

*The*

# Mycelium Book

everything I learned from capstone project



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# What is mycelium...

Mycelium is the network of threads, called hyphae, from which mushrooms grow. Working much like single-celled yeast, mycelium takes in small molecules of food—typically sugar but often from sources such as wood or plant waste—by excreting enzymes that break these materials down into digestible morsels.

**As the mycelium grows it assembles a dense network of long, microscopic fibers that grow through the substrate like a superhighway system.**



# Different mycelium materials...



Typically there are 2 kinds of mycelium materials. One behaves more like hard foam or plastic, the other behaves like soft foam. And due to the limitation of techniques, my project is focused on the first kind.





## How to grow mycelium materials...

For the hard mycelium material, there are 3 steps to get the final material:

- 1) prepare the mycelium;
- 2) make the form;
- 3) dessicate the growing process.

To achieve that, substrate is needed as a media to facilitate mycelium to grow onto. As long as it is carbon-based, it can all be used as a source of substrate, such as agricultural waste, coffee grounds, cardboard box, etc.

Image from Ecovative



# Existing Applications



# Furniture







**Fashion**



# Packaging

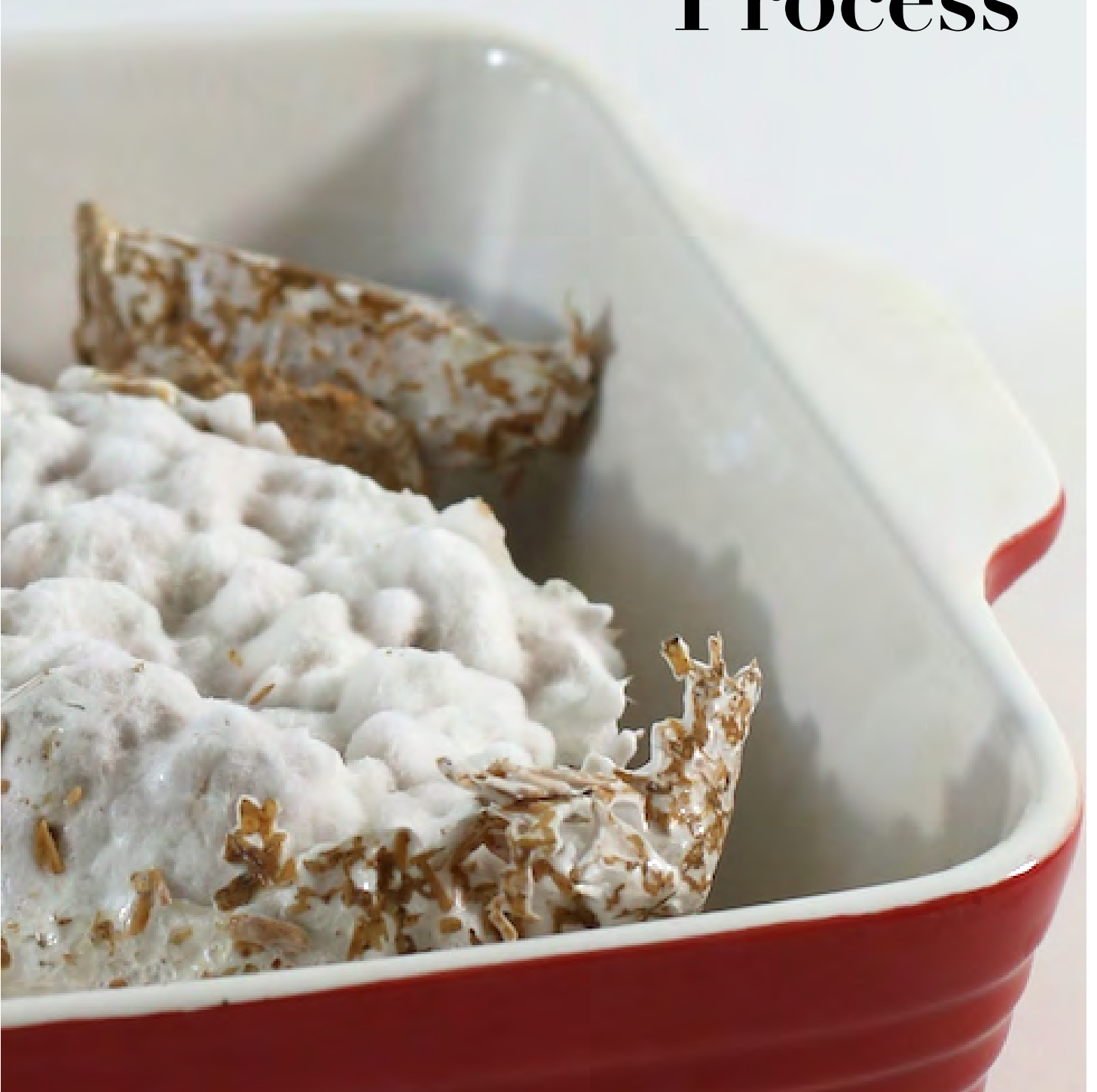


# Construction

# Others



# Growing Process



# 01. Growing from GIY Kit



## Raw Material

This is a GIY kit with premix mycelium material inside. I bought it from [grow.bio](https://grow.bio), an online shop run by Ecovative, the biggest mycelium material manufacturer in the US.

Since Ecovative starts to grow the material after customers make the purchase, so it usually takes around 1-2 weeks for you to get the material.

Also, the whole growing process takes about 10 days. So it needs a bit of time management for the whole process.

Also on their website, they have very detailed growing instruction. It's a benefit for new growers.

# Growing



- Mix certain amount of water and flour and pour inside the bag to activate the material
- Wait 5 days for it to grow



- Crumble everything into a bowl until all the particles are loose



- Add certain tablespoons of flour and thoroughly mix by hand

# Growing



- Prepare the growth form



- Fill up the form with mycelium material



- After 6 days, bake the creation in 200 F for 30 min to desiccate



I checked online for some instruction about growing mycelium from the stem of mushroom. Based on the instruction, I prepared fresh mushroom and cut the core of the stem. Then, prepare the agar base to let the mushroom grow on top to get mycelium.

I've tried 3 times without getting a successful result. All of the 3 experiments ended up with the jello of agar become liquid after couple days after mushroom stem put inside. I think it might be because of the cap makes the mushroom hard to breath, so it had anaerobic fermentation effect.

## 02. Growing from Mushroom



## 03. Growing from Mycelium Brick

Since I want to try using different substrate as my raw material, I need to grow my own mycelium source. So I tried another way to get mycelium source, to use mycelium brick. It's sold as a block with mycelium already all around the substrate. I broke a bit of the block and mix it with used coffee grounds. Then I put the mixture into baking silicone molds. And it turns into something different than the first method.



# Learnings from the result

Firstly, the side that touches the silicone mold forms a smooth white shell. And when peeled off, the inside coffee grounds will expose. It seems that the mycelium and the substrate didn't mind themselves well, instead the mycelium forms a protective case outside. Secondly, there are obvious threads-like mycelium growing from the side that is not touching the mold. Yet again, it feels more like growing on top of the substrate.

My assumption would be that compared to agricultural waste, coffee grounds are so granular, so it's hard for mycelium threads to grow around and form a network. But the shell like texture is quite interesting. If we are trying to achieve something very smooth, that might be something to explore more.

Also, a next step I want to explore is to mix mycelium block with bigger substrate, such as agricultural waste, and see what kinds of result it gets.



# Material Properties



# 01. naturally white



The mycelium material is naturally white with a texture of substrate showing.

## 02. different finishing



The side where it touches the growth form has a smoother surface than the open-up side.

## 03. light weight



It's super light weight, only approximately 1/8 the weight of the same amount of water.

## 04. hydrophobic & bouyant





# 05. absorb oil and hot wax





I tried different ways to dye the material. For example, I used colored water to revive the mycelium. I also put the block in colored water afterwards. Yet, the material cannot be dyed in traditional ways.



## 06. hard to dye



## 07. easy to paint

I used different pens to draw on top.  
They all show up the color very well.  
And I can also spray paint it.

## 08. pressure & shock resistant

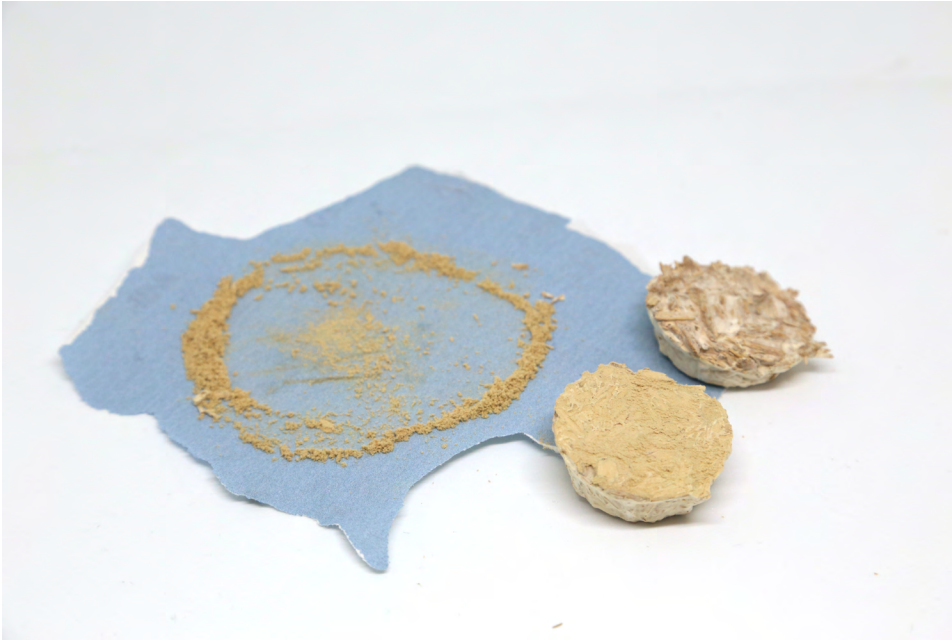


When I put heavy staff on top, or step onto it, it can resist pressure and shock well.

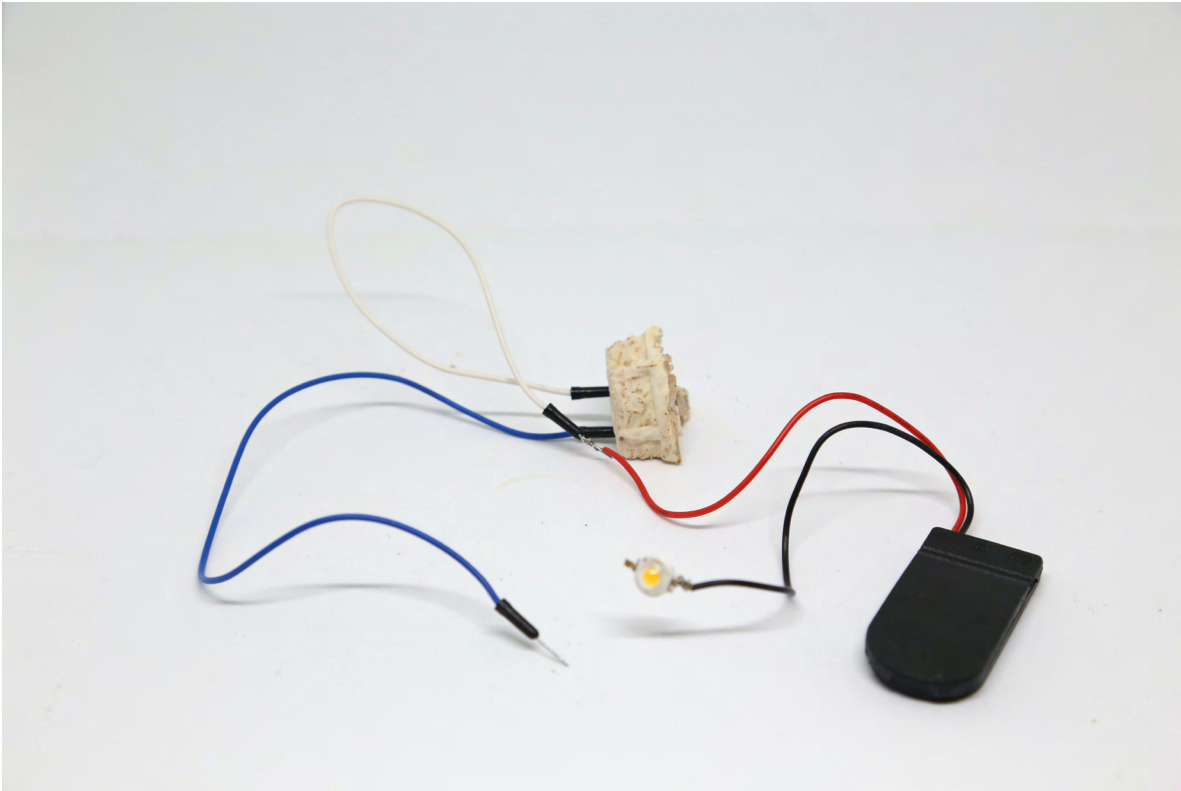
## 09. versatile in shape



It will grow into whatever shapes the material is put into.



## 10. MDF-like texture



**11. not conductive**



**12. electromagnetic field  
goes through**





**13. insulator & fire resistant**



## 14. bind carbon-based material

Based on the way mycelium grows, if put a carbon based bridge in between two blocks of substrate, they will be connected together. Similarly, if put new substrate on top of an old block and let it grow, they will bind together.

# Benefits & Limitation



flax



Hemp



Corn



## waste to assets

Agricultural waste is widely used as the substrate of the material, such as the stalk of flax, hemp and corn. Since almost every country grows its own crops, we could say the raw materials is super easy to get.



## good for all stakeholders

Using hemp as an example, industrial hemp absorbs 3 times more CO<sub>2</sub> than forests. So using mycelium as the material is both good for the environment as well as empowering local farmers.

# everything about bad mold

Starting from the second half of my project, I started to notice bad mold growing in my mycelium everytime I grow. I tried to sanitize the working surface thoroughly and use rubbing alcohol to clean every surface that could be in contact with the material, and it didn't help.



## possible reasons for mold

The first reason could be that I used my meat grinder to grind up the substrate, trying to see how a smaller substrate grows. Possibly the grinder was not cleaned up thoroughly.

Another reason might be a rotten lemon in my fridge. Since I bought two packages of materials together, and everytime I only use 1/4 of the material, I put the rest in the fridge as instructed. Yet I found a tiny piece of rotten lemon from the corner of my fridge. Based on the discussion online, this green mold is cross-contaminated, so once appeared in the environment, it's really hard to avoid.

So next time, I shall buy all new tools and a specific fridge for materials.



# learnings from remaking apple packaging from mycelium materials

1) Even though the material is versatile in shape, it still has thickness limitation in regards to the size of the substrate. If the structure is too thin, substrate might not be able to fill in.



2) After the material is dry thoroughly, there is about 1.5% shrinkage length-wise. So my first attempt was not big enough for iPhone to be put in.







3) Based on an online video from Myco, a company making mycelium leather, if we take out the mycelium material after 4 days of growing and put it directly in the environment, it should get a little bit more of a velvet-ish finishing. Yet, it is not the case in my experiment. Also, this material grows better if put in a plastic mold, based on my the whole term experiments.



4) If the material is too thin, it will bent after oompletely dry, no matter whether it is air-dry or oven-dry.



## If we make the iPhone packaging with mycelium materials, then...

### Benefits

- Light weight, less carbon footprint during shipping
- Provides protection similar to foam
- Fully compostable within 30 days
- No new materials needed, only use agriculture waste as raw material
- Simple manufacturing process, less in-between steps and manufacturing waste

### Limitations

- Limited amount of color and finishing
- Limitation for thickness and square edges
- Relatively slow in the growing process
- High sanitary requirements for the manufacturing environment



## Looking into the industry

- For mold making, the industry is using rPET, since it's a material that can be recycled and reused again and again.
- The furniture industry is using heat pressing techniques to strengthen the mycelium board as well as desiccate it. It's an opportunity to use heat pressing to achieve more detailed and stronger structure for packaging.



## Useful materials

1) How to grow from GIY kit

- <https://grow.bio>

2) How to grow from spawn

- <https://www.instructables.com/Grow-Architectural-Models-with-Mushrooms/>
- <https://www.youtube.com/watch?v=c6nurN-Hii8>
- <https://www.instructables.com/Mycelial-Forms/>

3) How to prepare agar or gelatin substitution

- <https://soeasilydistracted.com/backyard/homemade-agar-using-rice-water-and-gelatin-to-grow-oyster-mushroom-spawn/>

*Have Fun!*

