Lumínico

Bioluminescent Habitat to enhance the Biodiversity by Germarilis Ruiz Galloza

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Lumínico: Bioluminescent Habitat to enhance the Biodiversity explores the potential of bioluminescent fungi to create low-intensity lighting using living materials.

Author: Germarilis Ruiz Galloza
Mentors: Petra Garajova, Ana Correa, Cecilia Raspanti & Oscar Tomico

ABSTRACT

How could we use bioluminescence to create small habitats that contribute to biodiversity conservation and CO2 reduction?

According to data from the Emissions Database for Global Atmospheric Research, Puerto Rico´s power industry is the primary contributor to greenhouse gas (GHG) emissions, with a 10% increase in contamination during 2022-23. Of these emissions, 86% are carbon dioxide (CO2), contributing to biodiversity loss, light pollution, and rising temperatures. Four of the world´s 15 bioluminescent bays are in Puerto Rico, and 10% of the 71 known fungi species, including bioluminescent species, grow on the island. Bioluminescence can be observed in insects, bacteria, fungi, mollusks, fish, and dinoflagellates.

In response to the increase in CO2 and GHG emissions, this research focuses on the use of bioluminescent fungi to develop a biomaterial structure designed to form luminescent habitats. These habitats aim to clean the air through carbon capture and attract luminescent species, such as insects. The purpose is for these structures to serve as low-intensity lighting alternatives to help reduce light pollution.

The proposed bioluminescence living lights will meet the technical specifications of a low-intensity or standard LED and attract insects that aid in spore dispersal. Redesigning the low-intensity light with a living organism will help create new models of sustainable urban illumination while reducing greenhouse gasses produced by the excess use of electricity power for illumination.

Challenges

The lack of useful information about the life of bioluminescent organisms creates a market barrier to the development of functional and sustainable product design. I will insert an alternative to traditional lights into the market using a living material that is not dependent on electricity. One of the challenges we expect to overcome is the cost of production and the lifespan of the light.

Keywords: Bioluminescence, Mycodesign, Low intensity lights, 3D printing, Bioart

ACKNOWLEDGEMENT

My sincerest gratitude goes to my global and local mentors: Cecilia Raspanti, Oscar Tomico, Petra Garajova, and Ana Correa. Their guidance and significant contributions, stemming from their respective areas of expertise, have been fundamental to the development of this research. I thank Carolina Souza for her support and input on the scientific procedures I carried out during the experimental process. Without the dedication and knowledge of this exceptional group of experts, completing this work would not have been possible.

CONTEXT

Puerto Rico has 7 of the 71 bioluminescent fungi species.

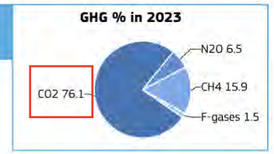
Power industry is the primary contributor to greenhouse gas (GHG) emissions, with a 10% increase in contamination during 2022-23.

86%
Carbon dioxide CO2 (power industry).

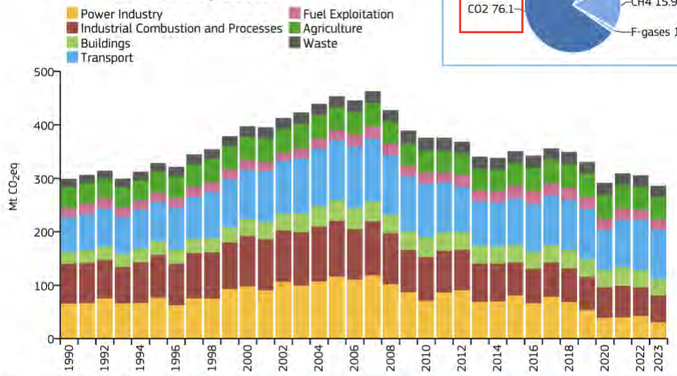
4 of 15 bioluminescent bays in the world are in Puerto Rico.

EDGAR

Spain and Andorra



GHG emissions by sector

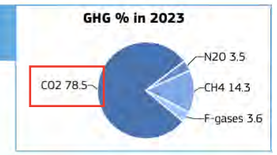


Year	GHG emissions Mt CO_2eq/yr	GHG emissions per capita t CO_2eq/cap/yr	GHG emissions per unit of GDP PPP t CO_2eq/kUSD/yr	Population
2023	285.384	6.152	0.127	46.387M
2015	350.235	7.549	0.177	46.398M
2005	452.782	10.281	0.240	44.043M
1990	297.736	7.575	0.244	39.306M

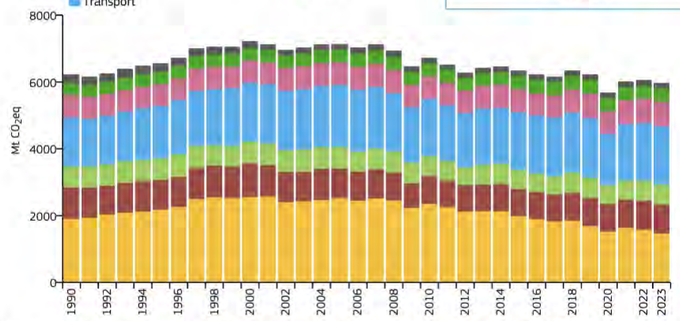
2023 vs 1990 **2023 vs 2005** **2023 vs 2022**

EDGAR

United States



GHG emissions by sector

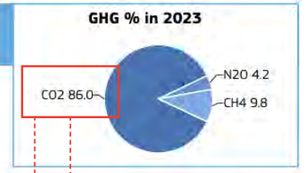


Year	GHG emissions Mt CO_2eq/yr	GHG emissions per capita t CO_2eq/cap/yr	GHG emissions per unit of GDP PPP t CO_2eq/kUSD/yr	Population
2023	5960.804	17.608	0.242	338.524M
2015	6328.998	19.783	0.305	319.929M
2005	7123.633	24.137	0.404	295.130M
1990	6209.295	24.588	0.560	252.530M

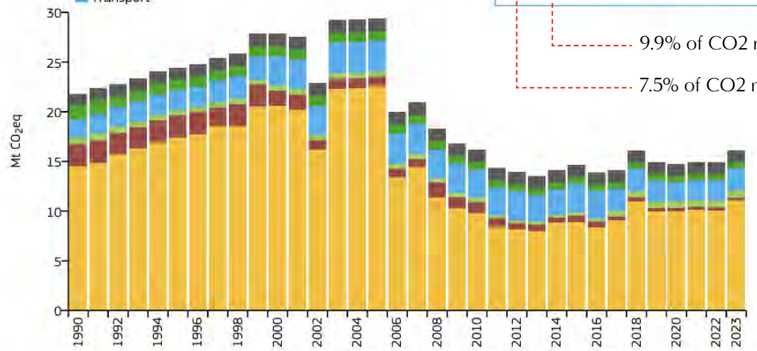
2023 vs 1990 **2023 vs 2005** **2023 vs 2022**

EDGAR

Puerto Rico



GHG emissions by sector



9.9% of CO2 more than Spain

7.5% of CO2 more than the USA

Year	GHG emissions Mt CO_2eq/yr	GHG emissions per capita t CO_2eq/cap/yr	GHG emissions per unit of GDP PPP t CO_2eq/kUSD/yr	Population
2023	16.064	4.420	0.117	3.634M
2015	14.626	3.981	0.099	3.674M
2005	29.352	7.795	0.180	3.765M
1990	21.747	6.182	0.230	3.518M

2023 vs 1990 **2023 vs 2005** **2023 vs 2022**

Power Industry -24% -51% +10%

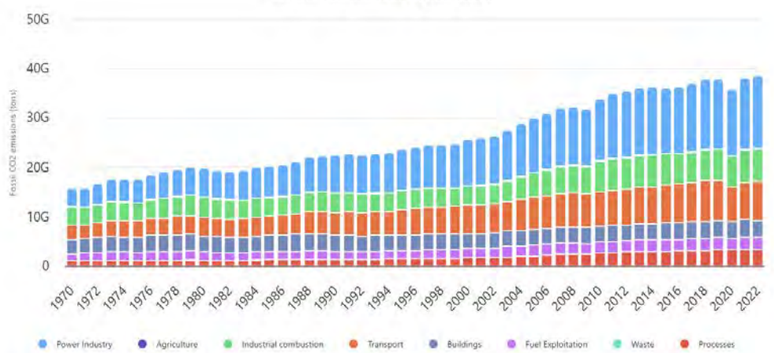
CO2 Emissions

Fossil CO2 Emissions (2022) **38,521,997,860** tons

Change **+1.15%**

Per capita **4.80** tons

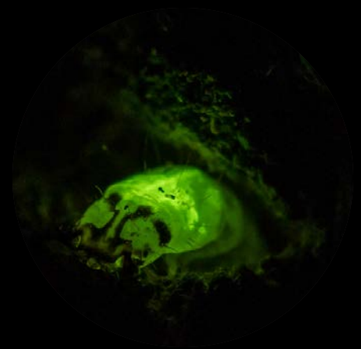
Global CO2 emissions by Year (tons)



MATERIAL RESEARCH

Bioluminescence is the emission of light by living organisms through different biochemical reactions. The word bioluminescence comes from bios (life) and lumen (light). Some organisms, such as insects, use it as an effective means to ensure mating, while others use it as a defense mechanism against predators.

BIOLUMINESCENCE PROPERTIES:



Fungi

Type: Oxidation of compounds

Intensity: Low to medium

Duration: Constant and visible in darkness

Environment: Humid and tropical

Temperature: 15-25 C

Maximun CO2 Tolerance: Low, less than 2% CO2

Insects

Type: Natural reaction

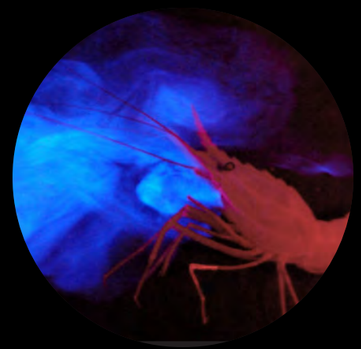
Intensity: Medium to high

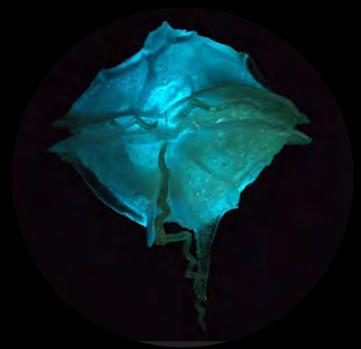
Duration: Visible in darness

Environment: Humid and tropical

Temperature: 20-35 C

Maximun CO2 Tolerance: Low, less than 3% CO2





Jellyfish

Type: Natural reaction

Intensity: Medium, visible in water

Duration: Constant

Environment: Open ocean

Temperature: 4-20 C

Maximun CO2 Tolerance: Moderate, less than 5% CO2

Shrimp

Type: Secretion of bioluminescent fluids

Intensity: Medium

Duration: Visible in watwer

Environment: Deep ocean waters

Temperature: 2-10 C

Maximun CO2 Tolerance: High tolerance, up to 10% CO2

Dinoflagellates

Type: Movement- introduced bioluminescence

Intensity: Variable

Duration: Brief, only when agitated

Environment: Require saline waters

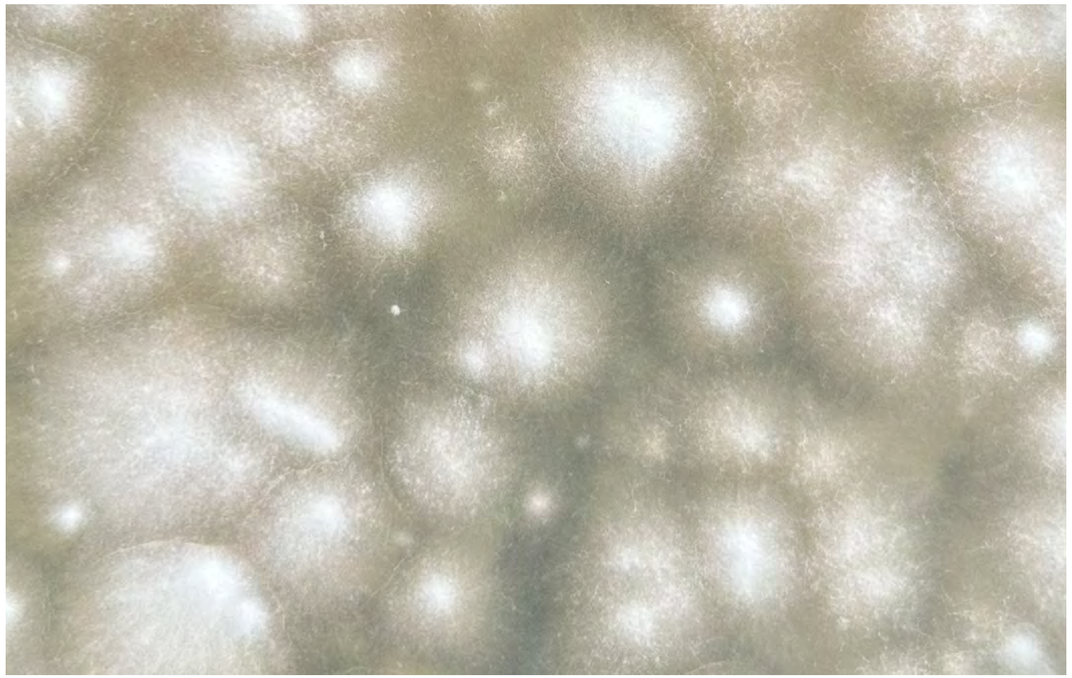
Temperature: 30-30 C

Maximun CO2 Tolerance: Moderate, less than 5% CO2

15-20 lumens per square

LED standard 200 lumens

BIOLUMINESCENT FUNGI TAXONOMY



WHY FUNGI?

Unlike algae and bacteria, bioluminescent fungi were relatively unexplored in the design industry. Their nighttime glow, which can persist for days in living cultures and fruiting bodies, is best observed in dark, natural settings.

Bioluminescent fungi, commonly known as glowing fungi, emit a green light and thrive on decaying organic matter such as dead bamboo, tree trunks, and leaves. Their nighttime glow, which can persist for days in living cultures and fruiting bodies, is best observed in dark, natural settings. Despite their global distribution across diverse terrestrial environments, the mechanisms driving their bioluminescence remain largely unknown. The process generally involves the chemical oxidation of luciferin, catalyzed by luciferase in the presence of oxygen, resulting in a high-energy intermediate that decomposes and releases energy as light from excited singlet oxyluciferin. One proposed function of this bioluminescence is to attract insects for spore dispersal, a theory supported by observations of beetles interacting with fruiting bodies.

Reference: Fungal Bioluminescence: Past, Present, and Future

PANELLUS *stipticus*

Panellus stipticus is found in tropical and humid areas, attract insects to spread spores and serve as a defense against predators.

Fungal taxonomy: Panellus *stipticus*
Glowing Part: Mycelium, Fruiting Bodies & Cap
Africa, Australasia, China, Europa, Japan, USA and South America.

Registering existence in Puerto Rico (non-native).

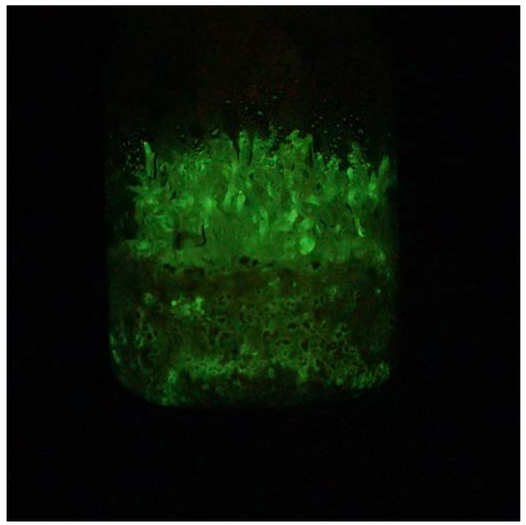
Growing process: 8 weeks
PH: 4.0
Temperature: 20 - 30 C
CO2: during the fruiting phase, levels should not exceed 1,000 ppm
Bioluminescence: Constant light, 5-10 minutes after exposure to darkness.

Mycena *luxperpetua*

Fungal taxonomy: Mycena luxperpetua
Glowing Part: Mycelium, Fruiting Bodies, Cap & Stipe
Distribution: Puerto Rico

Mycena *aspratilis*

Fungal taxonomy: Mycena aspratilis
Glowing Part: Fruiting Bodies Stipe
Distribution: Puerto Rico & Barazil



Material Research

Living materials	Fabrication materials	Aggregates	Methodology	Expected results
Panellus Stipticus Fungi	Glass	Substract Medium solution	Liquid cultures	Bioluminescent fungi
N/A	Clay & Hemp	N/A	3D printing	Parametric module CO2 absorbents
N/A	Smart citizen sensor and Humidity sensor	N/A	3D printing	Controled Environment

Experimental Design & Methods

Test	Methodology	Expected results
Humidity	Smart citizen sensor and data	Identify the best humidity percent to grow the materials
Light intensity	luxometer and photography	Measure the bioluminescent
Growing process	Agar plate	Documentation of the growing and behavior of the living material
Bioluminescent properties absorption	Transfer the mycelium to cotton	Bioluminescent material
Product development	3D printing	A 3D model that can be use as a carbon filter and ecosystem for the living material (fungi)

Alternative Approaches

1. Exploring the bioluminescence of fungi & bacteria to create a solution for light pollution (myco terrarium).

2. If the experiment was unsuccessful I developed a parametric structure to collect CO2 using biomaterial and aggregate Pure Tech Polymer.

Expected Outcomes

	January	February	March
Objective 1: Validate the potential of bioluminescence to use as a low intensity light			
Task 1.1: Growth of bacteria and fungi cultures			
Task 1.2: Design a data collection and monitoring tool			
Task 1.3: Making low and medium fidelity prototypes to explore the design and functionality			
Task 1.4: Prove the bioluminescence of fungi and bacterial life span and possibles uses			
Objective 2: Design			
Task 2.0: Implementing the feedback of the mentors and iterate the design			
Task 2.1: Biomaterial development and aggregates test			
Task 2.2: 3D printing models			
Objective 3: Test the prototypes in natural environment and documenting changes			
Task 3.0: Implementing the feedback of the mentors and iterate the design			
Task 3.1: Create a consistent biomass and identify the best prototype and recipe			
Task 3.2: Develop a final prototype			
Task 3.3: Organize data and presenting the final project			
Task 3.4: Establish a collaborator network. Design and implement a marketing plan and commercialization strategies.			

MEDIUM EXPLORATIONS

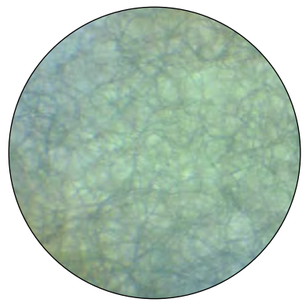
Best recipe

Malt extraction 5 g
Potato starch 2.5g
Distillate water 250 ml
Pure culture

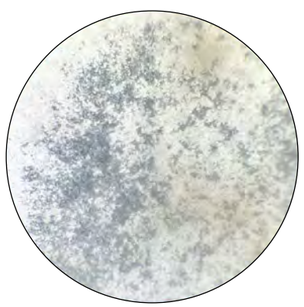
Agar 5g Malt extraction 5 g Potato starch 2.5g Distillate water 250 ml Pure culture

Agar 8 g
Pure culture
Distillate water 400 ml
Cotton

Agar 8 g
Pure culture
Distillate water 400 ml



Malt extraction 1.5 g
Pure culture
Distillate water 100 ml



Yeast 3g
Agar 350 ml (original solution)
Pure culture

TEST & EXPLORATIONS

01

Malt extraction 5 g
Potato starch 2.5g
Distillate water 250 ml
Pure culture

Temperature: 22 °C (incubator)

Observations:
Liquid medium. After 2 weeks the culture continues growing good and faster.

02

Agar 5g
Malt extraction 5 g
Potato starch 2.5g
Distillate water 250 ml
Pure culture

Temperature: 22 °C (incubator)

Observations:
Solid medium. After 2 weeks the culture continues growing good and faster.

03

Yeast 3g
Agar 350 ml (original solution)
Pure culture

Temperature: 22 °C (incubator)

Observations:
Solid medium. Two test, one of the samples had black spots, which indicates that it was contaminated.

04

Malt extraction 1.5 g
Pure culture
Distillate water 100 ml

Temperature: 22 °C (incubator)

Observations:
Liquid medium. After 4 days, it´s growing faster than the others. Contaminated (2 smaples)

05

Agar 8 g
Pure culture
Distillate water 400 ml

Temperature: 22 °C (incubator)

Observations:
Solid medium. Two test, one of the samples had black spots, which indicates that it was contaminated.

06

Agar 8 g
Pure culture
Distillate water 400 ml
Cotton

Temperature: 22 °C (incubator)

Observations:
Solid medium. After 4 days, some mycelium appears on the top of the fabric. On February 17, all the surface was covered by mycelium. Unfortunately on February 21, I found the incubator open and the culture contaminated.

07

Pure culture (substrate)

Temperature: 20 °C (room temperature)

Observations:
Solid medium. 10 days after cultivating the mycelium cover the top of the bottle of subtract. After 4 weeks the culture has 2 fruits and glow in the dark.

08

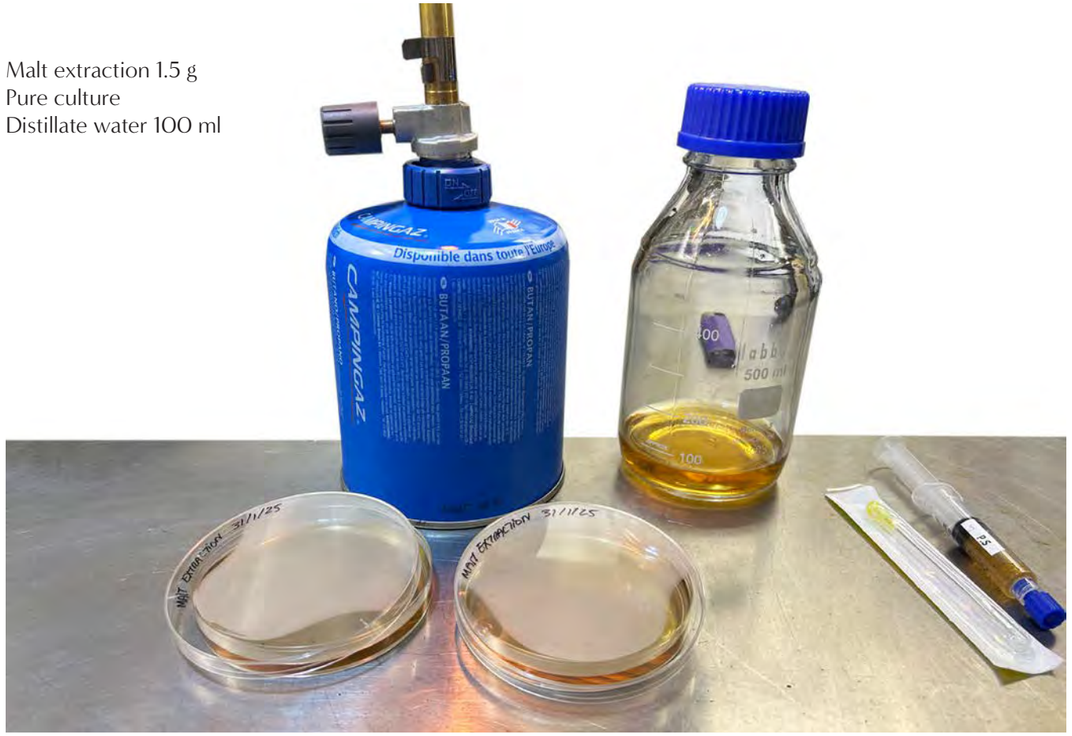
Pure culture

Temperature: 20 °C (room temperature)

Observations:
Liquid medium. The surface is covered with mycelium and the fruit starts growing but doesn´t emit bioluminescent.

INOCULATION PROCESS

Malt extraction 1.5 g
Pure culture
Distillate water 100 ml



Step 1: Sterilize all tools with alcohol and dry thoroughly. Then weigh the nutrients and mix them with water in the bottle until the nutrient is dissolved.

Step 2: If you are working with different recipes, you should label the bottles to differentiate the nutrients. In my case, I labeled the medium containing agar with tape.

Step 3: Place water in the pressure cooker with water ( ). Place the bottles and all the materials you are going to use in a bag and leave the lid of the bottles a little open.

Step 4: Close the bag by rolling it up, then put it into a pressure cooker for 30 minutes.

Step 5: After 30 minutes, remove the instruments and materials from the pressure cooker and place them in the sterilized area as close as possible to the burner. Wait 10 minutes while the medium cools down so you can use it.

INOCULATION PROCESS

Materials:

Pressure cooker
Alcohol
Plastic grap
Pressure cooker bags
Gloves
Scissors
Laboratory bottle
Clay geometry
Incubator
Nutrients (Agar, Malt extraction, Yeast or Potato starch)
Pure culture
Substract 1/2 cup

Step 6: Place the sterilized petri dishes and medium in the sterilized area. Then bring the bottle close to the burner to open it and prevent contamination, place the mouth of the bottle in the fire, keep the bottle close to the fire, open a little of the lid of the petri dish, and carefully place the medium.

Step 7: Then open the lid of the petri dish a little in the direction of the fire so that the medium solidifies and does not generate steam stains on the lid.

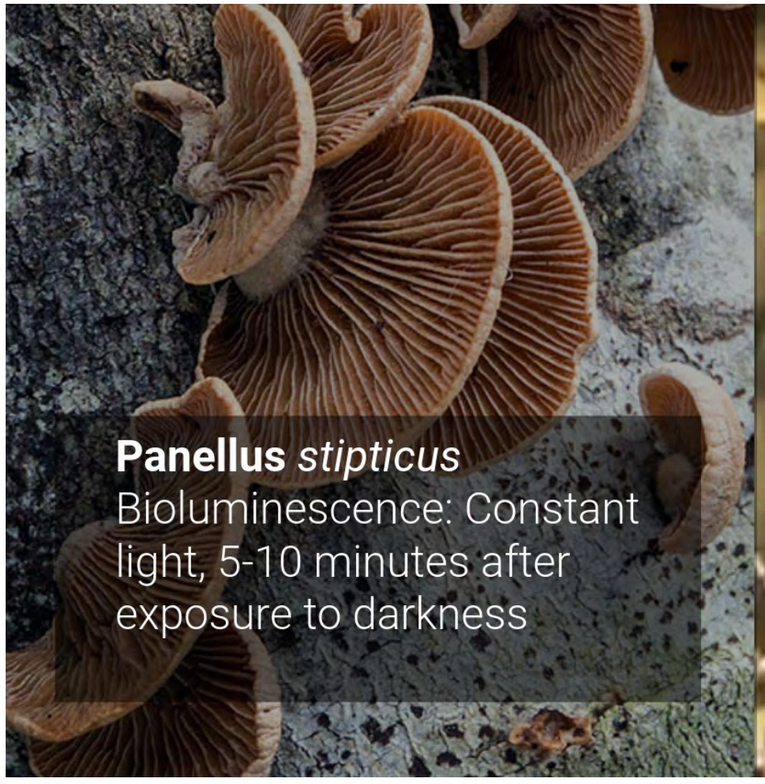
Step 8: When the medium has solidified, add the pure culture.

Step 9: Identify the sample on the edge with the date, nutrient name, and culture, and seal the lid with paraffin.

Step 10: Finally, place the samples in the incubator in the temperature range of 20-30°C. Monitor the samples daily.

MICROSCOPE IMAGES

MATERIAL PROPERTIES



Panellus *stipticus*
Bioluminescence: Constant light, 5-10 minutes after exposure to darkness

Temperature: 20℃ - 30 ℃
Humidity: 70-85%
Tropical and Humid areas

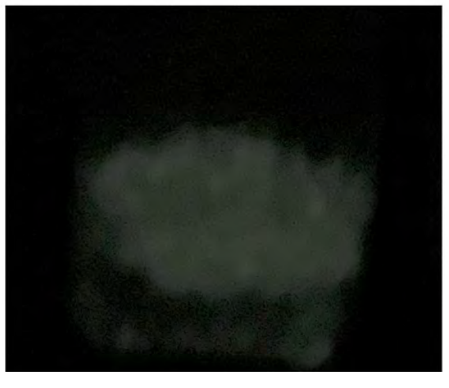
Glowing Part:
Mycelium, Fruiting Bodies & Cap

Growing:
12H of light & 12H darkness

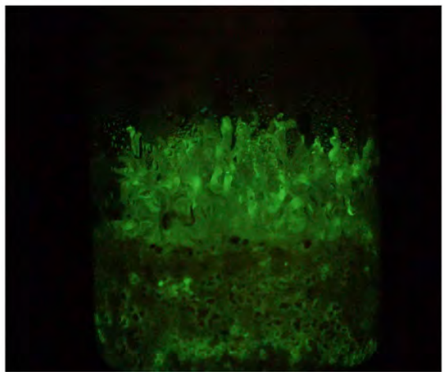
01 weeks

02 weeks

03 weeks



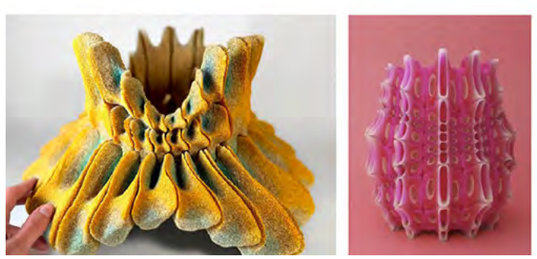
06 weeks



STATE OF THE ARTS

VAULTEd Willow & Zephyr
MARC FORNES / THEVERYMANY

Microbes Makes Mountains, MIT Keller Gallery
Laura Maria Gonzalez

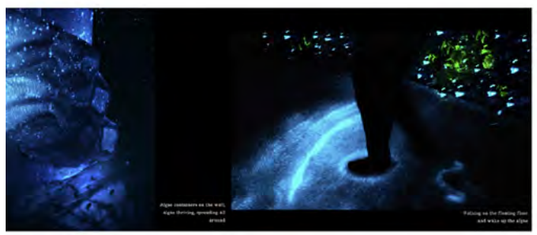


Mycelia house: functional and minimal container for mushrooms

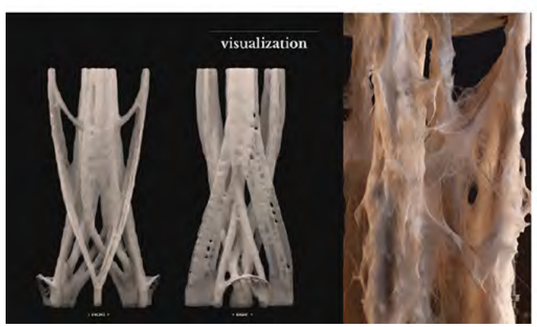
Rollo Bryant
Independent design studio

My design precedents were inspired by the work of Marc Fornes, who uses mangroves as inspiration to develop parametric pavilions that integrate with the natural environment. Other designers who caught my attention are the parametric colorful sculptures and material research of Laura María González and Rollo Bryant, with his luminous organic sculptures. Finally, Mycelia House inspired me for its simplicity and functionality. This project proposes growing fungi to build the house.

The bioluminescence fantasy night
by Emma Huang



Mycelium Tectonics
Gianluca Tabellini



The Living Room
by Jane Scott, Ben Bridgens, Romy Kaiser, Dilan Ozkan - Newcastle University
Armand Agraviador - Independent Researcher and Designer

The BioKnit Prototype
Jane Scott, Dilan Ozkan, Aileen Hoenerloh, Romy Kaiser, Armand Agraviador, Ahmet Topcu, Ben Bridgens, Elise Elsacker.

01. Emma Huang proposes a future symbiosis between mycelium, bioluminescent algae, and constructed structures, set approximately one hundred years in the future in the historic Radcliffe Camera of Oxford. The project explores the integration of living organisms into architecture, proposing a harmonious coexistence between the natural and the built.

02. The Living Room is a research project that explores the use of textiles and biofabrication to develop regenerative architectural solutions using mycelium and kombucha as primary materials. The project proposes to make architectural structures where textiles are used at multiple scales, growing mycelium, and integrating biological materials and textile techniques to create sustainable living spaces.

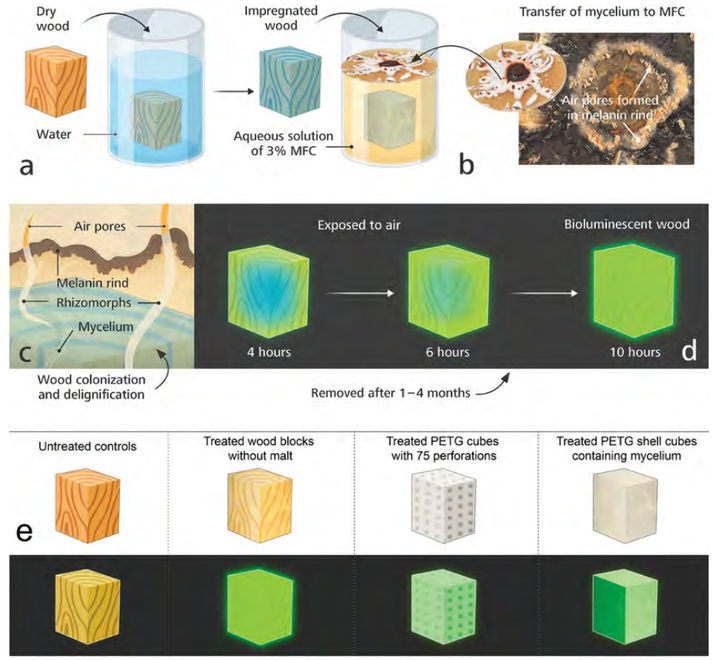
03. Mycelium Tectonics is a research thesis that explores the use of mycelium in architecture. Mycelium, the vegetative part of fungi, is characterized by its ability to grow and form dense fibrous structures. This approach suggests that mycelium can serve as a living agent system in architectural applications, offering possibilities for the creation of sustainable and self-assembled composite materials.

04. BioKnit is a prototype of an architectural construction that combines textile, mycelium, and bacterial cellulose. This work integrates biological experimentation with parametric modeling and textile programming. The article includes specific aspects to achieve scalability in architectural bio-construction.

STATE OF THE ARTS

05. Bioo is a biotech and Research and Development Company. Bioluminescent urban lightning (bacteria & fungi)

06. Lo Lamento by Victoria Geaney, in collaboration with Bernardo Pollak and Anton Kan.



Material Reaearch Inspiration

As part of my experiments and material design, I am interested in embedding the bioluminescence of fungi into wooden blocks. This would help me develop a way to enhance bioluminescence, from cultivation to the printing of a wooden structure that supports the intensity of the bioluminescence.

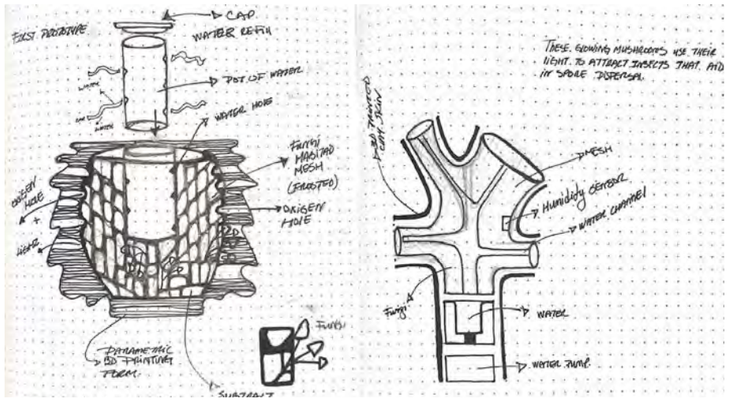
This diagram presents a methodology to create a living hybrid material combining the bioluminescent fungus with balsa wood, achieving controlled autonomous bioluminescence.

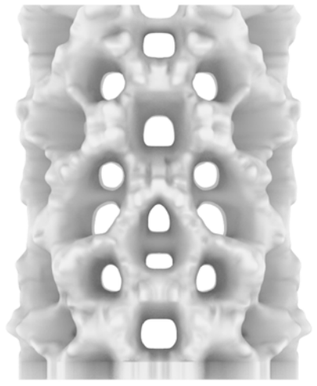
Source: Taming the Production of Bioluminescent Wood Using the White Rot Fungus Desarmillaria Tabescens.

DESIGN & PROTOTIPYNG

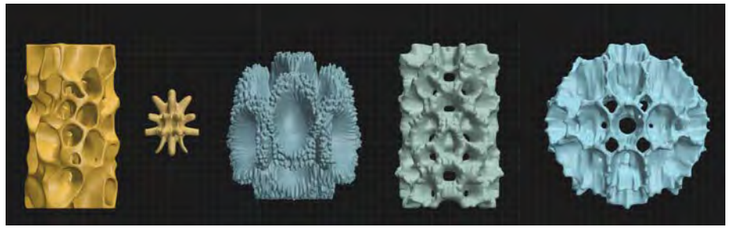
DESIGN PROPOSAL

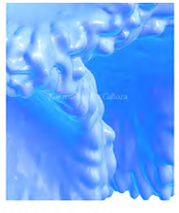
I propose to create a modular structure of 3 principal layers: inside I include a 3d printed clay pot with a humidity sensor and different channels for water, and vitamins and monitor the humidity of the living material; the second layer is a mesh structure to put the subtract and grow the fungi bioluminescence and for the bacteria, I use a crystal vase that provokes refraction and intensifies bioluminescence; the final layer is a parametric 3d printing biomaterial with the properties to collect CO2 to reduce the air pollution. This is important because the brightness of the bioluminescence can be affected by environmental pollution. These structures aim to replace or reduce the use of low-intensity lights in urban spaces. The modular design allows for scaling the structures according to need.





My initial design exploration was inspired by the organic growth patterns and textures of the fungi. I selected, how they grow in the trees. I created a series of volumetric studies to conceptualize a luminous micro-habitat that could support fungal growth and provide low-intensity lighting for urban, forest, and interior environments.

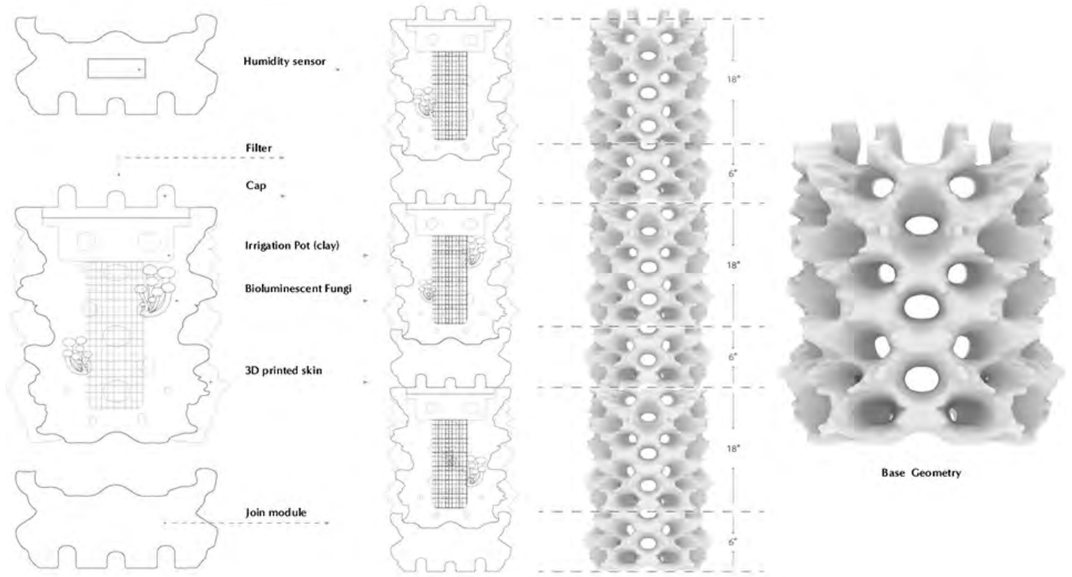



Biomaterial Agar + Bacteria


Biomaterial fungi


bioluminicent pattern


3 Layers results



Base Geometry

Conceptual & Functional Diagram by Germarilis Ruiz Galloza

The diagram includes the basic geometry, joints, and functional components. Through this visual exercise, I determined the optimal placement of essential elements to sustain the fungus. The design incorporates perforations, layered materials, and humidity sensors to create a suitable environment.

The first prototype I made is a 3D print of one of the modules that contains a crystal container to hold water and maintain the humidity of the fungus. Then, inside, I placed a mesh where I initially thought the fungus could grow. However, since bioluminescence is affected by the environment, I decided to incorporate an opaque glass container that allows light to enter but at the same time has a filter at the top to help maintain a controlled environment. In this prototype, I include an environmental monitoring sensor at the base to collect data on pollution and CO2.

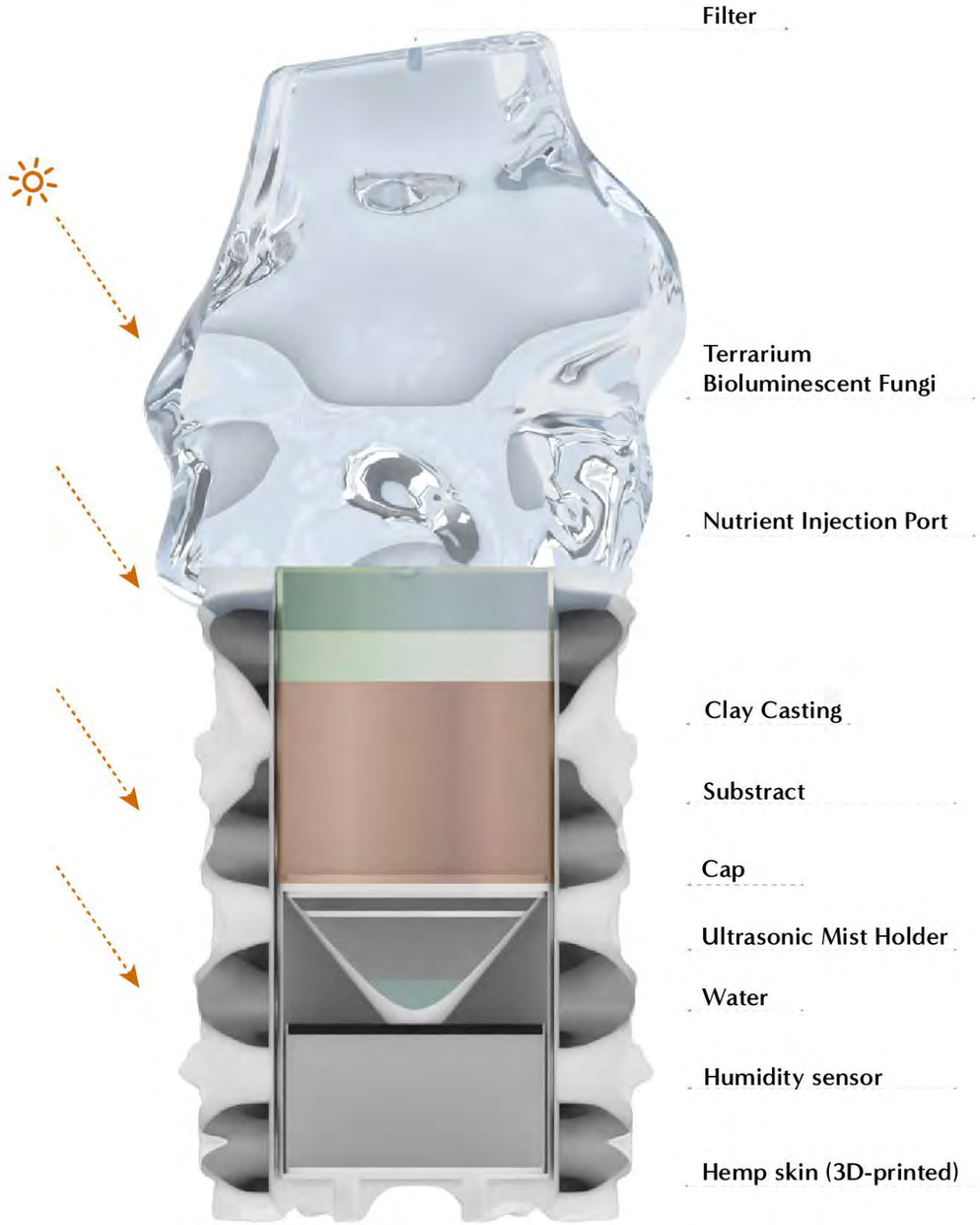
SMART CITIZEN SENSOR

I grew my fungi in two different environments. The first batch was cultivated in the biolab and kept in an incubator at 22°C. Meanwhile, the substrate cultures were taken to my home and placed in a room with a temperature of 21.3°C. To monitor environmental changes, I used the Smart Citizen sensor.

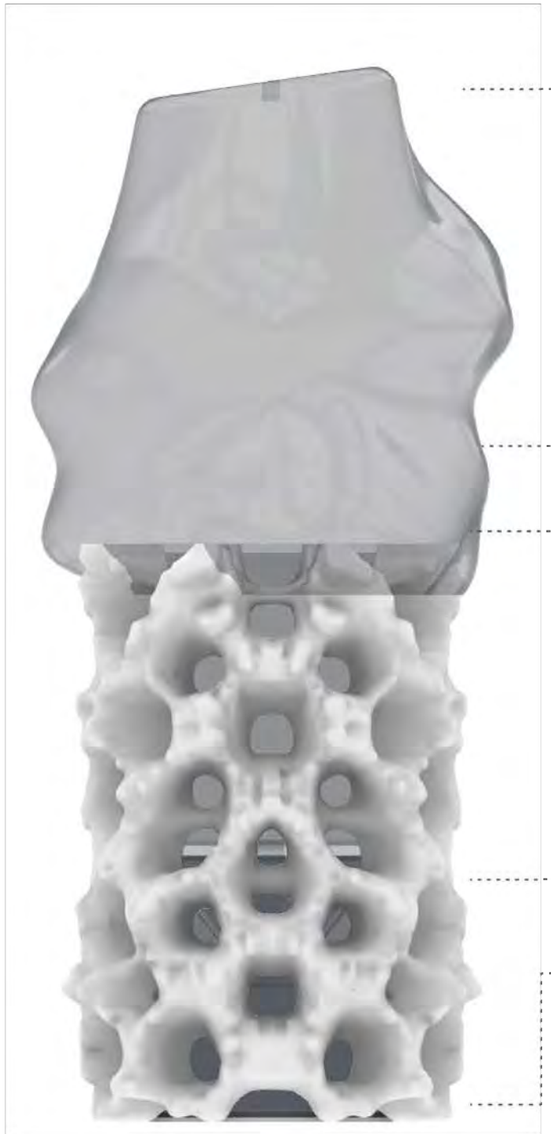
Three out of four fungus cultures grown under the environmental conditions recorded by the sensor glow in the dark.

Data: Luminico, Barcelona

This is the final terrarium design, which features an inner container for growing the fungus. The container has a cover with an injection port for nutrient input and an oxygen inlet. Inside the terrarium, I include an ultrasonic mist sensor that helps maintain humidity, while at the bottom, a Smart Citizen sensor is placed alongside a compartment for battery storage.



FUNCTIONAL DIAGRAM



Oxigen Filter

The filter allows oxygen to enter and prevents contaminants from entering.

Nutrients

A self-healing injection port was integrated into the side to insert liquid malt extract nutrients and keep the fungus alive for 3 months to a year.

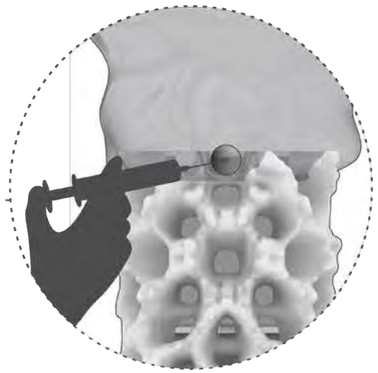
Substract + Fungi

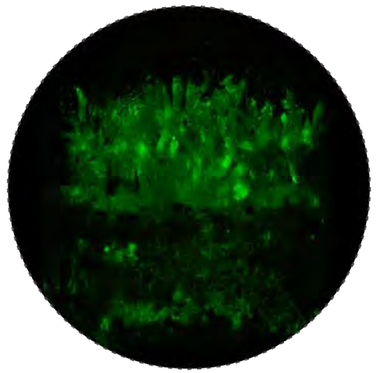
The fungus will be inoculated using a liquid culture, in 8 weeks the person will be able to perceive the bioluminescence and observe the growth of fruits.

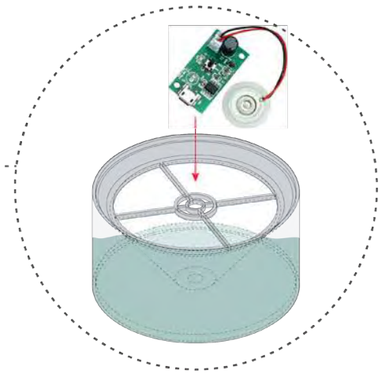
Ultrasonic Mist

Environmental Monitor Sensor

The filter located at the base of the glass helps maintain the humidity generated in the distilled water container at the base.





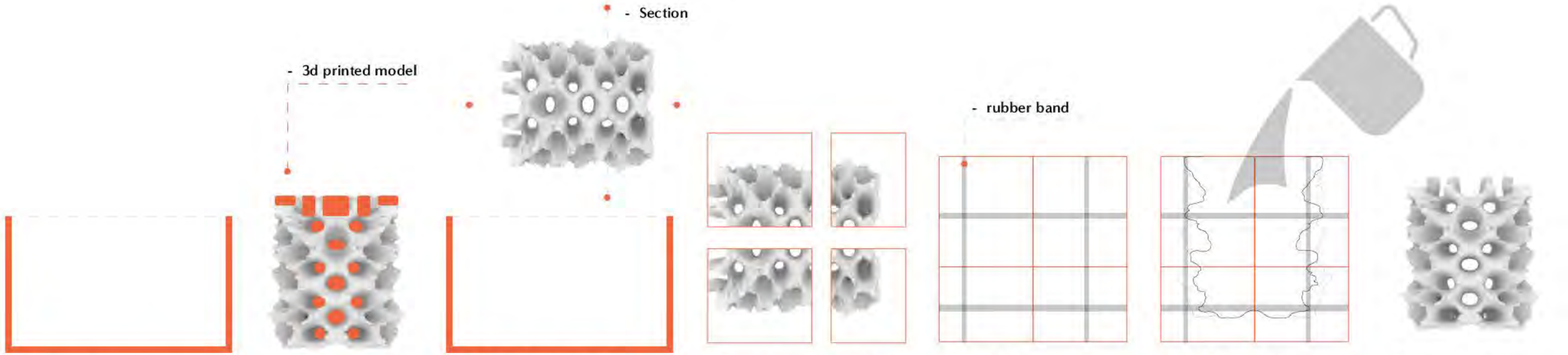


Large scale render by Germarilis Ruiz

FABRICATION

CASTING CLAY (8 part mold)

My first fabrication technique was Clay 3D printing. However, during the drying process, this piece cracked and broke into several parts. This happens when the clay has too much water. So, considering the time we had to complete the project, I decided to experiment by creating a plaster mold and pouring a slip into it. If it doesn´t work, I´ll go back to one of my initial ideas which was prints using organic waste-based filament.



- Cardboard or wood box
- Seal all the open areas with plasticine
- Place the object in the middle of the box
- Add the mixture of plaster and move to remove air bubbles
- Repeat the process for all the parts (x8)
- Wait for the mold to dry
- Join all the pieces with a rubber band
- Add the liquid clay
- Set a timer for 45 min. to 1 hour
- Remove the excedent of liquid clay
- Wait to dry
- Remove the piece
- Remove the imperfections
- Wait to dry
- Put in a Klint

Materials

- Plaster for mold (yeso)
- Water - Box (cardboard or wood)
- An object
- Petrolium Jelly
- Brush - Plastiline
- Liquid clay
- Pot to mix the plaster
- Plastic spatule

PREPARING THE MOLD

1. Make a wooden box. In my case, I used cardboard because it was what I had available. However, it´s best to use a box made of a rigid material that allows you to create a mold without imperfections.

2. With a brush, cover the piece you want to copy with a mold release agent. For this, you can use soap or Vaseline. Make sure not to leave lumps, as these will be reflected in the mold.

3. Next, place the piece you want to copy.
If you use a 3D print with perforations like the one I used, you must cover the voids with plasticine.

4. The piece should be centered in the box, but detached from the surface so that the mold has thickness.

5. To prepare the mixture, you must place two parts plaster and half part water. The proportion of water should be less than that of the plaster.
A good reference is that, for example, when you pour the plaster powder, you should see small mountains and the water below.

6. Mix quickly to eliminate lumps and pour into the box.

7. Move the mixture a little to eliminate air bubbles.

8. Wait for the mixture to dry (24h)

9. Remove the mold.

10. Repeat the process until you create all the parts.

11. Join all the parts using a rubber band. If there are open spaces in the joints, you can seal them using plasticine.
12. Then, mix slip (liquid clay) to homogenize the mixture and pour it over the mold until it fills the entire void. Wait between 45 minutes and 1 hour, and you will see that the slip begins to dry and a border begins to appear with the contour of the figure you are making. If the border is very thin, you can wait longer for it to dry.

13. Then, remove the excess material, pouring the slip into a container. Wait for the piece to dry (approx. 2 days).

14. Remove the piece from the mold.

15. With the silicone brush, smooth the lines of the mold joints.Wait for the piece to dry completely.

16. Fire the piece in an oven at the temperature indicated by the slip.

GLASSBLOWING

The technique of blown glass, known as glassblowing, is an art performed at temperatures close to 1200 degrees Celsius, commonly using borosilicate glass for its resistance and ability to be reheated and welded, which allows for modifying or adding parts to an existing piece. The process involves heating the glass, shaping it with tools like pliers and fire, and then gradually cooling it to prevent stresses that can cause breakage. The piece must have an air outlet to prevent fractures from internal pressure. The choice of the appropriate blow tube, depending on the desired size and shape, is fundamental. The pillars of this technique are precise temperature control, uniform heat distribution, gradual cooling, ensuring an air outlet, and choosing the correct tools.

After several attempts at shapes and textures, we began creating terrarium-scale pieces and adding material in different areas to enhance the reflection of bioluminescence. All the blown glass pieces were prototyped with 3 holes: oxygen, nutrients, and humidity.

GLASSBLOWING PROCESS

1. The first step in creating blown glass is to join the glass rods. For this, a solid rod and a hollow rod are used. Then, both are heated and fused, starting to rotate until a ball is formed. Once the mass is obtained, it begins to be stretched to create a channel that can be blown into. It´s important to maintain balance when stretching the glass so that the rod remains as straight as possible.

2. Next, we begin heating the centerpiece that we will be blowing. To ensure the piece heats evenly, it can be placed diagonally. When heating the piece, it´s important to have one hand above and one below, this will help create balance while heating the glass. Once the glass has an orange color, you can begin to blow.

3. To create organic shapes, you can heat certain areas more than others and blow slowly. During blowing, if the piece sags, it means it is too hot and/or the material is too thin.

4. To create holes, you can heat a significant area and then blow until you create a thin bubble of glass. You can also remove material by heating it and gently pulling it with pliers. It will depend on the size you need to create the hole.

3D PRINTING MODEL (PETG)

Bambu Lab P1S 0.4 nozzle

Plate type: Textured PEI Plate

Filament

1 Bambu PETG HF

Process: Global | Objects — Advanced

* 0.20mm Standard @BBL X1C

Quality | Strength | Speed | Support | Others

Layer height

Layer height	0.2	mm
Initial layer height	0.2	mm

Line width

Default	0.42	mm
Initial layer	0.5	mm
Outer wall	0.42	mm
Inner wall	0.45	mm
Top surface	0.42	mm
Sparse infill	0.45	mm
Internal solid infill	0.42	mm
Support	0.42	mm

Walls

Wall loops	2
Detect thin wall	☐

Top/bottom shells

Top surface pattern	Concentric
Top shell layers	5
Top shell thickness	1 mm
Bottom surface pattern	Concentric
Bottom shell layers	3
Bottom shell thickness	0 mm
Internal solid infill pattern	Concentric

Sparse infill

Sparse infill density	0 %

Advanced

Infill/Wall overlap	45 %
Infill direction	45 °

Quality | Strength | Speed | Support | Others

Support

Enable support	☑
Type	tree(auto)
Style	Default
Threshold angle	30 °
On build plate only	☐
Support critical regions only	☐
Remove small overhangs	☑

Raft

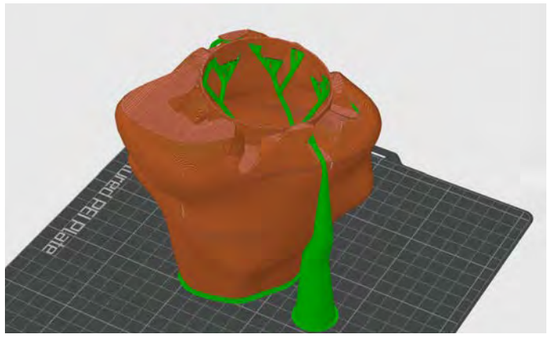
Raft layers	0 layers

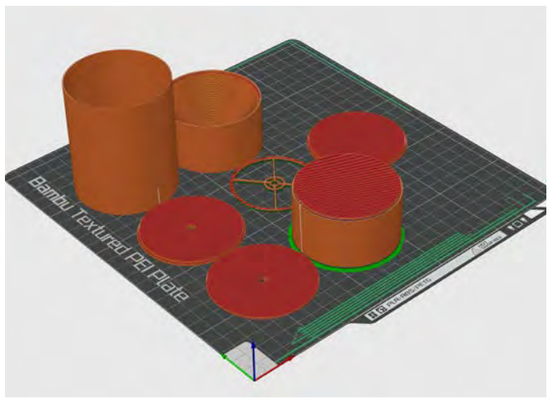
Filament for Supports

Support/raft base	Default
Support/raft interface	Default

Advanced

Initial layer expansion	2 mm
Support wall loops	0





3D PRINTING MODEL (HEMP)

Bambu PLA ORGANIC Germa — Advanced

Filament | Cooling | Setting Overrides | Advanced | Notes

Basic information

Type	PLA
Vendor	Bambu Lab
Default color	
Diameter	1.75 mm
Flow ratio	0.98
Density	1.25 g/cm³
Price	29.99 money/kg
Softening temperature	45
Recommended nozzle temperature	Min 200 °C — Max 230 °C

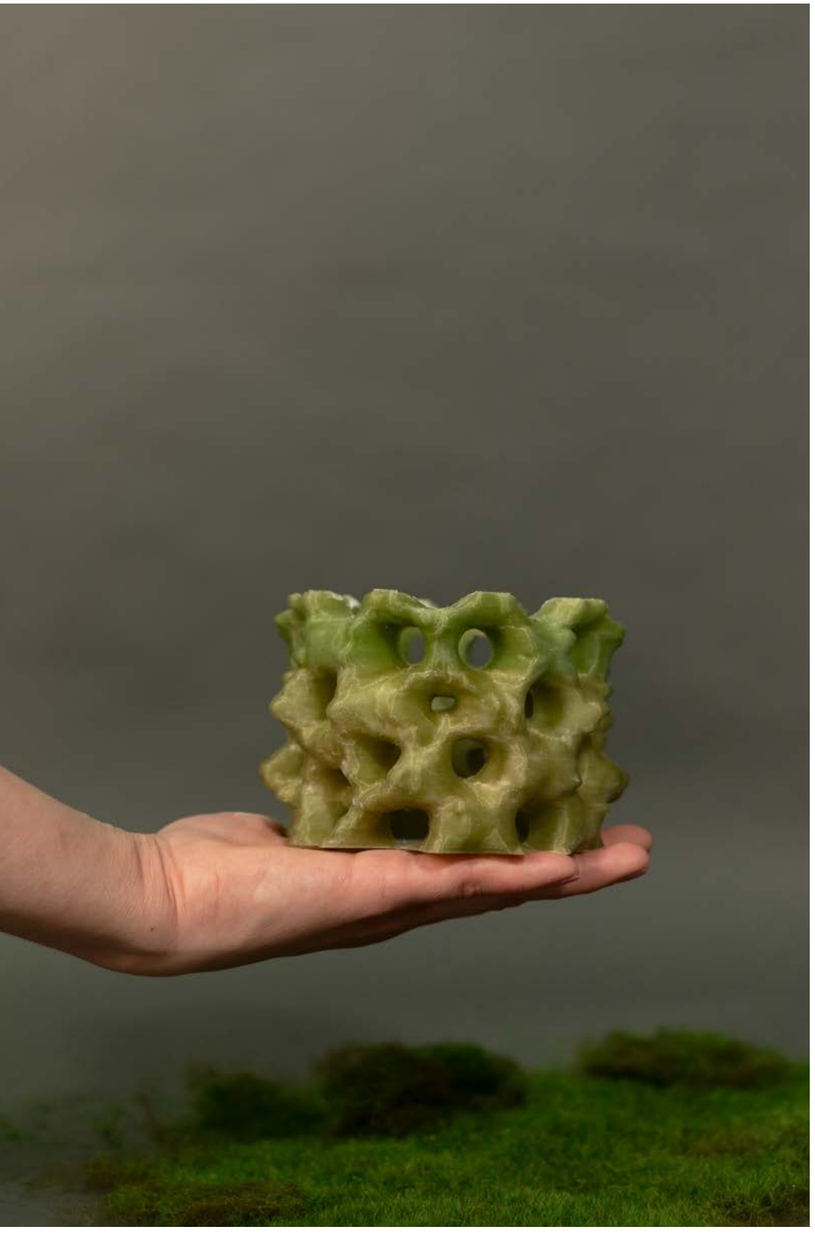
Print temperature

Nozzle	Initial layer	220 °C	Other layers	220 °C
Cool Plate / PLA Plate	Initial layer	35 °C	Other layers	35 °C
Engineering Plate	Initial layer	0 °C	Other layers	0 °C
Smooth PEI Plate / High Temp Plate	Initial layer	55 °C	Other layers	60 °C
Textured PEI Plate	Initial layer	55 °C	Other layers	55 °C

Volumetric speed limitation

Max volumetric speed	21 mm³/s

FINAL DESIGN



CONCLUSION

The goal during the development of Luminico was to understand bioluminescence, focusing on designing low-intensity lights derived from bioluminescent fungi. Through discussions with mentors, broader possibilities emerged, exploring how bioluminescence and humans could coexist in urban and domestic environments. That presented an opportunity to develop an artistic installation. This installation would allow humans to experience the bioluminescence of fungi within a living ecosystem, illustrating how to care for a living organism and parallel how pollution diminishes their glow and kills our ecosystem.

During the research process, the potential for spatial coexistence was explored, that is, how we can design solutions to mitigate the environmental impact of light pollution, in which humans play a central role in maintaining the life and bioluminescence of the fungi.

Consequently, the idea arose to transform this artistic installation into a home terrarium. The proposed terrarium, designed for a one-year lifespan in a controlled environment, requires specific lighting and water to maintain the bioluminescence of the fungi. It fosters a direct connection between humans and living organisms, connected by bioluminescence and its repercussions in the immediate context. This approach suggests a future where low-intensity lights could be replaced by bioluminescent fungi that can be cultivated at home.

The design is a lighting installation for natural environments and an interior light source. It also offers a visual representation of how the bioluminescent object interacts in the forest, showcasing how both humans and living organisms coexist.

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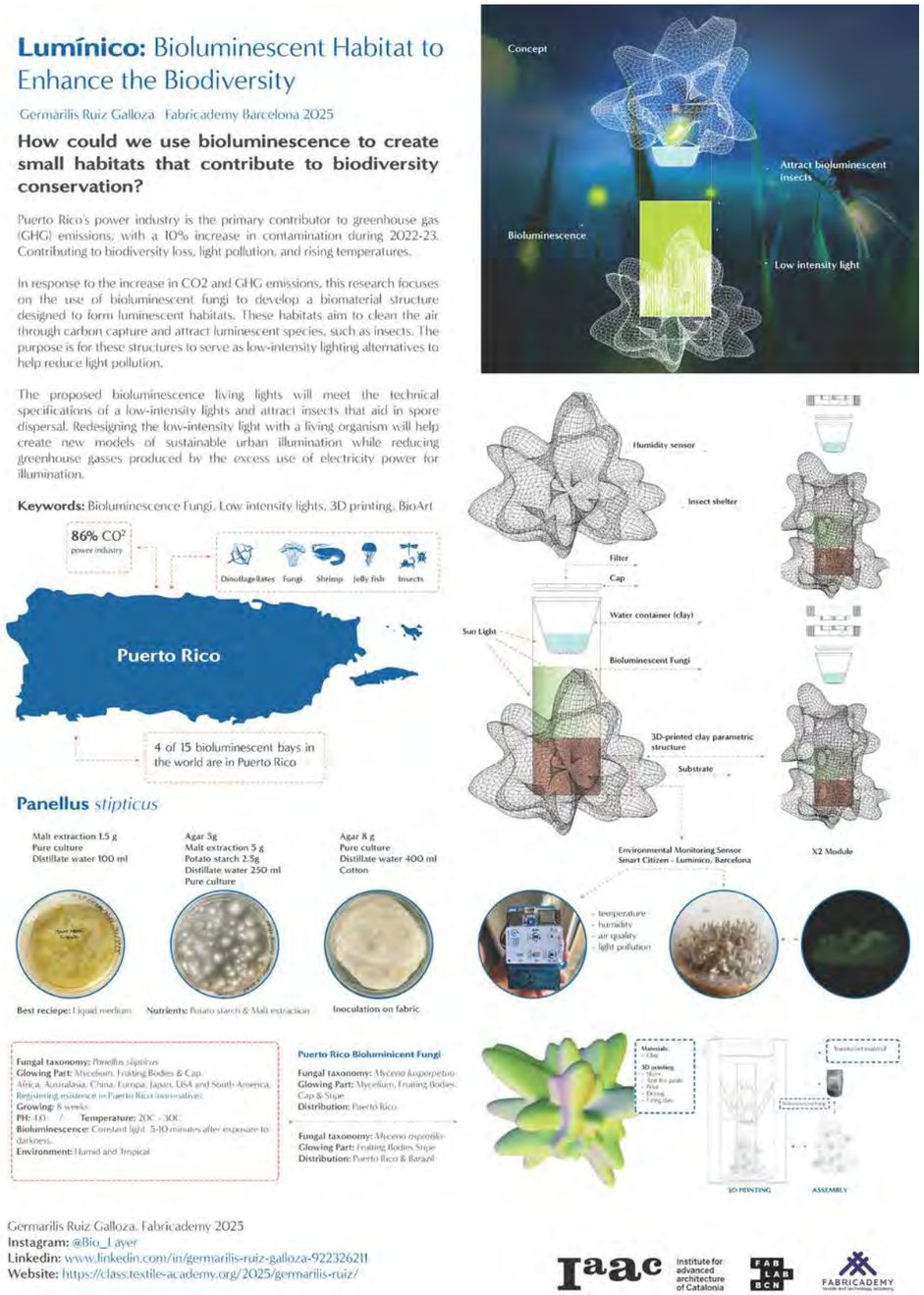

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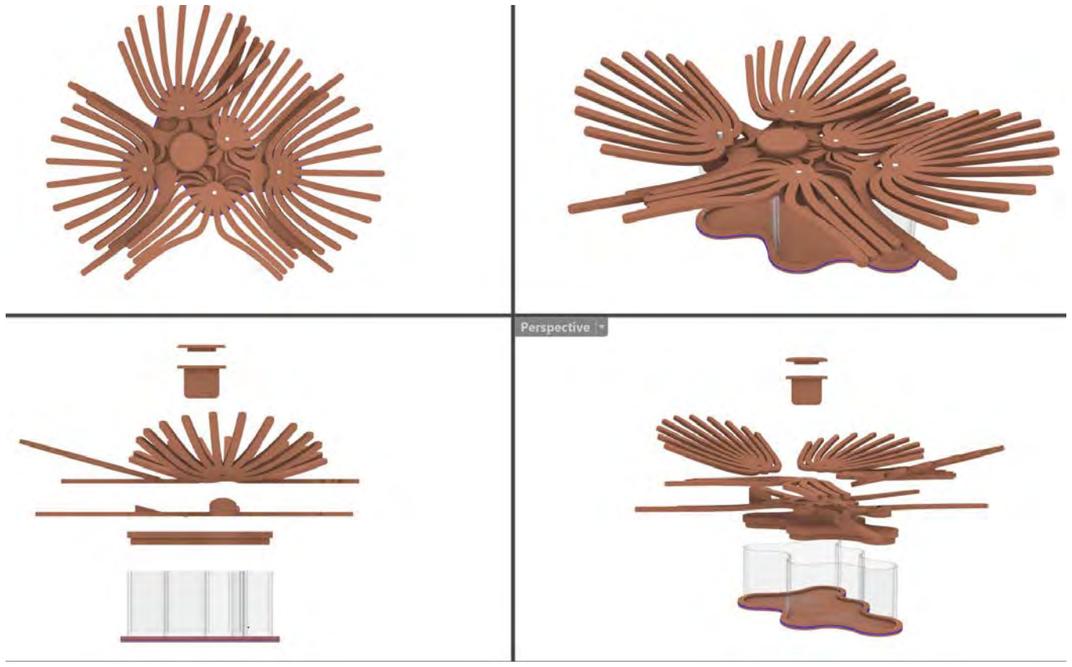

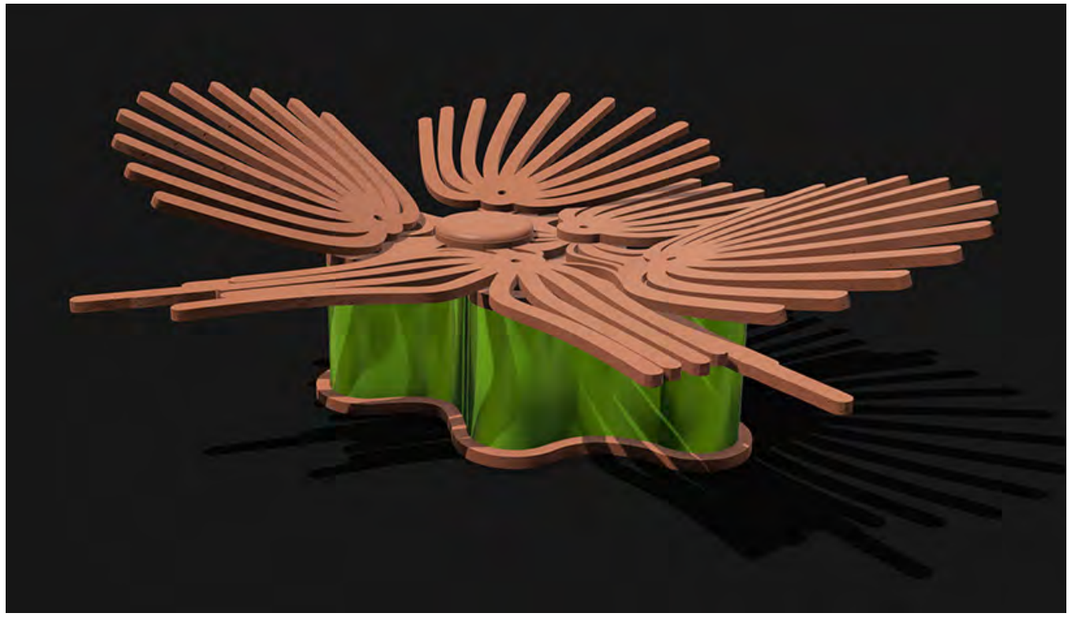

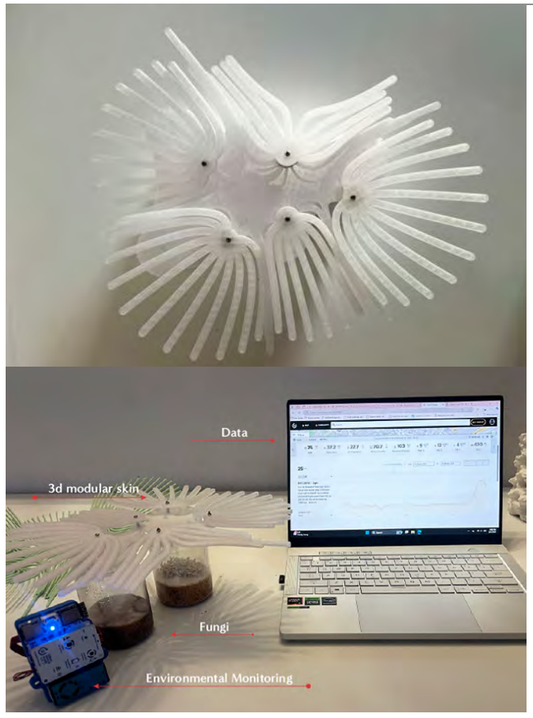

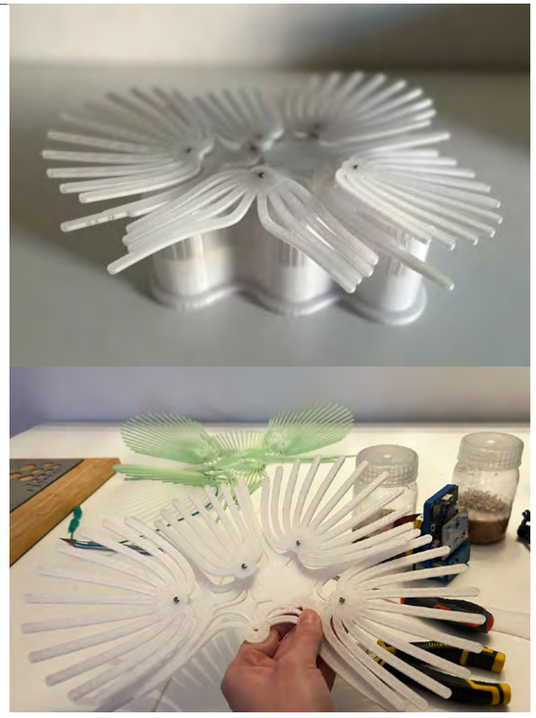

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