The Lunar Bamboo Greenhouse

Congratulations for being chosen to be a NASA HUNCH Finalist for Design and Prototyping. Know that there were a lot of very good teams with great ideas competing for these spaces. Being a Finalist means you are already a winner. There is not a 1st, 2nd, or 3rd place—there are only Finalists. Although HUNCH would like to have all of these projects turned into flight hardware, most won't make it that far. However, some of these ideas may inspire other hardware and equipment. This is like real engineering where any of the projects or ideas in a project that are deemed valuable to NASA could be incorporated into another project. NASA has no intention of taking or stealing ideas. HUNCH has every intention to keep your names attached to those projects so that you and your team retain credit for your ideas and efforts. In general, NASA does not seek patents on space hardware unless there is a use for it on the ground that could be valuable.

Suggestions for the Final Design Review

Houston in the middle of April is warm and humid. The building is air conditioned but there will be lots of people. Rain is possible.

- Look professional.
- Everyone on the team should plan to talk.
- Update your brochure with you latest prototype and information.
- Make sure your QR code works for everyone.
- Update your tri-fold with your latest information—less about early concepts, more about features.
- The better your model looks, the less you have to say.
- Take a video of everything working well so if it fails when you arrive, you can still show functionality.
- You will be sharing a table with another team. Make sure your display will not take up more than half of a 6 ft x 2ft table. There will be some tables with power and some without. We will try to give priority to those who need it for the presentation—video.

Suggestions for The Lunar Bamboo Greenhouse

- Start your discussion with why bamboo makes a good potential plant for the moon.
- Make sure your model has a good representation for air flow, lighting, water path, stored water, entrance.
- Bring pictures of your bamboo and your data—not your bamboo.
- How could you repurpose space for growing other or additional plants, ie. Vegetables?

MATERIALS

ALUMINUM
$1.50 PER POUND / NON-TOXIC / NON-SPARKING / CORROSION RESISTANT / LIGHTWEIGHT / NON-FLAMMABLE / DURABLE

CARBON FIBER
$15 PER POUND / HIGH STIFFNESS AND STRENGTH / LIGHTWEIGHT / CORROSION RESISTANCE / CHEMICAL RESISTIVITY / ELECTRICAL CONDUCTIVITY / THERMAL CONDUCTIVITY

CLUMPING BAMBOO
PRICE VARIES / NON-INVASIVE / COMMONLY DROUGHT RESISTANT / GROWS DECENTLY FAST / EDIBLE

POLYESTER SPONGES
$3.29 PER SPONGE / ELASTIC / LIGHTWEIGHT / CHEAP / DURABLE / CHEMICAL RESISTANT

POLYVINYL CHLORIDE / POLYETHYLENE PIPES
$3.62 PER FOOT / CORROSION RESISTANCE / HIGH MELTING POINT / DURABLE / LIGHTWEIGHT

ABS PLASTIC
$1.50 PER POUND / THERMOPLASTIC / IMPACT RESISTANT / RESISTANT TO CHEMICAL EROSION / NON-FLAMMABLE / LOW COST

REGOLITH ROCKS
$0 PER POUND (IF ON THE MOON) / MOST LIKELY ACCESSIBLE / PROVEN TO AID PLANT GROWTH TO AN EXTENT

WATER
$4.83 PER 1,000 GALLONS. / ELECTRICAL CONDUCTIVITY / LIQUID /

MICRONUTRIENTS
$0.85 PER OUNCE / BORON (B) / ZINC (ZN) / MANGANESE (MN) / IRON (FE) / COPPER (CU) / MOLYBDENUM (MO) / CHLORINE (CL)

GROW LIGHTS
$100.00 PER SQ. FT / PROVIDES NECESSARY ENERGY FOR PHOTOSYNTHESIS
1KW PER DAY PER SQ. FT

NYLON LIGHT CABLES
½ IN. $0.43 PER FOOT / ALLOWS FOR EASY MANUAL ADJUSTMENT OF LIGHTS

SILICON
$2.80 PER POUND / ELECTRICAL INSULATOR / FLEXIBLE / WITHSTAND HIGH TEMPERATURES / DURABLE / KEEPS SHAPE

BAMLOONA

DEMO VIDEO

CONTACT

Bamloona@gmail.com

BAMLOONA

LUNAR BAMBOO GREEN HOUSE

LAKEWOOD HIGH SCHOOL

TEAM

ELIJAH SANCHEZ
BLAKE HOFFER
ALEX HILL
ZION CLARK

TEACHER

ASHLEY PEDERSON

CAD

SOLUTION

ENTRANCE CLOSED OFF WITH A PHYSICAL DOOR.
WHEN OPENED, AIR DOOR ACTIVATES TO SEPARATE ATMOSPHERES AND PREVENT TRANSFER OF MOISTURE

ALL GROW CHAMBERS UTILIZE COMPONENTS OF A DRIP HYDROPONIC SYSTEM TO MINIMIZE WATER USAGE AND SPACE.

FOUR INNER GROW CHAMBERS WILL HAVE 3 LARGE GROW PODS EACH TO SUPPORT THE GROWTH OF LARGE PLANTS (BAMBOO).
CONNECTED TO THE CENTER RESERVOIR.

FOUR OUTER GROW CHAMBERS WILL HAVE 21 GROW PODS EACH TO SUPPORT THE GROWTH OF SMALLER PLANTS AND GERMINATION OF BAMBOO PLANTS.
HAS ITS OWN RESERVOIR INSIDE.

CLUMPING BAMBOO SUCH AS BLACK BAMBOO, MOSO BAMBOO, AND GOLDEN BAMBOO WERE FOUND TO BE GREAT OPTIONS FOR LUNAR CULTIVATION.
EDIBLE, CONTAINED, FAST GROWING, RESISTANT TO CLIMATE INCONSISTENCY.

CENTRAL TOWER IS 8 FEET TALL. IT CONTAINS CLIMATE TRACKERS, A CENTRAL LIGHT RING, AND A CIRCULATION FAN.
MODULAR

INNER GROW CHAMBERS ARE EQUIPPED WITH ADJUSTABLE UV LIGHTS FOR <6 FOOT HEIGHT.
USE CENTRAL TOWER LIGHT ONCE BAMBOO GETS >6 FEET.

OUTER GROW CHAMBERS ARE EQUIPPED WITH UV LIGHTS ON LIPS ABOVE PLANTS.

ALL GROW LIGHTS FOLLOW A DAY-NIGHT CYCLE.

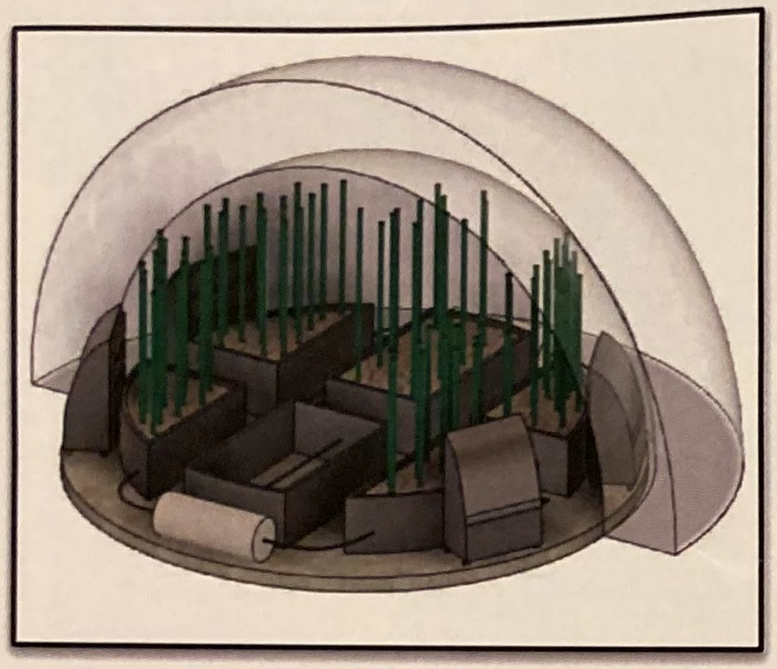
OUTER GROW PODS AND LEGS OF THE CENTRAL TOWER CONSIST OF MOTION-ACTIVATED AMBIENT LIGHTING.

FLOOR CONSISTS OF 8 HATCHES THAT EXPOSE ELECTRICAL SYSTEMS AND STORAGE FOR MAINTENANCE.
ELECTRICAL PANELS IN BULKHEAD DESIGN TO PREVENT COMPLETE LOSS OF ELECTRICAL SYSTEM IN SPILL

DEHUMIDIFICATION SYSTEM USING CLIMATE OF EXTERIOR TO CONDENSE WATER

MODEL

Overview



CAD Model

Project Goals

Design a lunar bamboo greenhouse that can be used as a carbon sequestration system, food and building source that can accommodate other plants. Our criteria includes the design of:

- Plumbing
- Lighting
- Grow beds/walkways
- Air circulation

Our Team

From left to right: Joyna Qin, Caroline Vernon, Isabel Forand

Contact us:

ghsbamboogreenhouse@gmail.com

Visit our website!

https://sites.google.com/inst.hcpss.org/ghs-lunar-bamboo-greenhouse/home

NASA HUNCH 2024

MoonShoots

Lunar Bamboo Greenhouse

Isabel Forand, Joyna Qin, Caroline Vernon
Glenelg High School
Instructor: Mr. Gerstner

Calculations

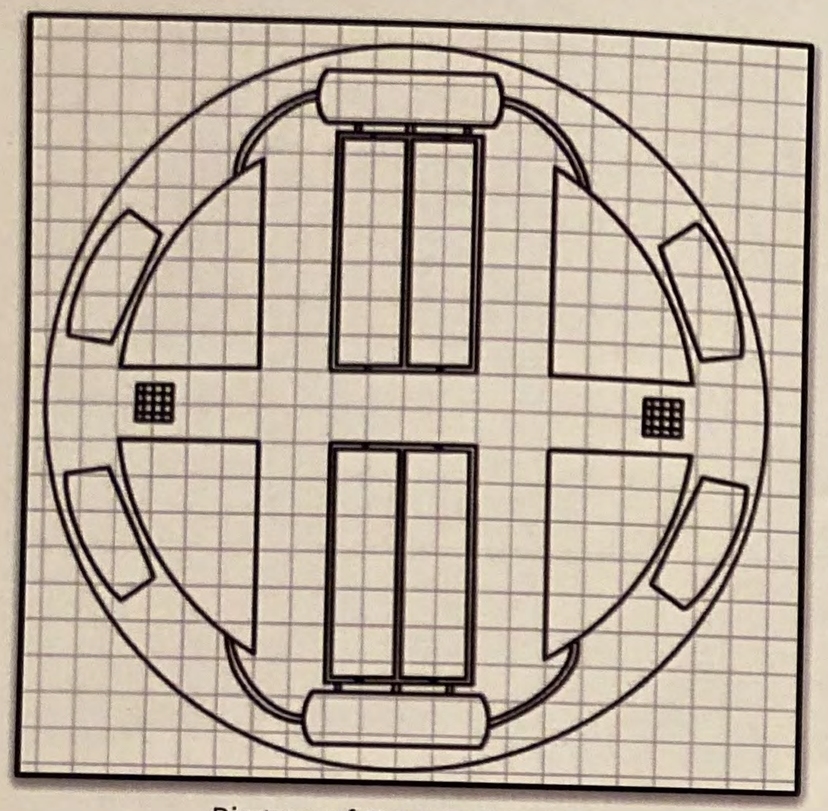


Diagram of Grow Bed Layout

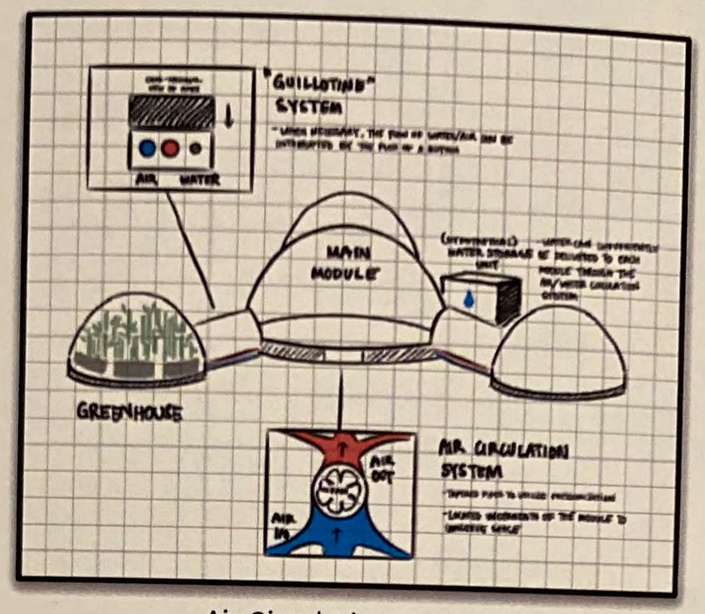
- **174.113 ft.²** of usable surface area
- **934.953 lb.** of CO_2 sequestered per year
- **41.577%** of CO_2 sequestered per year

We recommend carbon fiber as the main material based on its overall cost, weight, and 2-5 times greater strength.

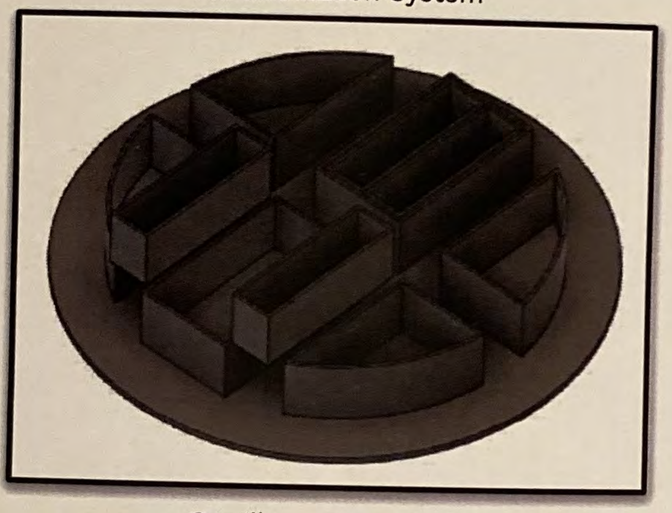
Material	Price ($/kg)	Weight (kg/m², 6mm thick)	Total Shipping Cost ($/m², in millions)
Aluminum	1.8	16.2	19.44
Carbon Fiber	85~220	16.2	19.441~19.443
Stainless Steel	6.61~22.05	47.1	57.600~57.601
Steel	0.25	48	56.52

Material Comparison Chart

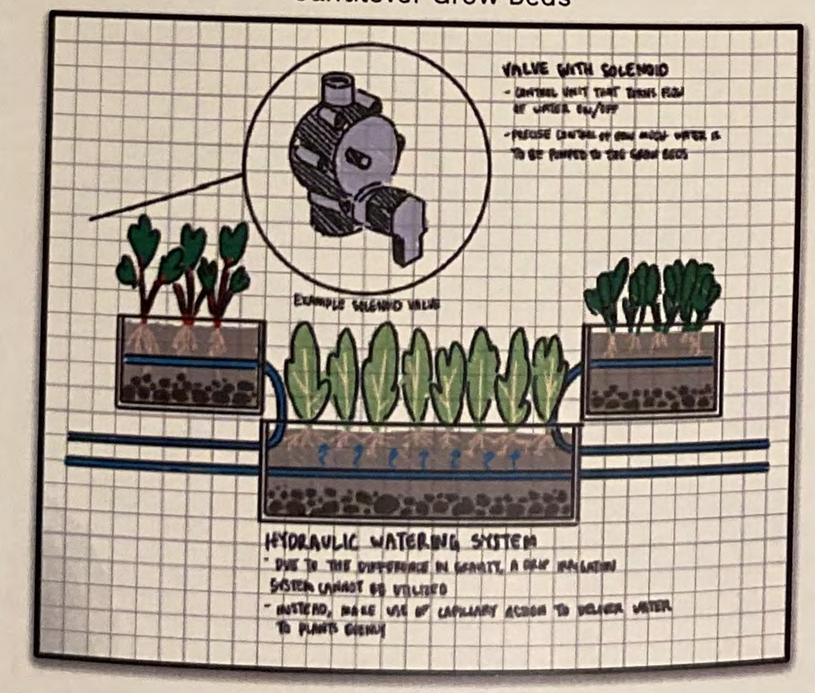
Design Details



Air Circulation System

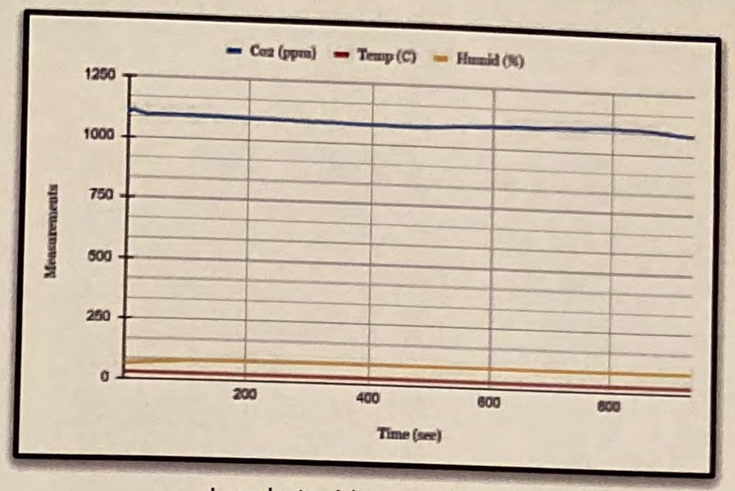


Cantilever Grow Beds



Hydraulic Watering System

Data Collection



Levels Inside Greenhouse

Bamboo Testing Habitat Setup

- **Avg. CO_2:** 1091.396 ppm
- **Avg. Temp.:** 23.245℃
- **Avg. Humid.:** 79.101%

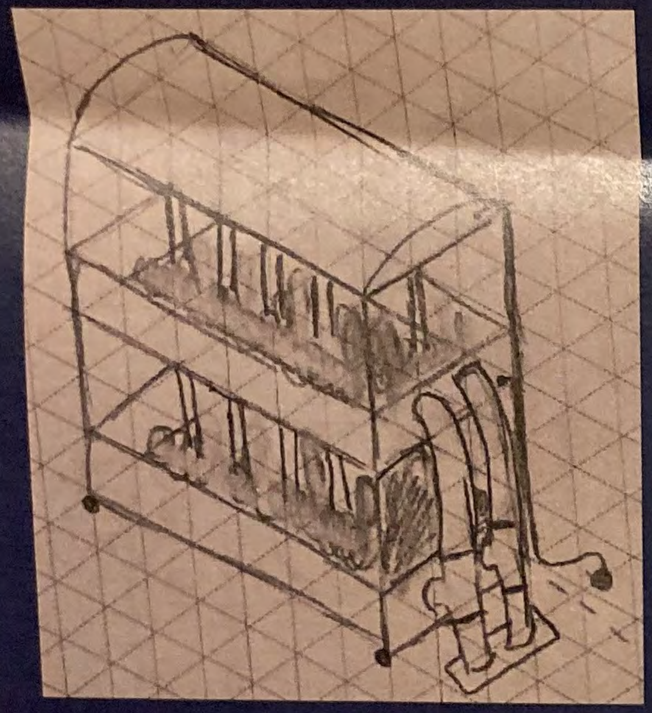
Substrate Test

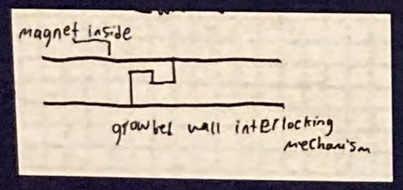
We grew various hardy plants and replaced regular soil with 50% and 100% sand and lava rock to find the following results:

Plant Type	Survivability (by Substrate)					Overall Survivability
	100% Soil	50% Sand	100% Sand	50% Lava Rock	100% Lava Rock	
Beets	100%	100%	100%	66.7%	66.7%	88.9%
Swiss Chard	100%	100%	100%	100%	66.7%	94.4%
Spinach	83.3%	100%	100%	100%	100%	94.4%
Mustard Greens	33.3%	0%	0%	0%	0%	11.1%

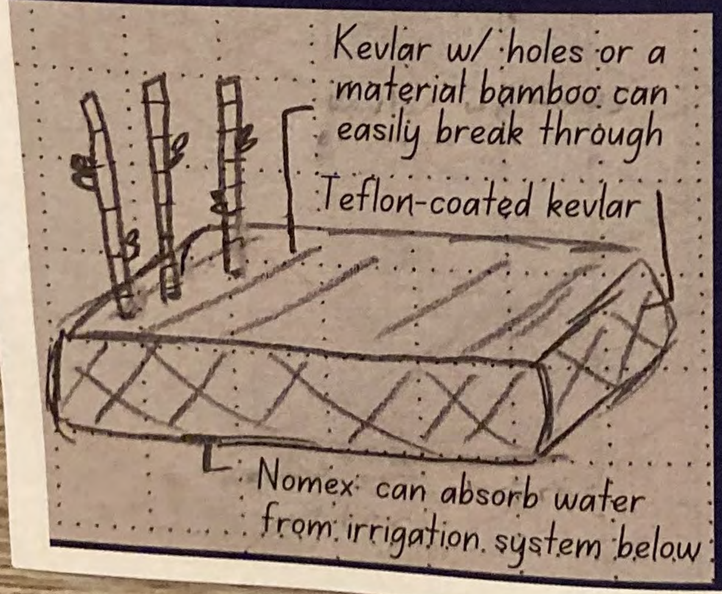
Substrate Test Summary Chart

GROW BED

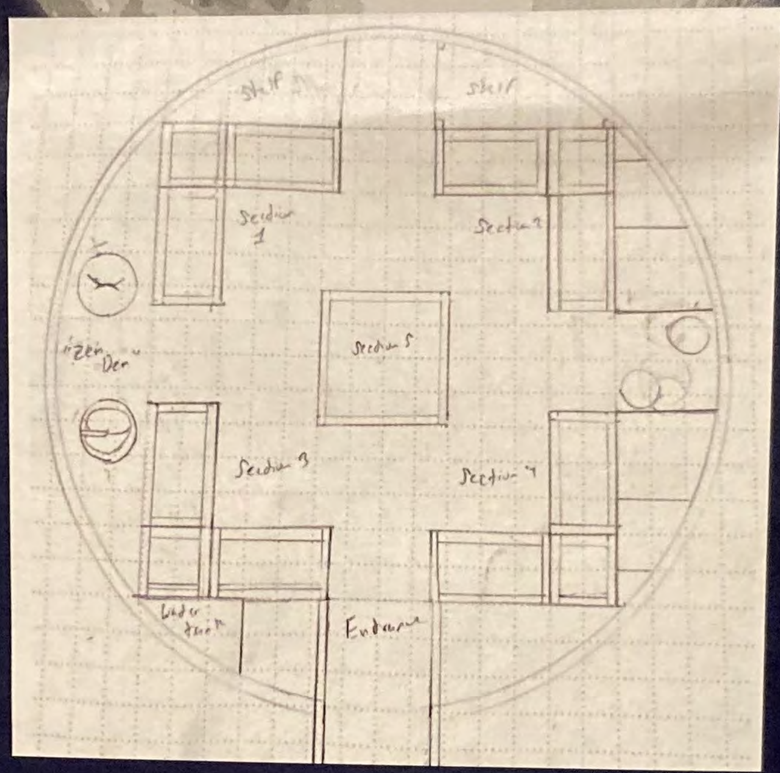




PLANT PILLOW



FLOOR PLAN



Maximum height of side grow beds is 8 ft

You can see a bigger version of this image in the QR code link

WORKSPACES

Semicircle areas are used for storage workspaces, and as a zen den. They can modified for other purposes like growing plants.

ELECTRICAL

- LED growlights will be red, blue, and purple
- Each color helps the plant achieve a different goal

GROWTH MEDIUM

- Bamboo will be grown in packaging materials already sent up to the moon
- Helps reduce waste
- Studied alternative materials in experiments

EXPERIMENTS

MARSfarm

Experiment Data & Greenhouse floor plan

BAMBOO TYPES

Bambusa tulda

Easily propagated, solid for construction

Phyllostachys edulis

Edible, able to survive in cold temperatures

Thyrsostachys siamensis

Edible, low maintenance, solid for construction

THE CUBE

LUNAR BAMBOO GREENHOUSE

Half Hollow Hills High School East
Mr. Regini

Avani Jairam, Carly Lansky, Aisha Ouechtati, and Stasya Selizhuk

Stasya Selizhuk

Aisha Ouechtati

Carly Lansky

Avani Jairam

Our task

We were tasked with designing a model showcasing our ideas on how to construct a modular bamboo greenhouse on the moon. The purpose of this greenhouse is to remove CO2, produce O2, and provide food and structural materials for the astronauts. Along with designing the habitat, we were also tasked with growing, testing, and recording data on bamboo to use in our design.

Our solution

In order to meet the design requirements, we specifically designed a system to grow vegetables and bamboo, along with an irrigation system to store, reclaim and implement treated water. We also designed workspaces, lighting systems and air ventilation systems as outlined in the "Our design" portion of this pamphlet.

How to reach us

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Lillian Anderson - 011322@mtka.org
Leo Feist - 007759@mtka.org



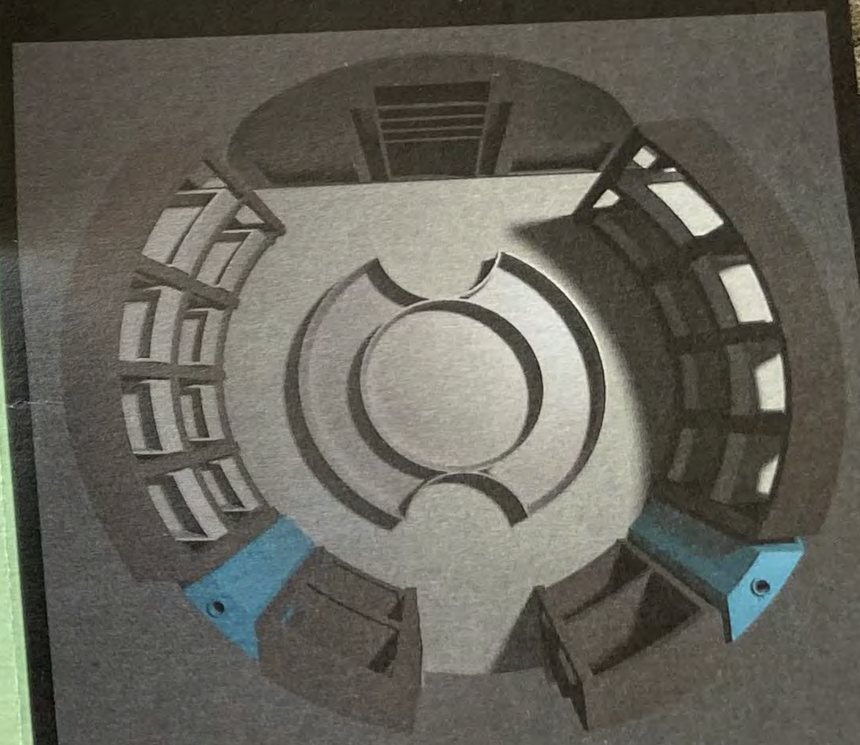
Bibilography / Sources

More Information

Lunar Bamboo Greenhouse

Minnetonka High School

Joshua Larson, Lillian Anderson, & Leo Feist



"One small step for man, one giant leap for mankind"-Neil Armstrong, 1969 - The Moon

More information

Our design also includes ventalation that runs around the circumfrance of the top of the dome providing porper air circulation between moduels. There is also highly individualized and customizable lighting in all of the extra grow spaces and for the bamboo grow spaces

Our design

Our design for the lunar base consists of many complex parts we designed for the unique project requirements.

Our research

We chose to use Moso bamboo for its edible and structural qualities, along with it being one of the fastest growing bamboos. We also chose Guadua angustifolia for is properties to grow in volcanic ash, which resembles lunar regolith, as well as it medicial, edible, and structural properties.

The design has interchangable grow beds in order to accomadate for growing bamboo in soil as well as hydroponically. The hydroponic system will consist of water along with liquid nutrients. The soil compesition consists of minerals, silt, clay, brown forest soil, and if desired, lunar regolith.

Luna Viridis

Lunar Bamboo Greenhouse

Our Bamboo

- Ended up going with plants over seeds
  - Golden Bamboo
- Ran experiments on plants, determined:
  - Purple lighting works best
  - Can grow in regolith

The Group:

Rebecca Winters

Jonas Nazario

Mario Cortes

Mentored by:

Mr. Merz

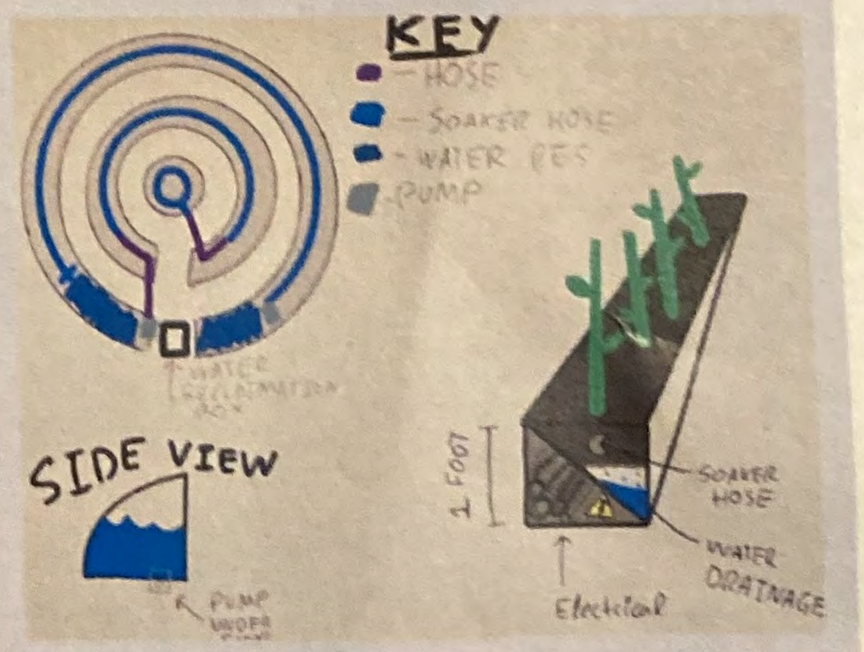
Our Design

- Water reservoirs on sides of entrance
  - Each holds 126 gallons
- Circular rings for maximum growth space

- False floor allows space underneath for support systems
- Work tables on ends of second ring

Support Systems

- Electrical system uses DC
  - Powers water pump for reservoirs & ligthing
- Plumbing will collect runoff water in basin
- HVAC filter in fans will control humidity
  - Use of ERV will circulate air througout base



COLUMBIA AREA CAREER CENTER
COLUMBIA PUBLIC SCHOOLS

TESTING

VERTICAL GROWING DATA TABLE

	Color	Height	Number of Stalks	New Growth?
Balcooa	Green	1.5 ft	2	Yes
Viridius	Yellow/Brown	3 ft	1	Yes
Black	Brown/Green	2 ft	3	Yes

BAMBUSA BALCOOA

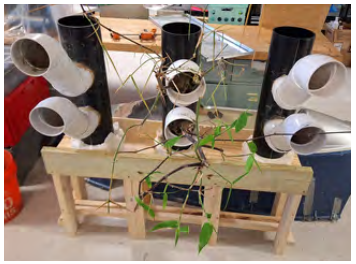
- Dark Vibrant Green
- High Survivability
- Short Stalks
- Large Leaves

PHYLLOSTACHYS VIRIDIS

- Yellow Stalk
- High Survivability
- Very Tall
- Small Leaves

PHYLLOSTACHYS NIGRA

- Numerous, dark, very thin stalks
- Low Survivability
- Small and Medium Leaves



GROWING BEDS

The growing beds were filled with sterilized regolith. This regolith was layered in large and small pieces of sterile gravel. The vertical growing is in a trough that allows for drainage. The horizontal growing beds are on a drainage stand and allows for 2 plants per structure.

IRRIGATION

In both designs, the water source is above so that gravity could help with the flow of water. A switch is built into the irrigation system for when the flow of water needs to be cut off. The drip irrigation technique was used in both designs.

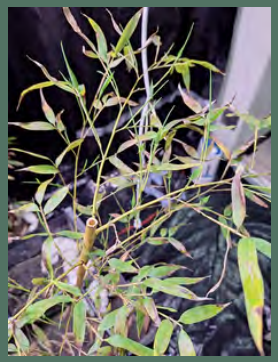
TYPES OF BAMBOO

BAMBUSA BALCOOA

- Clumping Rhizome
- Sterile seeds
- Efficient at processing CO2

PHYLLOSTACHYS VIRIDIS

- Running Rhizome
- Edible
- Fast growing



PHYLLOSTACHYS NIGRA

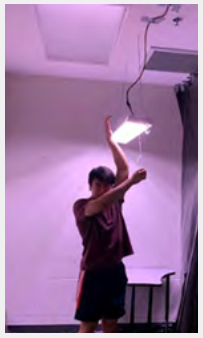
- Running Rhizome
- Prefers Consistent Watering
- Good for Construction

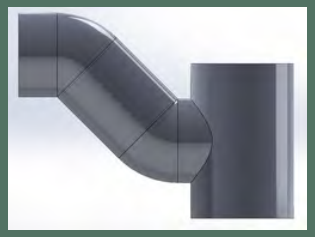
PREPARING BAMBOO

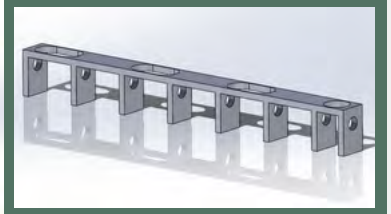
First, all the dirt needed to be removed from the roots of the bamboo. Then, the the roots needed to be cut in order to fit in their growing beds. They were then placed in the sterilized regolith, and finally, fertilized and watered.

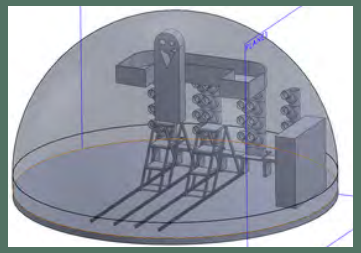
LIGHTING

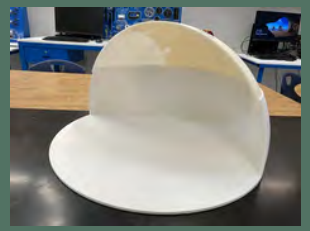
For the vertical growing of bamboo, the lighting would be top-down. For the horizontal growing, the lighting would be from the side. The testing room needed to block out all other external lighting that could affect the results of the testing process.











CAD / 3D MODEL

Final design for horizontal growing (top left). Draining Stand for horizontal growing (top right). Lunar Dome with some components (bottom left). 3D printed dome for the model (bottom right).

TEAM

Rishaan Ajmera, Yash Aravind, Nathan Clough, Joshua Do, Daniel Feingold, Cyrus Mohtaj, Gavin Valentino, Renee Zhu, and our advisor, Mr. Paul Platt

Northview HS Lunar Bamboo Greenhouse

Below is a QR Code linked to our website that goes into much more depth and detail about our progress on the project.

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nhslunarbamboogreenhouse.weebly.com