MYCELIUM LEATHER

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Fablab Reykjavik

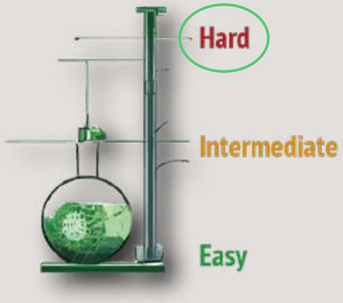
Make leather like material with mycelium

Timeline

Days

1-2 weeks: mycelium growth

1month: mycelium leather growth and harvest process



1|ABOUT

1.1| Context

Mycelium is the fungus that produces mushrooms. Think of the Mycelium as the roots and building blocks of the mushroom. The mycelium can grow on many different organic materials called substrates including wood chips, corn stalks, hemp and also liquid substrates as will be used in this module. The mycelium feeds on the substrate and grows a web-like material that by time thickens. The web-like mycelium can then be processed into a sheet of leather like material (Raman et al., 2022).

Mycelium leather has advantages over animal and synthetic leathers. It's biodegradable, has a lower environmental footprint, and doesn't rely on livestock or fossil fuels, making it a promising choice for eco-conscious products. It can be grown and manipulated to create various textures and thicknesses, offering versatility for fashion and design applications. Mycelium leather is being used in fashion, furniture, and accessories. Brands are increasingly incorporating it into their collections, highlighting its potential as a sustainable material (Faunalytics (2023).

Mycelium in jar

1.2|What is the Module?

The outcome of the module is to teach you how to make mycelium leather. The leather can be grown in different sized glass jars depending on desired future use.

1.3|What is the Organism

Mycelium is a tubelike structure that is fungi. The mycelium grows under the ground in vast networks connecting different plants and fungi. As it grows it can also form into structures like mushrooms. Mycelium eats organic materials by breaking the material down externally into carbohydrates and proteins that are absorbed through the wall. For this module, the mycelium being used will be the mycelium of edible mushrooms as it is safe and readily available.

The Reishi mushroom is also known as Ganoderma lucidum. For centuries, Reishi has been the go-to for natural healers in Asia and has recently taken the biohacking community by storm, probably because it's like the WiFi of well-being—once you experience it, you wonder how you ever lived without it. Reishi mycelium has a lazy side and is known as the sloths of the fungi kingdom as they take a long time to grow (Näckrosgården - Reishi Mushroom Growkit, n.d.).

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.fiberjournal.com%2Fmycelium-fibers-of-the-future%2F&psig=AOvVaw2h1hivOi852b2Kh8trjWnO&ust=1732654726230000&source=images&cd=vfe&opi=89978449&ved=0CBcQjhxqFwoTCNDx_oGw-IkDFQAAAAAdAAAAABAE

1.4|Explain the Process

The process takes time, as cultivating the mycelium requires patience both on the petri dish and later in the jar. Reishi mycelium is slow-growing, so patience is essential for this module. By cultivating mycelium under controlled conditions, it can be shaped and processed into sheets that resemble traditional leather in both texture and appearance.

To start cultivating mycelium for leather, use a small sample from a Reishi mushroom grow kit and cultivate it on a petri dish containing malt extract agar. From the petri dish, transfer a piece to a glass jar prepped with liquid growth medium. Maintain a temperature of 25–30°C in a dark area to promote faster growth. Under these conditions, the mycelium can take up to 30 days to reach the desired thickness, typically around 1 cm. Once thick enough, compress the mycelium into sheets using a heat press, which will kill the mycelium to prevent further growth. Finally, tan and finish the sheets with a glycerol bath and beeswax to make the material durable, flexible, and visually similar to leather.

TIP!

•Be patient! Reishi mycelium grows slowly, so give it time to develop.
•Ensure optimal conditions.

Mycelium in jar

HEALTH AND SAFETY

BSL-1

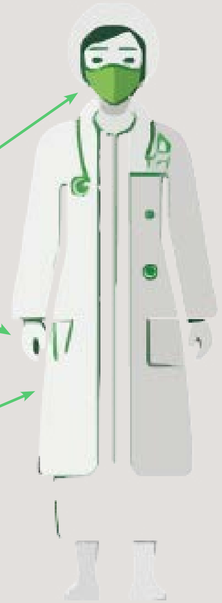
For work involving BSL-1 organisms, such as non-harmful bacteria, a sterile lab is not strictly necessary, but a clean and controlled workspace is essential. You can conduct these activities in a well-maintained studio or similar environment outside of a traditional laboratory, provided the space is organised and protocols are in place to minimise contamination and ensure safety. Ensure that surfaces are disinfected before and after work, and avoid areas where food is prepared or consumed. Additionally, restrict access to the workspace during experiments to avoid unintentional exposure or contamination of materials.

SPACE

•Lab environment
(bioFABLAB, biology classrooom or a very clean kitchen canbe use

•Access restrictions
(guests can bring new contaminants)

STYLE



•Glove up
(witch clean hand)

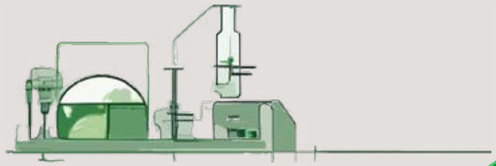
•Mask up
(nose and mouth)

•Dress up
(like a pro)

STERILISE

•Ingredients
(keep ingredients in closed containers)

•Tools
(clean all tools)



•Tables
(clean all surfaces and workbenches)

CHECK BOX

INGREDIENTS
- ☐ Agar Agar
- ☐ 4 gr malt extract
- ☐ 2 gr yeast or 6 gr honey
- ☐ 300 ml distilled water

30% glycerol bath
- ☐ 150 ml glycerol
- ☐ 250 ml water

melted bee's wax
- ☐ 5 gr bee's wax

SPACE AND EQUIPMENT (KITCHEN AREA)
- ☐ Clean table
- ☐ Pressure cooker + kitchen stove or autoclave
- ☐ Sink with tap
- ☐ Camping gas stove
- ☐ Heat press 150°C
- ☐ Dehydrator
- ☐ Incubator (option 1)
- ☐ Heat mat (option 2)

TOOLS
- ☐ Kitchen scale
- ☐ Measuring cup / beaker
- ☐ Spoon
- ☐ Parchments paper
- ☐ Aluminum foil
- ☐ Scalpel
- ☐ Hammer and 5mm drill
- ☐ Micropore tape

HEALTH AND SAFETY EQUIPMENT
- ☐ 70% ethanol
- ☐ Face mask

DESIGN CASING (CONTAINMENT)
- ☐ Glass jar of any size with metallic lid
- ☐ Cotton kitchen towel

STERILISE ALL CASING EQUIPMENT THOROUGHLY

Timeplan

Day 1: Autoclave liquid medium and incubate with mycelium from petri dish
Days 2 - 30: Monitor growth.
Day 30+: Harvest the mycelium, heat press and put into glycerol bath overnight
Day after: Coat with bee's wax and heat press

Prep Nutrients
1-Prep metallic lid with 5mm hole and cover with micropore tape on both sides
2-Mix ingredients in the jar and close with metallic lid
3-Cover lid with aluminium foil
4-Autoclave for 1 hour and let cool down to room temperature

Prep mycelium incubation
1-Sterilise table with isopropanol
2-Put on mask and turn on gas stove on the table for 3 minutes to create a sterile bubble
3-Place petri dish and jar near the gas stove
4-Sterilise scalpel and cool and cut 1 cm mycelium from petri dish
5-Inoculate the jar with mycelium piece
6-Close jar with metallic lid
7-Turn of gas stove

Grow mycelium
1-Place in incubator 30°C for 30+ days
2-Monitor growth regularly

Harvest mycelium
1-Remove from growth media by using clean scalpel
2-Turn on heat press for 150°C
3-Heat press between two sheets of parchment paper 3x for 20 sec
4-Prepare 30% glycerol bath
5-Soak mycelium in glycerol bath overnight (12 hours)

Harvest and Dry
1-Take mycelium out of glycerol bath and damp with tissue for extra liquid
2-Place in dehydrator 35°c for 8 hours (if on baking sheet flip mycelium after 4 hours

Process SCOBY
1-Melt bee's wax
2-Cover mycelium with bee's wax using a pencil
3-Heat press 3x 20 sex, 150°c

TIP!

STERILIZE: Always sterilise tools and surfaces, then handle all ingredients with clean hands

No direct sunlight: Make sure to grow the SCOBY out of direct sunlight, as the UV light kills the bacteria in the culture.

OVEN DRYING: You can dry the material faster in an oven or drying cabinet. At 35°c the material can be dried in 24 hours.

SHRINKAGE: Note that warmer and faster drying generates more shrinkage. Uneven texture generally creates uneven surface.

OBSERVE: Always keep an eye on the mycelium during the growth and drying process, check for contamination.

WATERPROOF: Coat with bee's wax to waterproof the fabric.

2|SETTING UP (Sourcing)

2.1|Sourcing Living Organism/main material

There are many ways to get mycelium, and most local garden stores sell “grow-your-own” mushroom kits. Choosing the right kit can help speed up growth and improve success. Most kits come as either dehydrated pouches or mycelium in a substrate. The Reishi mushroom is great for making mycelium leather because its fine strands create a smoother texture. Although growing your own kit can be expensive, it can be used effectively. To start, place a small piece of mycelium from the kit on a petri dish—this will be the base for cultivating more mycelium. The rest of the kit can continue to produce mushrooms while additional mycelium is cultivated for future projects.

For this module, the Reishi mushroom mycelium was purchased from Näkros Gården, a Finnish “grow your own” mushroom kit, with good results. https://nackrosgarden.com/collections/mushroom-grow-kits/products/reishi-growkit

2.2|Sourcing the Growth Media

The most challenging part of this project is sourcing the mycelium. The other ingredients should be easier to obtain.

Growth Media
Two types of growth media are required for this module: one for the petri dish to cultivate the mycelium and another for the liquid growth media to grow mycelium leather.

Additionally, ingredients for processing mycelium leather are necessary and listed below. All items can typically be found in online stores like Amazon or at local stores, pharmacies, hardware stores, or brewing supply shops.

Ingredient List
- Reishi mycelium
- Agar
- Malt extract
- Yeast extract
- Glycerol
- Bee’s wax
- Isopropanol

2.3|Spatial Requirements

Generally, a laboratory setting is best for the project, but not strictly required. Make sure to keep the workspace clean and equipment and ingredients nearby.

Making a Sterile Zone
A sterile area is needed when introducing the mycelium to the petri dish and the jar. Be sure that the air is as still as possible, windows closed and if possible put on a mask so to stop breath breaking the sterile zone. Below are instructions on creating a Sterile Zone with an open flame.

1-Clean all glassware with 70% or more isopropyl alcohol solution and let dry.
2-Clean the surface with 70% or more isopropyl alcohol solution and let dry.
3-Place a camping stove or bunsen burner in the area where a sterile zone is needed.
4-Light the flame and wait 3 minutes
This method will create a sterile zone in a radius of approximately 10- 70 cm to work by. (Seyfried & Czjzek, 2013).

Growth conditions
For the mycelium to grow optimally the growth must be kept slightly above room temperature, around 25-30 degrees °C and in a dark place. The inside of an incubator is the most comfortable, but a cabinet near a heating source will suffice and research having a thermometer near the mycelium is smart. Just make sure that you are monitoring the growth every couple of days.

TIP!

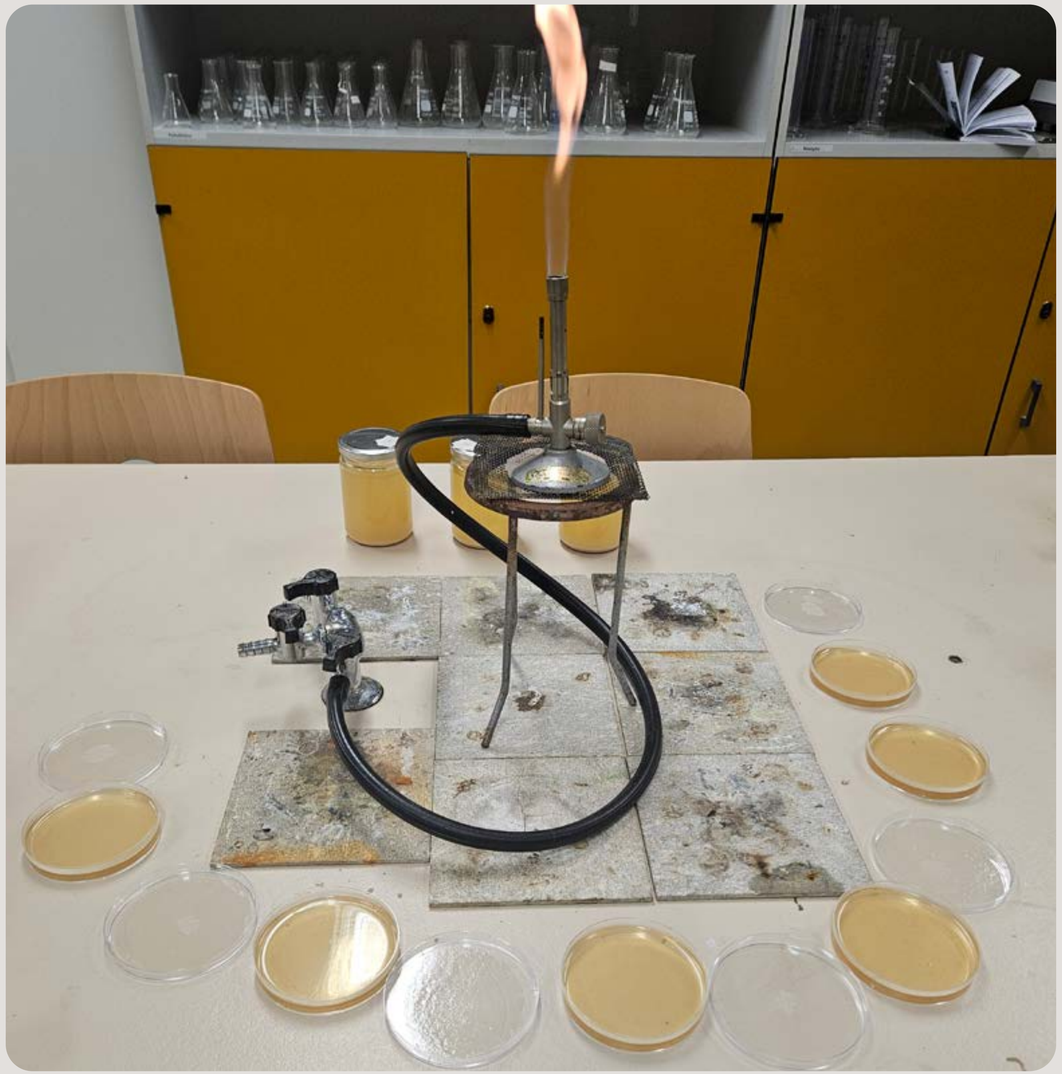
•Use extreme caution when using an open flame and be sure to have a fire extinguisher nearby. No not spray Isopropanol near an open flame and keep it out of safe distance from the fire.

2.4|Tools and Equipment

Tools
- [ ] Hammer
- [ ] 5 mm Drill
- [ ] Scalpel

Equipment
- [ ] Autoclave or pressure cooker
- [ ] Pressure cooker minimum: xx kPa and xx degrees C.
- [ ] Refrigerator
- [ ] Bunsen burner or camping stove
- [ ] Dehydrator or oven
- [ ] Incubator (optional)
- [ ] Heat press

General Supplies
- [ ] Autoclavable Bags
- [ ] Mask
- [ ] Lab coat
- [ ] Isopropyl Alcohol
- [ ] Glass jar of any size with metallic lid
- [ ] Kitchen scale
- [ ] Measuring cup
- [ ] Measuring Spoons
- [ ] Cotton kitchen towel
- [ ] 70% ethanol (for disinfecting)
- [ ] Petri dish
- [ ] Micropore tape
- [ ] Aluminium foil



Tools

3|PREP (You are in the lab)

3.1|Prep Recipe

Cultivation in agar plates and the incubation period will take a total of 2 weeks. Below are the instructions to make the growth medium and transfer the culture.

Tools
- ☐ Scalpel

Equipment
- ☐ Autoclave or pressure cooker
  - •Pressure cooker minimum: xx kPa and xx degrees C.
- ☐ Refrigerator
- Bunsen burner or camping stove
- Incubator (optional)

General Supplies
- ☐ Mask + Lab coat
- ☐ Isopropyl Alcohol
- ☐ Kitchen scale
- ☐ Measuring cup and spoons
- ☐ Glass bottle with blue cap
- ☐ Petri dishes
- ☐ Micropore tape
- ☐ Aluminium foil

Recipe for malt extract agar

•200ml Distilled water
•4g Agar
•4g Malt extract
•0.5g Charcoal (optional)
This recipe is suitable for cultivating most mushroom strains, including Reishi mycelium.

3.2|Make Growth Medium

Start the process by preparing a nutrient growth medium for her to grow in.

1-Prepare the Nutrient Mix: Combine all ingredients in a jar or blue-capped bottle. Loosen the lid and sterilise the mixture in an autoclave or pressure cooker for 15 minutes. (if no lid is available use aluminium foil to cover jar/bottle)
2-Disinfect the Workspace: Clean your workspace thoroughly with 70% isopropanol, then place the bottle away from the Bunsen burner which is place in the middle of workspace
3-Cool the Nutrient Agar: Allow the nutrient agar mix to cool until the bottle is comfortable to hold but the agar is still liquid. Light the Bunsen burner and let it burn for 3 minutes to create a sterile zone.
4-Pour the Agar into Petri Dishes: When pouring the agar mix, open each petri dish lid just enough to pour, keeping the lid tilted down to prevent contamination. This step helps avoid dirt entering the petri dish and reduces the risk of mould.
Culture Transfer
5-Transfer Mycelium: Once the agar in the petri dishes has solidified, work within the sterilised area. Flame-sterilise a scalpel until red-hot, then allow it to cool in the sterile zone. Carefully slice a small piece from the Reishi mushroom kit and transfer it to the fresh plate. Repeat 2-3 times for each plate if desired.
6-Seal and Label the Plates: Seal each plate with micro-pore tape or parafilm, and label them with the date, mushroom strain, and type of media. The plates are now ready for incubation.
7-Incubate the Plates: Place the plates in an incubator or a dark area at 25–30°C, monitoring them carefully for signs of mould. Allow enough time for the petri dish to fully colonise before moving on to the next step, which involves transferring the mycelium into a glass jar with a liquid growth medium.

TIP!

•If mould starts to form, repeat the steps to prepare the petri dish. Select a clean piece from the original petri dish, [illegible]ing any mouldy areas, and [illegible]sfer it to a new dish.

Recipe from Jessica Dias S-BIOTICA // BIOBABES

4|GROWTH/MAKE/TRANSFORMING/APPLY ETC.

4.1|Growth Conditions

Reishi Mycelium grows best in a dark incubator at 25-30°C. The reishi strain is slow growing so each growth step may take some time, both for cultivating petri dish and glass jar.

4.2|The Process

This section will provide instructions on how to transfer a piece of mycelium from petri dish to glass jars

Incubation period - 4 weeks

Tools
- ☐ Hammer
- ☐ 5 mm Drill
- ☐ Scalpel

Equipment
- ☐ Autoclave or pressure cooker
- ☐ Pressure cooker minimum: xx kPa and xx degrees C.
- ☐ Refrigerator
- ☐ Bunsen burner or camping stove
- ☐ Incubator (optional)

Supplies
- ☐ Mask + Lab coat
- ☐ Isopropyl Alcohol
- ☐ Glass jar of any size with metallic lid
- ☐ Kitchen scale
- ☐ Measuring cup and spoons
- ☐ Micropore tape
- ☐ Aluminium foil

Recipe for Liquid Growth medium

•4 gr Malt extract
•2 gr yeast or 6 gr honey
•300 ml distilled water tap water is also fine

1-Prepare the Jar: Use a metallic lid with a 5mm hole and cover it with micropore tape on both sides. Mix the ingredients in the jar, then close it with the lid and cover the entire jar with aluminium foil to prevent the filter from getting wet.
2-Sterilise the Jar: Sterilise the jar in a pressure cooker or autoclave for 1 hour, then allow it to cool to room temperature.
3-Set Up a Sterile Workspace: Clean your work area with ethanol or isopropanol. Place a camping gas stove in the centre of the area and let it burn for 3 minutes to create a sterile zone.
4-Transfer Mycelium: Sterilise a scalpel in the flame. Before cutting, dip the scalpel into an area of agar that you won't be cutting. Cut a piece of mycelium approximately 1 cm from the petri dish and inoculate the jar with it.
5-Incubate: Incubate the jar at 30°C for approximately 30 days, or until the surface shows thick mycelium growth.

Recipe from Annah-Ololade Sangosanya project, The Purhyphae Prjocet

Cut a piece of mycelium approximately 1 cm from the petri dish

5|HARVESTING

5.2|Harvesting mycelium

Harvesting mycelium and post processing will take 2 days

Tools
- ☐ Hammer

Equipment
- ☐ Dehydrator or oven
- ☐ Heat press

General Supplies
- ☐ Isopropyl Alcohol
- ☐ Kitchen scale
- ☐ Measuring cup
- ☐ Cotton kitchen towel
- ☐ 70% ethanol (for disinfecting)
- ☐ Petri dish
- ☐ Baking paper

•Grown mycelium in Jar
•Scalpel
•Dish to put mycelium on
•Glycerol bath
•Bee's wax
•Baking paper

1-Remove from Incubator: Once the mycelium has reached the desired thickness, take the jar out of the incubator.
2-Detach Mycelium: Open the jar and use a clean scalpel to gently release the mycelium from the walls. Dipping one end into the liquid can help the other end pop up for easier handling.
3-Heat Press: Heat press the mycelium three times for 20 seconds each at 150°C. For the first press, do so slowly, and have parchment paper and tissue ready to absorb any excess liquid.
4-Glycerol Bath: Place the mycelium into a 30% glycerol bath for 12 to 24 hours (overnight).
5-Dry the Mycelium: After soaking, remove the mycelium from the bath and gently blot off excess liquid with tissue. Then, place it in a dehydrator set to 35°C for 8 hours.
6-Coat with Beeswax: Coat the mycelium with melted beeswax on both sides. Finally, heat press it three times for 20 seconds each at 150°C to ensure an even coating.

Recipe for glycerol bath

•150 gr Glycerol
•250 gr water

TIP!

• After removing the mycelium from the jar, any leftover mycelium on the walls can be collected and reintroduced to the liquid medium for further incubation. A second growth may begin to appear within a few days.

things neededpetri dish

jar with leftover growthpetri dish

6|DISPOSAL

The mycelium being used in the module should be food-safe and non-toxic. Meaning that it can be disposed of in the biowaste or residential waste. There are other things to consider when disposing of mycelium.

Planting
Any living mycelium can be disposed of by “planting” it. Once planted edible mushrooms may grow. Make sure that the species of mushroom exists in your country before planting.

Moulded
Any moulded mycelium should be disposed of in full. Mould can cause allergic reactions. Also, it is likely that the mould has “infected” the entire bag of mycelium. To ensure no spreading of the mould the material can be autoclaved on a dry discard setting.

Mycelium Leather

7|REPLICATION (CONTINUE THE PROCESS, OPTIONAL)

To maintain a healthy mycelium culture, it is advisable to replicate the preparation recipe for petri dishes by inoculating them with mycelium from previous dishes. If there is limited time for replication, refrigerating the mycelium can help slow the growth process.

As mentioned in section 5, leftover mycelium can be reintroduced to the liquid medium for the next batch of mycelium leather. Alternatively, replicating the process described in section 4 using jars of different sizes can be beneficial for research purposes.

mycelium leather replication

8|FAB TECHNIQUES

8.1|Fabrication Tools

Using mycelium leather for laser cutting opens up new possibilities for sustainable design. The natural variation in thickness is something to watch for, as it could affect the laser's performance—thicker leather pieces might need adjustments for a clean cut.
For creating larger pieces from smaller, container-grown sections, you can use modular patterns that fit together seamlessly.

The modular patterns used to achieve this outcome are designed by Laetitia Thomas and are available on the Open Source Circular Fashion website. Additional open-source patterns can also be found on the site.

Suggested laser cut setting on an Epilog Mini 40 laser

- Vector
- Speed: 60
- Power: 100
- Frequency: 500

Raster

- Speed: 100
- Power: 65

Sewing by hand

9|GET INSPIRED

9.1|What has been done?

Mycoworks

MycoWorks is an innovative biotechnology company specialising in creating mycelium-based materials, particularly their flagship product, Reishi™, a sustainable alternative to leather. MycoWorks combines advanced mycelium growth techniques with custom engineering to produce a material that closely resembles traditional leather in texture, strength, and durability. They have developed a patented Fine Mycelium™ process that grows mycelium in a controlled way, allowing for precise control over thickness, texture, and other material properties, which makes it suitable for high-end fashion and luxury items.

MycoWorks has made a name for itself with Reishi™ mycelium leather, particularly through collaborations that show off how versatile and high-quality this eco-friendly material can be. One of the most famous projects is their partnership with Hermès, where they used Reishi™ to make the “Victoria” bag. This was a big deal because it combined the brand’s luxury feel with a sustainable material that’s grown instead of sourced from animals. (MycoWorks, 2022).

From Hahn & Hahn, 2021
Hahn, J., & Hahn, J. (2021, July 9). Hermès creates mycelium version of its classic leather Victoria bag. Dezeen. https://www.dezeen.com/2021/03/18/hermes-mycelium-leather-victoria-bag-mycoworks/

Reishi™

They've also teamed up with designer Nick Fouquet, who used Reishi™ in a limited-edition hat collection. Fouquet's hats highlight Reishi's natural look and feel, proving it can be just as stylish and durable as leather. These projects show that Reishi™ isn't just a good leather alternative but a premium material that works well in luxury fashion (MycoWorks, 2022a).

From Silbert, J. (2022, July 18). Nick Fouquet & MycoWorks created mushroom leather luxury hats. Highsnobiety. https://www.highsnobiety.com/p/nick-fouquet-mushroom-leather-hats-mycoworks/

From Silbert, J. (2022, July 18). Nick Fouquet & MycoWorks created mushroom leather luxury hats. Highsnobiety. https://www.highsnobiety.com/p/nick-fouquet-mushroom-leather-hats-mycoworks/

MycoTex, created by designer Aniela Hoitink, focuses on making eco-friendly textiles from mycelium that grow directly into the shapes of garments without any sewing. A standout feature of MycoTex is its ability to blend colours into the mycelium during growth, allowing for unique, natural-looking designs with different textures and colour patterns. This process results in one-of-a-kind pieces that highlight sustainability and innovation in fashion (MycoTEX - 3D Produced Sustainable Textiles From Mushrooms Roots - Holland Circular Hotspot, 2020).

9.1|What can be done?

Mycelium leather offers various possibilities in both growth and post-processing stages. It can be cultivated in different forms using a variety of glass jars or other closed glass containers. Keep in mind that all containers need to be properly sterilised to prevent mould.

Colour can be introduced during the mycelium growth phase or in the pre-treatment glycerol bath (Aouf & Aouf, 2024).

From SAouf & Aouf, 2024
Aouf, R. S., & Aouf, R. S. (2024, January 31). Food-waste dyes bring colour to mycelium leather in Sages and Osmose project. Dezeen. https://www.dezeen.com/2024/01/31/sages-osmose-mycelium-dyes-food-waste/

In post-processing, patterns can be heat-pressed or use embossing techniques onto the mycelium, creating textures on its surface. This technique can add texture and visual interest to the material. Heat pressing involves using a heated press to imprint a design onto the mycelium, which responds well to this process due to its flexible and fibrous structure. When heated and pressed, the mycelium can hold a pattern effectively without significantly compromising its structure
Laser engraving is another option for adding detailed patterns and designs to mycelium leather, offering further customization possibilities.

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