Grow It Yourself™

Teacher Guide

The complete guide to teach Grow It Yourself™ mycelium materials in your classroom.

GIY TEACHER GUIDE

BY GROW.BIO

About Grow.bio

Grow.bio is the education and community division of Ecovative, providing MycoComposite™ technology to the people in the form of Grow It Yourself™ materials. At Grow.bio, we are excited to see all the projects you come up with using our GIY mycelium material, whether for designing world-changing solutions for fashion, architecture and product innovation, or growing beautiful objects like toxic-chemical free planters and lamps. Our dream is to live in a world where biomaterial products are literally grown in a new manufacturing paradigm using living materials. You just helped take the important first step towards turning this dream into reality.

There is a lot to learn about growing your own products, and this manual will get you started. But, before getting your hands dirty, make sure to pay close attention to The Essentials (because your hands definitely shouldn't be dirty!)

Join the GIY Community!

We love to see what you're working on. Tag us at @grow.bio on Instagram and we'll reshare! Add your project and any tips and tricks you've discovered to our community forum. Scan the QR code to join the GIY Community.

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Why Teach

Mycelium

Through this Teacher's Guide, you will explore the value of bringing biomaterials to your classroom and be provided all the resources you need to make it happen!

Sustainability topics in the classroom

21st century education means actively involving students in current issues in their world. The classroom is a place to explore the challenges around us in a safe and engaging way, and this includes environmental education. The National Science Teaching Association "strongly supports environment education as a way to instill environmental literacy in our nation's pre-k-16 students." Additionally, school programs around the world are using the United Nations Sustainable Development Goals to guide their curriculum, and for a good reason. "Education can, and must, contribute to a new vision of sustainable global developments." (UNESCO, 2015). It is crucial that students are actively engaged with solving today's challenges.

One of the goals specifically related to the environment is UN Sustainable Development Goal 12: Responsible Consumption and Production. There are a host of natural resources that are being depleted as we create the materials we need to prosper. Fossil fuels are used to create plastics and cement. Unsustainable amounts of water, energy and land are used to farm animal products. "Urgent action is needed to decrease our reliance on raw materials and increase recycling and "circular economy" approaches to reduce environmental pressure and impact. [2020 Sustainable Development Goals Report, page 50] Read more and view infographics from the UN's Sustainable Goals.

ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

In helping our students understand how production and consumption is related to the environment, it is helpful to ask these questions:

What is the environmental impact of constructing with cement?

Manufacturing of concrete is a significant contributor to CO2 emissions worldwide. According to an article by The Guardian, "After water, concrete is the most widely used substance on Earth. If the cement industry were a country, it would be the third largest carbon dioxide emitter in the world with up to 2.8bn tonnes, surpassed only by China and the US."

What happens to the packaging that my products come in?

According to a Smithsonian Magazine article "at least 85% of U.S. plastic waste went to landfills in 2021". There is a definite problem with the inability to recycle plastic in the U.S. and worldwide, leading to the pollutants of the environment in the form of both macro and microplastics, that end up in the food supply.

What is the life cycle of the clothes I wear?

According to the World Economic Forum, "In the last 15 years the [fashion] industry has doubled production, while the time clothing is worn before it is thrown away has fallen by around 40%. When it is thrown away, 73% will be burned or buried in landfill."

What is the environmental footprint of meat and leather?

According to Our World in Data sourced through the Food and Agriculture Organization of the UN, "Half of all habitable land is used for agriculture..Livestock accounts for 77% of global farming land. While livestock takes up most of the world's agricultural land it only produces 18% of the world's calories and 37% of total protein."

Explore biomaterials

....But it's not all bad news! Current innovators are doing amazing things in the world of sustainable biomaterial production. Unsustainable products like plastic, leather, meat and construction materials are being replaced by living, compostable materials. Consider companies like Mango Materials, who are recycling methane from agricultural waste to create a biodegradable polymer that can replace plastics. MycoWorks, Bolt Threads and Forager are using mycelium, the vegetative part of fungi, to create sustainable leather products being sold in the fashion industry. As global construction increases, companies like Prometheus Materials grow strong microalgae-based construction materials that are not carbon based. LifePack creates single-use disposable products that can be planted and grown afterwards. Ecovative creates materials replacing single-use plastic through the use of mycelium and agricultural byproducts.

Plant-based meats that take far less of a toll on the environment have become more mainstream, such as the products created by Beyond Meat, Impossible Foods or Boca Foods. Interestingly, mycelium has now emerged as a meat alternative that boasts complete protein content and meat-like textures. Companies like Meati and MyForest Foods are bringing these alternatives to consumers today.

The transformative power of mycelium

An emerging solution in creating biomaterials is mycelium. This is because of mycelium's ability to adapt to a wide variety of industry uses.

Mother Nature has already invented technologies that humans can use to make the products we need and love in harmony with the planet — we just need to know where to find them. This ancient, living knowledge is kept in the form of abundant mushrooms in old-growth forests, and the mycelial webs that produce them. We call this The Forager's Secret, because for centuries, those who wander the woods for mushrooms have developed productive relationships with this natural, resilient abundance, directly inspiring Ecovative's research into mycelial materials, engineering, and biofabrication.

Click the link below to continue reading and watch a video for a brierf overview on mycelium and it's many applications on Ecovative's "Why Mycelium" page.

Table of Contents

The Essentials

Safety and Warnings

- **Not for children under 13 years of age except under adult supervision.**
- **Choking hazard— contains small agricultural particles which may be harmful if ingested or inhaled.**
- **Not intended for human or animal consumption**
- **The process requires the use of flour, and may not be advisable for those with severe gluten allergies. Maltodextrin may be used as a substitute.**
- **This material is not rated or recommended for structural applications.**
- **The full Material Safety Data Sheet is available at grow.bio/pages/MSDS**

Keep it clean!

To get your project growing, you'll be creating a nutrient-filled, moist environment that is great for all types of organisms. That's why it is super important to keep everything extremely clean, and prevent contamination from bacteria that could ruin your project. Make sure to thoroughly wash your hands, wear gloves, never touch or breathe (or smell!) inside the bag - you might contaminate the material before it starts growing.

Avoid:

- Bacteria
- Yeast
- Molds

Follow the instructions and use the cleaning supplies listed to prevent contamination!

Timeline

Step 1: Mix

Day 1

Grow time: 3-4 days

Add flour and waterto the bag and mix to hydrate the dry Grow It Yourself material.

Step 2: Grow

Day 5

Grow time: 5-6 days

Break up the growing material, and add in more flour, then pack into a growth form.

Step 3: Pod

Day 9

Grow time: 1 day

Pop the mycelium shape from the form and seal in a pod to create a velvety overgrowth.

Step 4: Dry

Day 10

Dry time: 4-8 hours

Remove overgrown shape from the pod and bake in the oven to render the material inert.

Forming Guide

Options for forming your designs:

- Found forms- things like bowls, cake pans, sand castle toys, candy molds
- Custom forms- 3D printed designs or small thermoformed trays
- Grow.bio forms- we offer a variety of growth forms on our webstore

Materials that ARE porous:

- Wood
- Clay
- Plaster
- Cardboard

Materials that AREN'T porous:

- Wax
- Silicone
- Epoxy
- Plastic

Other tips and tricks:

- Use draft angles of 3 degrees and chamfered edges. Learn more here
- No negative drafts or undercuts
- Avoid features smaller than 1/4" wide or tall for structural and resolution reasons
- Plastic wrap is a great liner for porous materials and can help eject your part
- For more complex shapes, use multi-part growth forms
- Sculpt the material like clay by adding 1 tablespoon psyllium husk powder to 4 tablespoons water in Step 1.

What makes a good form?

- It's waterproof
- It's non-porous
- It's smooth
- It gives the desired resolution
- It can eject your part easily
- It can be reused

Order your forms from Grow.bio:

https://grow.bio/collections/shop

You will need:

Growing

- [ ] Flour
- [ ] Water
- [ ] Measuring spoons
- [ ] Measuring cups
- [ ] Large bowl
- [ ] Growth form*
- [ ] Plastic wrap
- [ ] Baking sheet

Basic Tools

- [ ] Tape
- [ ] Oven
- [ ] Scissors

Cleaning

- [ ] 70% Rubbing Alcohol / IPA (Isopropyl Alcohol)
- [ ] Spray bottle
- [ ] Gloves
- [ ] Paper towels

What's included from Grow.bio:

- GIY material
- Instructions
- Growth Form*

(if ordered from Grow.bio)

* You will need to make a growth form or repurpose an existing form if you did not order one from Grow.bio.

Step 1

Mix

Make time: 20 minutes
Grow time: 3-4 days

Begin here if you have dehydrated Grow It Yourself™ material!
Thoroughly clean your hands, tools, and your work environment before opening the bag.

Add flour and water

- Cut open the bag above the filter patch.
- Mix 4 Tbsp flour and 3 cups water into a slurry then pour into the bag.

Seal and shake

- Reseal the top of the bag above the filter patch.
- Shake it! Mix the bag for 1 minute to hydrate thoroughly.

Grow for 3-4 days

- Let grow until white in a clean area, out of direct sun, with a room temperature at 72° F
- Allow an additional day of growth if not well grown after 4 days.

Step 1: Mix

Checklist

- [ ] Gloves, tools, and work surface are sprayed with 70% Isopropyl Alcohol before the dehydrated Grow It Yourself™ bag is cut open.
- [ ] Make sure to shake until each and every particle is wet, and that there aren't any clumps of flour in the bag.
- [ ] The bag is sealed tight with the white filter patch uncovered so the mycelium can breathe.
- [ ] The bag is in a warm, clean area out of direct sun where it can grow for the next 3-4 days.

The Biological Breakdown

Thanks to your vigorous shaking & mixing, the dormant mycelium will begin to grow, absorbing nutrients from the flour and spreading root-like hyphae. As these individual white strands grow from the moist substrate, they'll begin to intertwine, binding the particles together, loosely at first. The material is alive and growing! As the days pass, you'll notice the substrate in the bag will grow increasingly white— this is the mycelium growing and colonizing the bag. You'll also notice condensation in the bag as the mycelium respires, converting glucose and oxygen into carbon dioxide, water, and ATP, just like humans! When the material has turned completely white after 3-4 days, you're ready for Step 2.

Step 2

Grow

Make time: 20 minutes
Grow time: 5-6 days

Begin here if you have already hydrated Grow It Yourself™ Living material!
Thoroughly clean your hands, tools, and your work environment before opening the bag.

Break up material

- Add material to a large bowl and break up all the chunks. We call this step “regrinding.”
- Add 4 Tbsp flour and mix well for 1 minute.

Pack the form

- Add material to the growth form and pack down as you continue to add more layers.
- Place a sturdy flat sheet on top of the form and tap all over to smooth the fill surface.

Grow for 5-6 days

- Cover the form with plastic wrap or a lid and poke a few small holes for respiration.
- Grow until fully white again in a clean area with the same growth conditions as step 1.

Step 2: Grow

Checklist

- [ ] Gloves, bowl, growth forms, and work surface are sprayed with 70% Isopropyl Alcohol before the bag is reopened.
- [ ] The GIY material was well broken up so no large chunks remained and an addition 4 Tbsp flour was incorporated into the mix.
- [ ] Growth form was well packed and is covered tightly with a lid of plastic wrap punched with holes approximately 1-inch apart.
- [ ] The bag is in a warm, clean area out of direct sun where it can grow until fully white again for another 5-6 days.

The Biological Breakdown

When you break apart your material, it damages and stresses the mycelium, so it's important to give it some extra food by adding flour in this step. Those nutrients will be essential to the strong bonds you need it to grow. Breaking the weak bonds that formed during the first step allows stronger bonds to form as the mycelium grows in a tighter formation. Over 5-6 days, the mycelium will grow exponentially to fill in all of the gaps, binding the loose particles together. When everything in the growth form has turned completely white, you're ready for the next steps— pop and pod!

Step 3

Pod

Make time: 5 minutes
Grow time: 1 day

This step is optional and will create a velvety overgrowth on the mycelium part. Thoroughly clean your hands, tools, and your work environment before popping.

Pop and pod

- Flip the growth form upside down and tap until the grown part "pops" out of the form.
- Seal part in a roomy plastic bag with a cup of water to grow for 1 day to create a white, fuzzy overgrowth on the mycelium part.

Step 4

Dry

Oven temperature 180° F
Dry time: 4-8 hours

This step is optional and will desiccate the mycelium and prevent mushrooms. If you want mushrooms to grow on your part, be aware of spore allergies.

Dry the part

- Remove from the overgrown part from the pod and place on a baking sheet.
- Dehydrate the part at 180° F for 4-8 hours or until fully dry. The part will shrink in size!

Step 3-4: Pod + Dry

Checklist

- [ ] The pod is well sealed around the part and cup of water, walls are not touching the grown part (which will cause no overgrowth in this area!)
- [ ] Want to dry faster? Place in the oven at 200° F and check every 30 minutes. Do not bake too long or hot or your part will discolor!
- [ ] After drying, check that the dry weight is 35% the original weight of the mycelium part. Once dry, the part will feel lighter, and will have shrunk!
- [ ] Choosing not to bake in an oven? Place your part elevated in front of a fan for at least 2 days to dry. Note: the mycelium could reanimate!

The Biological Breakdown

Because most people don't want household objects to grow of their own accord, it's important to halt any further growth of the mycelium by drying it with heat. The combo of heating and drying removes all moisture from your project and eliminates the mycelium's ability to continue to grow, creating stable, inert materials. If you decide to desiccate by air-drying without heat, this only places the material in stasis, and it could reanimate, but it is not likely without the right environmental conditions.

Student Observations

Daily Questions

Ask your students these questions and have them to draw and/or record observations of the GIY material's daily activity. The material will change rapidly from day to day.

Day 1

- What is mold? What is fungus? What is mycelium?
- Draw a scene from hydrating the GIY material.
- What clean practices are we using with the material?

Day 2

- What changes do you see within the bag?
- How does the color compare to yesterday?

Day 3

- Do you notice condensation in the bag?
- How does the mycelium compare to yesterday?

Day 4

- Draw the mycelium growing throughout the substrate.
- How does the GIY material compare to Day 1?
- Why did we grow the mycelium in a bag first?

Day 5

- What color was the material before regrinding? After?
- Why do we add flour to the material in this step?
- What growth form did you choose and why?

Day 6

- How does the GIY material look today?
- Draw the material growing to the form's shape.

Day 7

- What color is the mycelium today?
- Why does mycelium respire?

Day 8

- Draw the grown shape once removed from the form.
- How did the mycelium bind the hemp substrate?
- Why grow mycelium instead of making from plastic?

Notes

Day 9

- Why do we pod the grown parts for one day?
- Draw your observations of the part before and after.

Day 10

- What does heat do to the mycelium? Why do we dry?
- How does the weight of the part compare after drying?

Have students write any final notes, observations, or comments on their next page and utilize the full drawing spread for additional recording space.

Final Notes

Biology and Chemistry

Lesson Plans

Supplemental science lesson plans to teach during days of growth after students observe the mycelium. All are optional, pick and choose what you teach!

Biology

- Lesson 1: Introduction to Fungi Jigsaw
- Lesson 2: Fungi Lifecycle
- Lesson 3: Fungi Protein Synthesis
- Lesson 4: Being Multicelluar
- Lesson 5: The Food Chain
- Lesson 6: Feed the Fungi
- Lesson 7: Cellular Respiration in Fungi
- Lesson 8: The Problem with Plastic
- Lesson 9: Mycelium as an Alternative
- Lesson 10: Show What You Know

Chemistry

- Lesson 1: What do material sciences do?
- Lesson 2: Composites versus chemical
- Lesson 3: Mycelium as a material
- Lesson 4: Adhesion & electronegativity
- Lesson 5: Is mycelium safe?
- Lesson 6: Is mycelium water repellent?
- Lesson 7: Biodegradable materials
- Lesson 8: Advocate for mycelium
- Chemistry challenge roadmap
- Vocab & Curricular Standards

More lesson plans in math, engineering, business and design are coming soon!

FAQs

How many days does the mycelium material take to grow?

Like all living things, the temperature and environment affect the speed of growth of mycelium. Under ideal conditions, humid 72 degrees Fahrenheit, the dry GIY material grows for 3-5 days in the bag until white, then 4-6 days in the form until white again, and 1 day in a pod then 1 day to dry. From start to finish is around 10 days.

What is the shelf-life of the GIY bags and finished grown parts?

In indoor conditions the grown part is shelf stable for 30 years. Unless it is exposed to constant moisture and other environmental conditions, it should not grow mold. The dehydrated GIY material is shelf stable and should be used within 10 weeks of the date on the bag's label, but lasts longer if refrigerated. Living GIY material must be kept refrigerated at all times and used within 3 months.

Is the material waterproof?

Mycelium is naturally hydrophobic and water will condense on its surface. However, if the grown shape is immersed in water or repeatedly saturated, it will lose its rigidity and become susceptible to degradation. Inconsistent moisture exposure from varying weather may allow the material to passively dry and maintain some rigidity. If left in a waterway, the material will break down in 180 days with no harm to the environment.

Is the material compostable or recyclable?

Yes, it is 100% home-compostable. When divided into one cubic inch pieces, the grown part composted within 45 days in soil and 180 days in water. Do not recycle the material, it is only compatible with the composting process.

Where is GIY material made?

Grow.bio is the education and community division of Ecovative Design, headquartered in NY. We have a global network of growth and distribution facilities, and our EU licensee Grown.bio, also provides GIY kits to their region.

How can you post process GIY materials?

The mycelium material can be cut with a bandsaw, tablesaw, drilled, laminated with wood, etc. The more fine the substrate the better precision on a CNC router. Some artists blend the dry GIY in a blender to create a finer texture before hydrating and growing. The material can be sanded and finished with beeswax, milk paint, water-based polyurethane, and more. We recommend natural, biobased sealants as the purpose of the material is to not add toxins to the environment.

What is not a good application for the material?

GIY material is a blend of hemp hurd and mycelium. This composition is too woody for food contact and is not a substitute for food to-go containers, plates, cups, etc. It is not certified for direct food contact.

What are the properties of the GIY material?

The material is naturally hydrophobic, acoustically insulating, flame resistant, and more. See our full spec sheet here: https://grow.bio/pages/spec-sheet

Where can I find the MSDS for the GIY material?

We have the material safety data sheet available for viewing and downloading on our website here: https://grow.bio/pages/msds

Glossary

Biodegradable- can be broken down by living things like bacteria and fungi.

Colonize- the act of our chosen mycelium strain growing throughout the substrate.

Compostable- adds nutrients back into the earth. Compostable products are biodegradable materials that break down under defined conditions and support life.

Condensation- the collection of moisture into water droplets on a surface.

Degradable- the ability to break down. Something that is degradable doesn't require living organisms to break it down, and harmful things can also degrade.

Desiccate- to dry up. We remove moisture from the mycelium to make it inactive.

Filter patch- the white square on the front of the GIY bag which allows for respiration.

Fungus- (plural: fungi) any organism in the kingdom of Fungi.

GIY- abbreviation for Grow It Yourself.

Grow.bio- Ecovative's the education and community division.

Grow It Yourself™ material- the hemp hurd and mycelium blend offered by Grow.bio.

Growth Form- the container used to pack the mycelium material into in order for it to grow and take on it's shape.

Hydrogen Peroxide (H_2O_2)- a disinfectant liquid used to spot-treat desiccation on living parts. It has the unique ability to kill some bacterial contaminants but not mycelium.

Hypha- (plural: hyphae) a single white thread within the mycelium of a fungus.

Inert- the opposite of active, having little or no ability to react.

Isopropyl Alcohol (IPA)- also known as rubbing alcohol, a disinfecting liquid used to sanitize surfaces. Minimize respiratory, skin, and eye exposure as it may cause irritation.

Living material- GIY material that is already hydrated, growing, and ready to be added to growth forms. Begin instructions in in Step 2, skip hydrating, if using Living material.

Mold- unwanted fungal organisms that compete with our mycelium strains within the substrate. Common contaminant molds are Rhizopus and Trichoderma.

MycoComposite- Ecovative's patented mycelium technology consisting of agricultural waste and mycelium. The hemp hurd and mycelium blend that makes up the GIY material is an example of Ecovative's MycoComposite™ technology.

Mycelium- the vegetative tissue of a mushroom. It appears as branching threads, called hyphae, where nutrient absorption occurs. The sum of hyphae is a mycelium.

Overgrowth- the white, fuzzy outer layer of mycelium that grows as a result of podding.

Part- the final mycelium product popped from the growth form once fully grown.
See also: Shape

Particle- referring to the individual hemp hurd piece and size within the GIY material.

Pod- a sealed environment used to contain humidity around the popped part to produce overgrowth. Often constructed of a plastic lid or bag sealed with tape or clips.

Pop- the process of removing grown parts from the growth form.

Porous- a surface that is permeable to fluids and gasses.

Regrind- the process of breaking up living material before packing into a growth form.

Respire- to take up oxygen and create carbon dioxide. Mycelium respires like humans!

Shape- the final mycelium product popped from the growth form after fully grown.
See also: Part

Substrate- agricultural material that has been processed, inoculated, and colonized by a chosen fungal species.

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