Mycocomposite Workshop

An introduction to the wonderful world of mushrooms and mushroom based materials!

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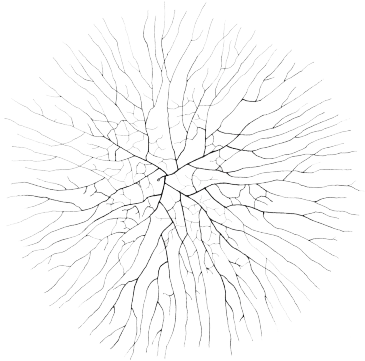
Fungi, Mushrooms & Mycelium

The Fungi Kingdom - fungus (plural: fungi or funguses) is any member of the group of eukaryotic organisms that includes microorganisms such as **yeasts** and **molds,** as well as the more familiar **mushrooms.**

Mushrooms **-** A mushroom is the fleshy, **spore-bearing fruiting body** of a fungus, typically produced above ground, on soil, or on its food source

Mycelium **- Mycelium** is the root-like vegetative part of the **fungi**, it is formed of a **filamentous hyphal network** that branches out, forming connections with other hyphae in search for **nutrients and moisture** from its surroundings



What is mycelium?

A **single cell** (hyphae) until it forms a **multicellular fruiting body** (mushroom)

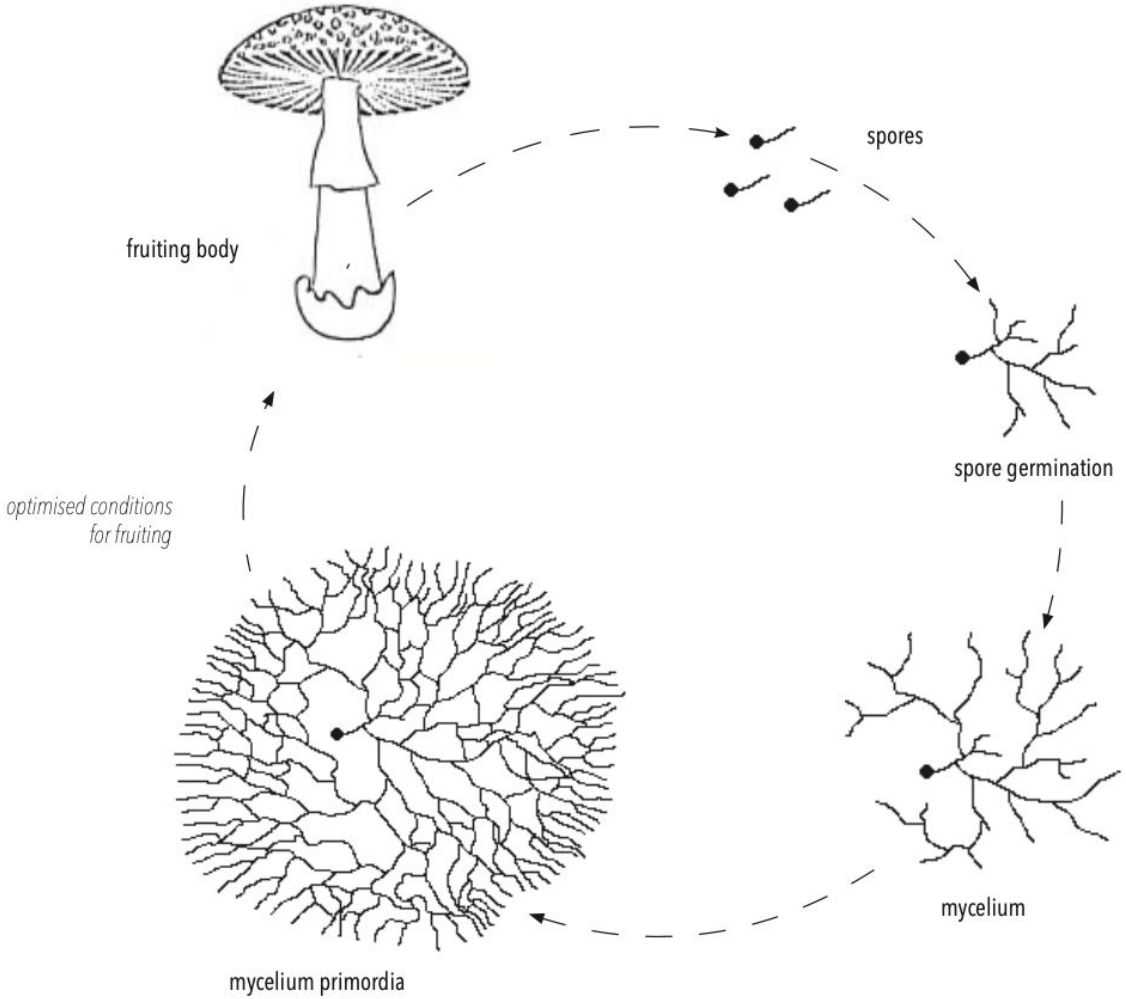
Nature's network - mycelium or a **mycorrhizal network** is found within soils and allows plants to communicate with one another, exchange nutrients and help decompose organic matter to break it up into soluble compounds as plant food.

It feeds on organic matter by **releasing enzymes** to help it digest the medium it grows on.

During this process it is able to fuse together the substrate, making it an excellent and **natural binder** for organic materials.

Fungi Life Cycle

Growth, death and rebirth...



Mushroom Species

A few examples of available species and what they can be used for:

Oyster *(Pleurotus ostreatus)*

The pearl oyster mushroom or tree oyster mushroom, is a common **edible mushroom.** It is a great starter mushroom as it is easy to cultivate and **consumes almost anything!**

Reishi *(Ganoderma lucidum)*

The lingzhi mushroom is a **polypore mushroom** belonging to the genus Ganoderma. Commonly used to make **myco-composites and leather** like materials. Can be digested as a tea and has **amazing health benefits!**

Horsehoof fungus *(Fomes fomentarius)*

The species produces very large polypore fruit bodies which are shaped like a horse's hoof and vary in colour. The mushroom itself has been used to make **Amadou** - a spongy leather material

Lions mane *(Hericium erinaceus)*

An edible and **medicinal mushroom** belonging to the tooth fungus group. its appearance on hardwoods and its tendency to grow a single clump of dangling spine.

Nature's natural binder, mycoremediation and the magic of mushrooms!

As well as being **nature's digesters,** Fungi have a range of wonderful properties and benefits.

Like **bacteria,** certain fungi strains have excellent **bio-remediation** properties, meaning they are able to digest particular **toxins from soils** and water and can be considered as a great **natural filtering system** in polluted areas.

Mycofiltration - Paul Stamets

Mushrooms themselves possess powerful **healing properties**, and have been used as holistic alternatives for energy, as **nootropics, immune boosting supplements,** for **focus** and **sleep aid.**

Medicinal mushrooms

Myco-composites & Myco-textiles

Properties:

Acoustic and thermal **insulation**
Highly **resistant to moisture** and steam
Water and **mold resistant**
Fireproof (can hold up to 800 ° C)
Biodegradable
Compostable
Stronger than concrete pound for pound
Not toxic
Scalable
Versatile (materials like foam, bricks, textiles)

Commercial products

Companies such as ***Ecovative and Mycoworks*** are taking advantage of mycelial binding properties, making use of **agricultural waste** or organic residue from another manufacturing process, and are spreading the awareness on Biotechnologies and encouraging designers and makers to design and cultivate their own pieces.

There are different techniques to produce different outcomes, each company and designer has their own protocols, species and nutrients for their desired outcome.

Hyper Articulated Mycomorph

http://www.iaacblog.com/programs/hyper-articulated-mycomorph/

Why mycelium based materials?

1 Use a **waste material** to '**grow'** your object

2 Can be **moulded** into almost any form, **extruded** and used to make **textile**

3 Variety of desired properties, **lightweight, water resistant, fireproof**

4 Can be returned back to the earth as a **nutrient**

Process for Bio-fabricating Myco-composites

1 - Cultivation in agar plates

Incubation period - 2 weeks

2 - Transfer to grain jars - Spawning (Optional)

Incubation period - 3 weeks

3 - Transfer to bulk substrate

Incubation period - 2 weeks

4 - Mould design

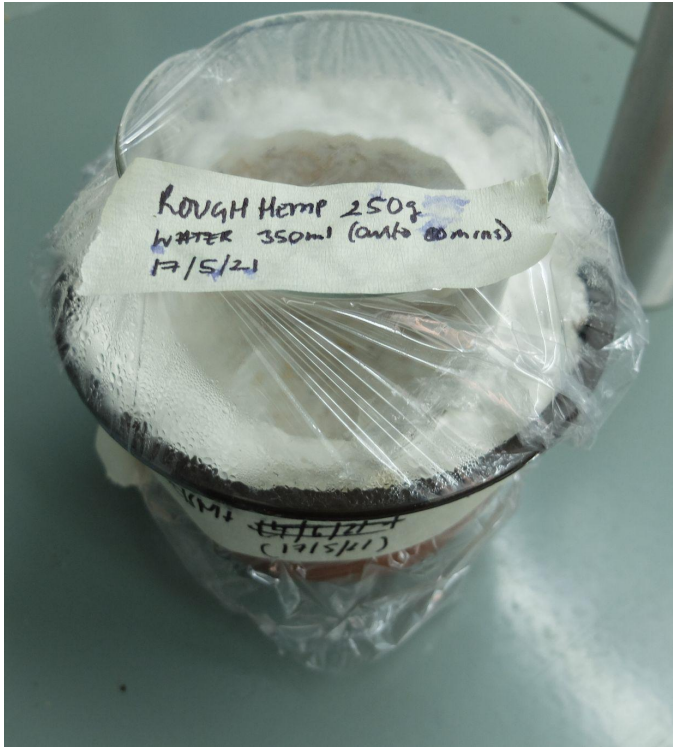
A few hours

5 - Deposit into mould

Incubation period - 1 week

6 - Dehydration

A few hours



Equipment and Tools

Pressure cooker (autoclave)
Sterile workspace
Agar agar
Malt extract syrup or powder
Petri plates
Scalpel
Open flame / Bunsen burner
Glove box (optional)
Gloves
Alcohol
Mushroom Grow bags
Ziplock bags
Aquarium heater (optional)
Plastic wrap
micropore or parafilm
Large container

Sterile experiment protocols

Sterilisation is imperative whilst working with mycelium as it **removes any traces of bacteria or moulds that could otherwise contaminate** the substrate and prevent mycelium from fully colonising it.

Generally this can be done by disinfecting the surface you are working on and the tools you are using with **Alcohol (at least 70 %),** wearing correct clothing with hair tied back and **working close to an open flame.**

Preparing Agar Petri Dishes

Malt Extract Agar is a good all rounder when it comes to agar recipes for most mushroom strains.

1. Mix all ingredients in a jar or blue capped bottle and sterilise the nutrient **mix for 15 minutes in the autoclave** - ensure that the lid is loose!

2. Disinfect the workspace with ethanol and place the bottle away from the bunsen burner

3. Allow the nutrient agar mix to cool just enough to be able to hold the bottle without burning your hand, light the bunsen burner and carefully pour the mix into Petri dishes working within the **10cm radius of the open flame.**

MEA Recipe

200ml Distilled water
4g Agar
4g Malt extract
0.5g Charcoal (optional)

Culture transfer

4. Once the plates are solid (approx 10-15 minutes) continuing to work in the **sterilised area**, **sterilise a scalpel** with the flame until the blade is red hot, allow to cool within the sterilized perimeter and then slice either a pre-colonised agar plate or the inside of a fresh mushroom - a triangular shape is often the most effective way to slice. Carefully transfer this to the fresh plate. you may choose to repeat this **2-3 times for each plate**.

5. Seal plates with either **micro-pore or para-film** and mark each plate with t**he date, mushroom strain and type of media.** They are now ready for incubation.

Incubation

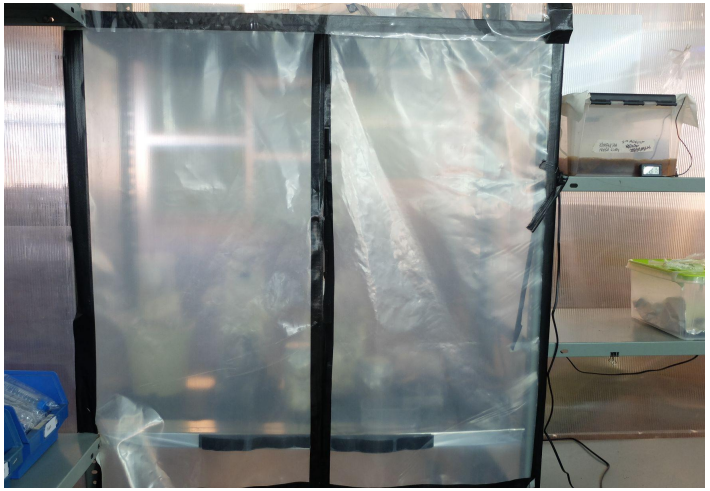
Incubation is a period where the conditions in which the mycelium is growing are **controlled to optimise growth.** These conditions vary depending on the growth phase or the mushroom strain.

The optimum temperature for growth in most cases is **24/25°C.**

Fresh & clean air exchange

Controlled humidity

Sterile environment



Colonised plate

After a few days of incubating, it should be clear that the mycelium is successfully growing on a plate. Allow the mycelium to fully colonise the plate before transferring to a fresh one. Continue this process to maintain a healthy culture!

Bulk substrate

Generally bulk substrates are l**ess nutritious** but larger in size then substrates used for spawning.

Good substrates are :
hemp husks
sawdust
straw
wood chippings
coffee grains
cow manure
wheat husks

and luckily **most organic matter.**

Bulk substrate - Controls

Pasteurization

Unlike spawn, the bulk substrate, only needs **pasteurising,** which means it is heated at a high enough temperature to **kill any nasty microbes,** but leaves those that help protect the substrate whilst the mycelium colonises it.

The process generally occurs between temperatures of **70°C - 80°C for an hour** and can be done using water in a **boiling pot, in the oven or with steam.**

Humidity / Moisture Content

It is worth noting that the substrate should maintain a **level of humidity of about 70%** as there is a danger of having too much water in the substrate which can attract **unwanted contaminants.** .

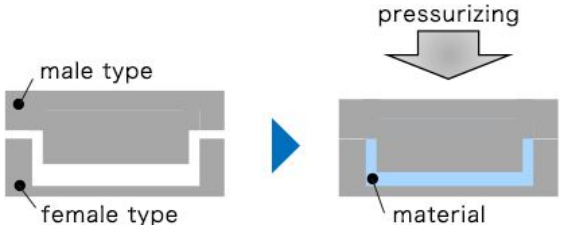
3D Forming & Mould Design

Once the bulk substrate bags are fully colonised, the material can be made more malleable by adding **flour and water to the bag,** the amount depends on the size of the substrate bag.

Your mould can be designed out of almost anything from **cardboard, wood, foam, silicone, plastic, even 3D printed forms**, however flexible plastic works best.

With larger forms in particular, the key is to design openings distributed around the mould, this will **allow airflow** and guarantee **uniform growth throughout.**

Ensure the mycelium can breath by cutting small air holes where possible. Store and protect for a week (depending on the size of the mould) and then remove the formed material from the mould.



Dehydration

Once the form is **myceliated** it is time to dehydrate it and deactivate the mycelium. For smaller samples, bake the mould in a food dehydrator or an oven on a heat of **50-70°C for 1-2 hours** until all moisture has evaporated.

For larger moulds the object can be placed in the **sun with airflow** (protected from insects and birds) or placed near a fan on low power.

When drying, its **volume is reduced by 10%** with the loss of water.

What can go wrong...

Contamination is when an **unwanted bacteria or mould infects the substrate** and the mycelium has to battle with it for nutrients, often preventing it from fully colonising it.

Best ways to avoid hijacking contaminants:

- Always make sure to use a **healthy spawn or agar plate** when transferring to a new plate or bulk substrate

- **Dispose** of any plates, substrates or anything the contaminant has been in contact with

- Act with caution, **disinfect everything,** and avoid breathing into your workspace when transferring healthy mycelium.

- Incubate in a **disinfected controlled space with temperatures of 24°C and airflow**. Reduce temperature and increase airflow of you find internal space overly humid.

Glossary / glosario

Mycelium / **Micelio**: cuerpo vegetativo de los hongos.

Hyphae / Hifas: conjunto de filamentos pluricelulares - construyen ramificaciones sobre el sustrato.

Substate / Sustrato: alimento que coloniza el micelio para obtener nutrientes.

Nutrients / Nutrientes: El micelio vivo acumula, almacena y redistribuye carbono, nitrógeno, fósforo y otros nutrientes. Para el cultivo de materiales utilizamos sustratos ricos en nutrientes (a base de carbohidratos, celulosa, cafeína o ricos en azúcares). Para crear cultivos podemos añadir malta o miel a un medio estéril.

Inoculation / Inoculación: proceso de introducir las esporas o **micelio** en el medio de cultivo estéril.

Agar plate / Placa de agar: placa de Petri que contiene un medio de cultivo (además de nutrientes como la malta para el micelio).

Autoclave (pressure cooker) / Olla a presión: recipiente hermético para cocinar. Puede alcanzar presiones más altas que la atmosférica. El cierre hermético de la olla permite subir la temperatura de ebullición por encima de 100 °C.

Mycoremediation / Micorremediación: forma de biorremediación, un proceso que usa hongos para degradar o retener los contaminantes en el ambiente. Pueden alimentarse de petróleo y pesticidas, sustancias orgánicas que convierte en hidratos de carbono simples.

Useful Resources

Books
Mycelium Running - Paul Stamets
Radical Mycology - Peter McCoy
Mushrooms Demystified - David Arora
Food of the Gods - Terrence McKenna
Bio Design : Nature * Science * Creativity - William Myers

Weblinks
https://www.mycoworks.com/ - here you will find links to a lot of useful resources!
https://www.madewithreishi.com/
https://ecovativedesign.com/
https://www.silviotinello.com/trilo-gallery
https://www.instagram.com/natura_studios/?hl=en
https://www.biohm.co.uk/materials
https://www.mycote.ch/
https://www.corpuscoli.com/
https://www.blast-studio.com/
https://www.mediamatic.net/en/page/184917/mycelium-knowledge
https://www.nature.com/articles/srep41292

Projects
http://www.iaacblog.com/programs/claycelium/
https://issuu.com/ziyilidesign/docs/_ziyi_li_s3592315_drc-compressed
http://www.iaacblog.com/programs/hyper-articulated-mycomorph/
https://www.behance.net/gallery/77767109/Fungi-Regeneration-System

Tutorials
https://biofabforum.org/t/method-of-making-mycelium-leather/218
https://www.youtube.com/watch?v=c6nurN-Hii8
https://www.mushroom-appreciation.com/pasteurize.html#sthash.zh1uGuvX.dpbs