchange between the Nano Lab and the astronauts atmosphere.
- All electronics give off heat when in use. Heat transfer does not happen as fast in zero-g since there is no convection without fans to move the air. Heat transfer by conduction (contact between objects) works well. All of the NanoRacks modules will be cooled by air being blown into the ISS Locker from the EXPRESS rack. The exterior of the Nano Lab is made of aluminum and is a good heat conductor but the more plastic against the interior walls of the Nano Lab the slower the heat will transfer.
- https://nanoracks.com/products/nanolabs/



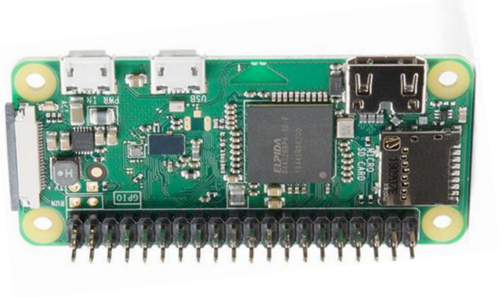
Shannon Walker activates NanoRacks

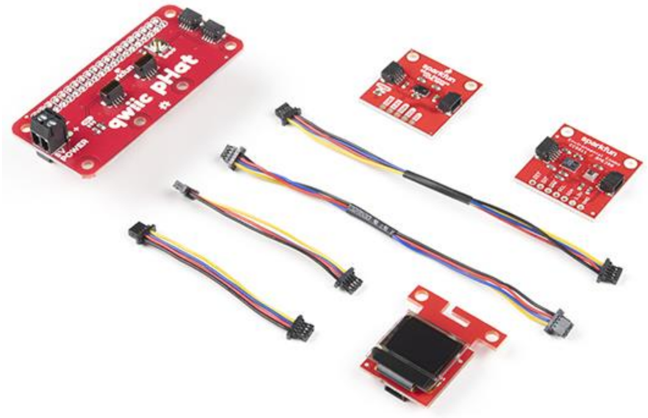
Hardware to consider--

<u>Fungus NanoLab</u>

- Raspberri Pi 4 or Arduino
- Temperature sensor
- Humidity sensor
- O2 sensor
- CO2 sensor
- Infrared Lights?
- Visible lights for taking photos?
- Infrared Camera(s)?
- Motor(water distribution)
- Motor (cut cap off mushrooms)
- Motor drivers

These are a few of the sensors and equipment that should be considered for your lab. You are trying to develop a NanoLab that many people could use to do their research with and not have to alter it significantly. It is impossible for your team to be the ‘everything lab’ for every researcher but try to give as many options as possible. There are limits for how many things can be in this confined space and still have enough room for mushrooms to grow. Remember to include cables and motor drivers as needed. There will be cables and they will need to be held down so they don’t vibrate loose during launch and then get in the way of cameras or get cut like the mushroom.

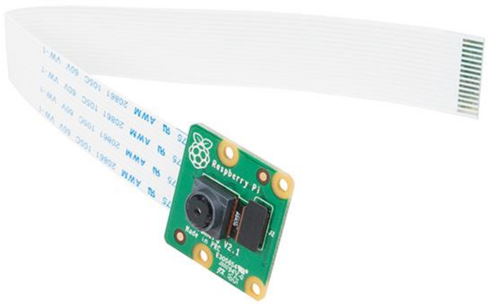


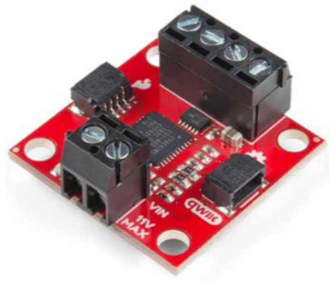


Read through the NanoLab GUI to understand the other team’s responsibilities.

Your job is to show a variety of ways how all the parts can be arranged inside the NanoLab and how they will attach so they don't vibrate out of place during launch. It is important for you to show where the lights, camera and other electronics go and even how it will look but you are not doing the programing. That will be the job of the students who are developing NanoLab Software GUI.
It is your job to work the mechanics of the how the NanoLab will function but still allowing room for the researcher to be creative(kind of like Legos-make it so you can do many things, not just one experiment).

HUNCH can not afford to send everyone a Sparkfun Kit—only the GUI teams. In the table you can see the dimensions of many of the components that researchers may want to use. I found the dimensions on the Sparkfun web pages for the part (usually under features). You can get more detailed information for each of the parts from the Sparkfun website. You may also find other components that you think would be valuable for your NanoLab.



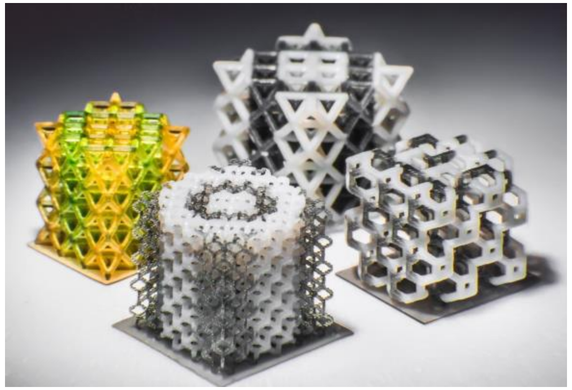


SparkFun Part Number	description	Qty	Notes
PRT-08430	Jumper Wires Premium 6\" F/F Pack of 10	1	155mm +/-5mm long, 26 AWG
TOL-13831	5.1V DC 2.5A Wall Wart (USB Micro-B)	1	AC to DC power supply
DEV-14028	Raspberry Pi Camera Module V2	1	25mm x 23mm x 9mmc, 15cm ribbon cable
PRT-14272	Pi Zero Camera Cable	1	
CAB-14274	MiniHDMI	1	
CAB-14276	USB OTG MicroB Cable	1	
PKG-14011	Large Red Box (9.25x6x2)	1	box it comes in
COM-15052	SparkFun Noobs card Raspberry Pi	1	
DEV-15470	Raspberry Pi Zero WH	1	65mm long x 30mm x20mm
ROB-15451	SparkFun Qwiic Motor Driver	1	25.4mm x 25.4mm x 12.5mm
PRT-16662	Jumper Wires Premium 6in. M/M Pack of 2: Red and Black	1	
WS2812B	SparkFun RGB LED Breakout - WS2812B w/ Headers	1	24 mm x 22mm x 5mm
KIT-16841	SparkFun Qwiic Starter Kit for Raspberry Pi	1	65.00mm x 30.5mm x 10mm
ROB-10189	Servo - Generic Continuous Rotation (Micro Size)	1	42.8mm x 33mm x 16.5mm

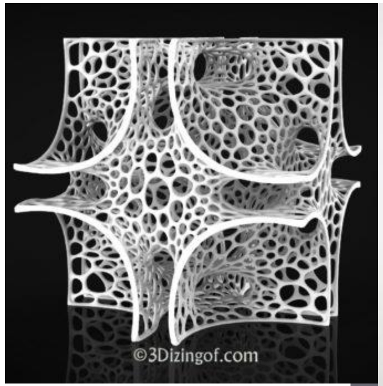
Bug structures

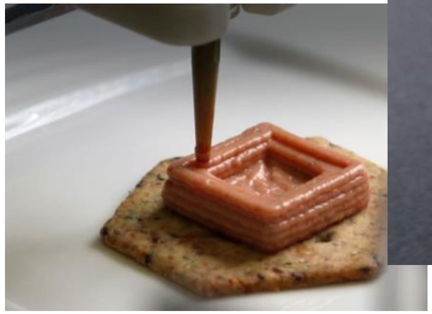
- Although eating the insects are the more interesting thing to talk about, the immediate problem at hand is can we grow them in space?
- People are already catching or growing enough bugs on Earth to feed 2 billion people. Some of them are grown on commercial farms and some may be captured from the wild. What mechanisms are being used on earth that could be helpful for growing them in micro-gravity?
- Which mechanisms need to be different in space? Instead of using egg cartons, could you design a structure they could cling to in micro-g?
- 3D printed structure made out of food—oatmeal, wheat paste, rice paste, …? As they eat, will parts break off and obscure the view of cameras?
- Maybe the food is stuffed into the structure and the bugs eat their way into or out of the structure.
- Maybe the structure is 3D printed but the food is coated on the structure—like dried pancake batter on a fork.
- What kind of food do the bugs need to eat? Does it have to be dry? Could it be slightly gooey without being too sticky for the bug?
- Water/moisture needs for bugs?
- The bugs may want to be in the dark but the researcher will want pictures and video of the insects' growth. How can you have room for the bugs to be seen in or through the structure but places for them to eat?

Bugs are sent to space for a lot of scientific reasons https://www.youtube.com/watch?v=ArHDSjfKDAs



Wikipedia has a listing of the many different types of animals including bugs that have been sent to space: https://en.wikipedia.org/wiki/Animals_in_space





Breeding insects

- This is a great video showing how Tatiana grows meal worms and dubia roaches as a food source for her pets and shows the life cycle that will be important as this experiment gets bigger.
- https://www.youtube.com/watch?v=noVClg1qyZc
- https://www.youtube.com/watch?v=cMPHekF-Ers
- Crickets are also a common food item
- https://www.youtube.com/watch?v=6rSw1SiCRh8
- https://www.youtube.com/watch?v=gNG7lOFBM84
- Flukers Louisiana
- https://www.youtube.com/watch?v=KzfQIanYHO4
- https://www.youtube.com/watch?v=OMNA4rbL9qw

Introduction to insect farming for a food source

- https://www.youtube.com/watch?v=PvEj2GL_hDU
- https://www.youtube.com/watch?v=40yXvtq8x8s

Eating bugs--TED

- https://www.youtube.com/watch?v=rDqXwUS402I&t=283s

Largest insect farm in the world

- https://www.youtube.com/watch?v=XF19hcXRIWA

Organic insect farm

- https://www.youtube.com/watch?v=RRv9uqjQsy4

The Hive—home growing insects

- https://www.youtube.com/watch?v=We_sZtdw0aU

As an added bonus, anyone who makes it to finals with their prototype NanoLab, Glenn will taste any bug dish they make along with the team. Hint: don't over power your bugs, ex—chocolate covered ants. Make it so the bugs still have texture and flavor. Maybe like an hors d'oeuvres?