

**MIDDLE SCHOOL**

**Green Chemistry**

**Lesson Four: Making Mushroom Materials**

**Background:** The engineering design process is all about iteration. After perfecting a prototype, engineers will then set to work on the final product. In this lesson, the students reflect on where their project is in the engineering design process and build their final product: a mycelium material cell phone case. They then create data tables that they will fill in throughout the growth process to help guide their product evaluation.

It is important to note that this lesson will refer to Grow.bio materials, not Ecovative materials.

Grow.bio, the educational spin-off of Ecovative Design, is where grow-it-yourself mycelium materials can be purchased.

**Objectives:**

* Follow lab instructions
* Test variables and collect data
* Use principles to determine amount of additives used in final product

**Key Terms:** biodegradable, design variables

**Materials:**

* Water
* Plastic wrap or plastic bags
* Alcohol prep pads
* Drying rack
* Baking sheet
* Oven
* Cell phone case mold/form
* Gloves
* Flour
* Guar gum
* Scale
* Tablespoon measuring spoon
* Containers for mixing
* Sharp object to poke holes in plastic wrap/bag (paper clips work well)
* Grow.bio mycelium material, available at <https://grow.bio/collections/shop>. Use code BEYONDBENIGN for 15% off your Grow.bio purchase!

**Time Required:** 10–15 days total\*

Day 1: 45 minutes

Days 2 through 14: 5 minutes

Final day: 45 minutes

\*Depending on speed of mycelium growth, which relies on classroom conditions

**Standards Met:**

**MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**Keys to Success:**

* Each bag of material will make about one class’ worth of cell phone cases.
* Use code BEYONDBENIGN at checkout to receive 15% off your purchase of mycelium materials from <https://grow.bio/collections/shop>.
* There are multiple mycelium materials that can be used to make cell phone cases. We have used the hemp mixture, but any should work. Varying the materials is also another great variable to add to the class project!
* Make sure you keep your start date in mind when ordering your mycelium materials. The shelf life is about 10 weeks from the date marked on each bag.
* Alcohol prep pads can be found with first aid supplies in your local store or pharmacy. We recommend these over rubbing alcohol, as it cuts down on the amount of solvent waste.
* Containers for mixing material can vary. Mixing bowls are referenced in the procedure, though aluminum pans will work perfectly well as an inexpensive alternative. Aluminum pans can be cleaned and reused or recycled.
* To make the mold, or form, for the cell phone case, you can use cardboard boxes from packs of Expo markers, staples, movie theater candy, and other similar-shaped/sized boxes in place of a plastic cell phone case.
* When students are deciding which variable they would like to test between their 2 cell phone cases, gently guide students to choose variables that will not lead to failure for both of their cell phone cases.
* It is important to thoroughly sanitize the surfaces that the mycelium material will touch in order to prevent contamination from other, more aggressive fungi and bacteria (like black mold).

**Safety Information:**

* Grow.bio material, when handled properly, is safe. However, the material is not for human consumption and, when dry, may irritate airways if directly inhaled.
* No spores are contained in the mycelium material. However, if the material growth is not stopped during the final drying step, mushroom growth may occur. Mushrooms may produce aerial spores, which are a potential allergen. It is advisable to prevent materials from growing to this stage.
* For individuals with severe gluten allergies, the materials may be rehydrated with maltodextrin instead of flour.
* Gloves should be worn to protect the material from contaminants on students’ hands. Materials are safe for direct contact with skin.
* A Safety Data Sheet (SDS) for the hemp blend material type is available here: <https://s3-us-west-2.amazonaws.com/ecovative-website-production/documents/GROW.bio-Hemp-SDS.pdf>
* Where composting is available, leftover mycelium materials can be composted.

**Teacher Preparation:**

*At least 6 weeks prior*

* Order mycelium materials from <https://grow.bio/collections/shop>
  + NOTE: The shelf life of the materials is 10 weeks. After 15 weeks, the materials will likely not grow successfully, resulting in moldy, weak forms.

*4–5 days prior*

* Rehydrate mycelium materials
  + For each bag of material, measure out 700 mL (3 cups) of room temperature tap water, add 20 g (4 tablespoons) of flour to it, and stir.
  + Pour the flour and water directly into the bag of mycelium material.
  + Hold the bag closed and shake until all the material is wet and evenly distributed.
  + Fold the bag over multiple times, then fold in the corners. Do not fold over the white filter patch, as this will prevent oxygen from flowing into the bag for the fungi.
  + Let grow at room temperature for 4–5 days.
  + Bags may also be kept up to 2 weeks, if refrigerated.

*At least 1 day prior*

* Invite students to bring in old cell phone cases to use for their mold.

**Procedure:**

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*Engage:*Students review the engineering design process and reflect on the progress they have made on their cell phone case.

* Using the board, ask students to draw the engineering design process.
* After each step in the process has been identified, ask the class where they believe they are with their cell phone case project.

*Explore:* Students once again use the engineering design process to guide the building of their final product.

* Explain to the class that they will soon be creating their final products. Each group will make two cell phone cases with one variable different between them. This variable could be related to the structure or quantities of the materials used to make the cell phone case (i.e., more or less thickening agent), or it could be related to the growth conditions themselves (i.e., light vs. darkness).
* Have students refer back to Lesson 2 Engineering Design Process Student Sheet
* Have the students get into their groups update the Engineering Design Student Sheet with any necessary information. Students will repeat the same tests that they performed on their prototype (procedures should be in their notebooks from Lesson 2), so they will be able to include that information in this initial process. If there are any changes to the procedures that they wish to make, based on their work with the prototype, they should also capture their proposed changes in the plans.
* Before moving on, make sure groups have defined which variables will be different between their 2 cases.

*Explain:*Groups use the information they gathered from their prototype testing in Lesson 2 to build a new mold/form for their final product.

* Once the groups have filled out their sheets, instruct them to build the forms for their cell phone cases (if they are not planning on using old plastic cell phone cases).
* If it is necessary to make changes to their design during this process, they should capture this information in their sheets.

*Extend/Elaborate:*Groups use their procedure from Lesson 3 to make their mycelium material cell phone cases.

* Have students pull out their Revised Lab Procedure sheet from Lesson 3.
* In groups, have students mold/form their cell phone cases using their procedures.
  + NOTE: The material is fairly forgiving if too much guar gum is added. If too much water is added, the material will likely take longer to grow and dry out, which will increase the risk of the material becoming moldy. In guiding the students, it is helpful to have an ideal texture in mind. The material will be ready to form when it holds itself together without crumbling, similar to a meatball.
* When each group has successfully made two cases, make sure that the cases are fully protected in plastic (with ventilation holes).
* Have students label their cases A and B (and indicate variables between the two).

*Evaluate:*Students will prepare their data tables for observing and evaluating the growth of their cases and they’ll make predictions about how their cases will perform.

* Instruct each student to create a data table in their notebook for both cell phone cases. They will fill in these charts each day until the growth of each case is complete.
* Each data table should have the information relevant to their experiment. Suggested information includes:
  + Date
  + Temperature
  + Approximate area-of-growth percentage
  + Direct sunlight/indirect sunlight/no sunlight
  + Weight
  + Sketch or picture
  + Observations
* To wrap up, instruct each group to predict how the difference in their two cases will affect the performance of each case and explain their prediction. Have groups capture this prediction in their notebooks for reference in upcoming lessons.
* Instruct students to save their Student Sheet.