LESSON PLAN 2:

KOMBUCHA LEATHER, BIOPLASTIC, & MYCELIUM

Curriculum: Introduction to Biodesign
Unit: 1––Biomaterials
Grade Level: 10th-11th

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Background Information For Teachers

Overview of this lesson:

This lesson is all about biomaterials. Building on our students' emerging understanding of biodesign, we used this lesson to expose them to the kinds of materials that scientists and designers at the forefront of biodesign are exploring and using in innovative ways. We created stations where students could make three types of biomaterials: mushroom mycelium composites, kombucha leather, and starch-based bioplastic.

In addition to having them begin working with materials they could use in future class projects, we felt that it was important for our students to have something to take home to make the work more meaningful to them. Out of the classroom, they might also use their biomaterial "samples" to educate their friends and family about what they were learning in class.

With our students, we emphasized the idea that to understand how materials are made and how they break down (if they break down at all) is to understand how to design in a way that creates a smaller impact on our planet. This is why, in this lesson, we talk about the chemical structures of synthetic materials and those of natural ones. To understand more deeply the materials **we** use, build, and interact with (their structures, their longevity, their impact) is to better understand how to design for positive change.

Science:

Introducing biomaterials is a very concrete way to frame the chemistry of polymers, and what makes a polymer biodegradable or not. We cover creation of polymers out of monomers, and the link between recycling numbers found on the bottom of containers and the types of polymers they relate to. We also delve into the chemical differences between the long chain hydrocarbons that result from synthesis of petrochemicals into plastic and the types of polymers found in nature, and the evolutionary forces that would lead to biodegradability of natural polymers over synthetic ones. This lesson will then link to decomposition action in the composting chambers in lesson 3.

Adapting this lesson to your classroom:

For this lesson, we took full advantage of our Biodesign Makerspace and the resources of RISD's Nature Lab, which meant that we had microscopes, mycelium, kombucha, multiple teachers, a flexible classroom arrangement, and much more at our disposal. We recognize that this is not the case for most teachers. In introducing your students to biomaterials, it is perfectly reasonable to adapt this lesson to focus on just one biomaterial rather than three (kombucha is perhaps the most fuss-free of the three, and bioplastic, while involving some set up and "cooking" has the most immediate, observable results.)

Standards, Objectives, & Supplies

Grade Level: 10th-11th

Duration: 2 hours

Lesson Concept: Polymers can be natural or human made. Natural polymers can be grown or made in the laboratory, and have many benefits that can be used for everyday objects.

Lesson Objectives/Learner Outcomes:

1. Understand what a polymer is and know the difference between a bio-polymer and a synthetic polymer.

2. Understand that we have choices when it comes to what materials we use to design, and designers can be agents of change by choosing to use materials that have a smaller impact on the environment.

3. Observe, experiment with, and create something out of biomaterials to bring home.

Instructional Support Materials (if needed):

- Powerpoint with necessary images + discussion questions.
- LCD projector/smartboard
- Vocab cards for each student to paste in journal (see end of PDF)
- Printed mycelium, bioplastic, and kombucha recipes for each student to paste in journal (see end of PDF)

Materials + Supplies:

General
- 3-D Models of Polymers (one for each small group of students)
- Pencils/Pens (for each student)

Bioplastics Materials and Supplies:
- Potato starch (6g per sheet)
- Glycerine (6g per sheet)
- Gelatine (6g per sheet)
- Water (60ml per sheet)
- Hot plates (one for each small group of 2-3 students)
- Beakers (one for each student or small group)

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Science / Art Standards

SCIENCE (Next Generation Science Standards):

PS. 1B Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.

ESS3A: Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits

ART (National Core Art Standards):

VA:Cn10.1.iia: Utilize inquiry methods of observation, research, and experimentation to explore unfamiliar subjects through artmaking.

Standards, Objectives, & Supplies

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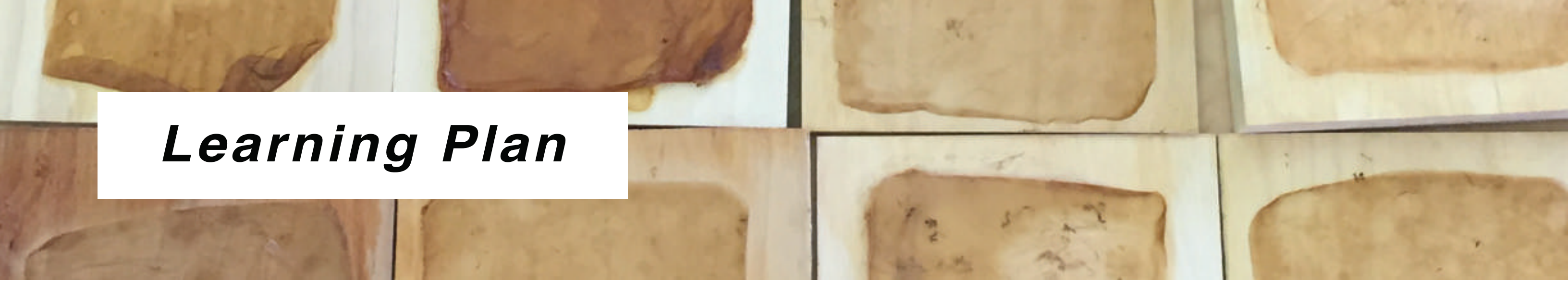
- 400 ml beakers (one for each student or small group)
- Glass stir rods (one for each student or small group)
- Scales/balances and weigh boats/papers to weigh ingredients (one set up for each student or small group)
- Protective Gear (goggles and aprons for each student)
- Trays to cool bioplastic (6”x8” for above amounts, one for each student)
- Post-it notes to label student work (one small pad)
- Tongs for picking up beaker (one for each student or small group)
- Food coloring to dye bioplastic (if desired)

Kombucha Materials and Supplies:

- Black tea teabags (4 per 7 cups water)
- Sugar (1 cup per 7 cups water)
- Water (dependent per amount made of recipe, at least 7 cups)
- Store bought kombucha (plain, raw/unpasteurized, unfiltered - ratio of 1:5 to sweet tea)
- Post-it notes to label student work (one for each student)
- Pyrex dishes or plastic take-out containers to store kombucha as it grows (one for each student)
- Microscopes (one for each small group of 2-3 students) + slides
- Paper cups (if students want to try kombucha, one for each student)

Mycelium Materials and Supplies:

- Cardboard (several sheets per small group)
- Masking or Duct Tape (one roll per small group)
- Scissors (several pairs per small group)
- Plastic Wrap (one roll)
- Mycelium Mix (available at grow.bio)
- Wheat Flour (at least 1/2 cup, see recipe at end of PDF)
- Water (see recipe)
- Spray bottles with rubbing alcohol for disinfecting (one for each small group)
- Toothpicks
- Nitrile gloves (a pair for each student)
- Post-it notes to label student work (one for each student)



Learning Plan

Stage 1: Motivation

1. Introduction Lecture Part I: What are biomaterials? Place bioplastic, mycelium, and kombucha leather samples on each table and ask students to touch them, manipulate them, and guess what they're made of. Once students have had the opportunity to explore and to talk about what they're seeing, explain what biomaterials are and why they're important in our study of biodesign. Tell students, "In this lesson, we are focusing on understanding the ways in which biomaterials are different from synthetic ones, but before we get to that, we have to first ask: What is a polymer?" *(5 minutes)*

2. Introduction Lecture Part II: What is a polymer? Walk students through basic atomic structures of various polymers. Give each table a model of the chemical molecules to manipulate, if possible. Emphasize: Why is this important to know as we begin our explorations of biomaterials? *(5 Minutes)*

Stage 2: Exploration

Station Learning: Kombucha, Mycelium, and Bioplastic. Students are divided into three groups and rotate between three stations (20 minutes at each) at which they will handle, explore, make kombucha, mycelium molds, or bioplastic. *(20 minutes at each station, total 60 minutes)*

1. Bioplastic (led by one teacher). Students each make a sample sheet of bioplastic at this station, using the recipe provided. For more information about bioplastic, see the "Biomaterials" section of our webpage, biodesignmakerspace.org

2. Mycelium (lead by one teacher). Show students real-life examples of mycelium as a building material or find examples online and print out to show students. Students then pack pre-made molds (glass cups, plastic containers, anything that will hold the shape of loose mycelium) with inoculated mycelium to grow over the next week. For more information about mycelium and how to use it see the "Biomaterials" section of our webpage.

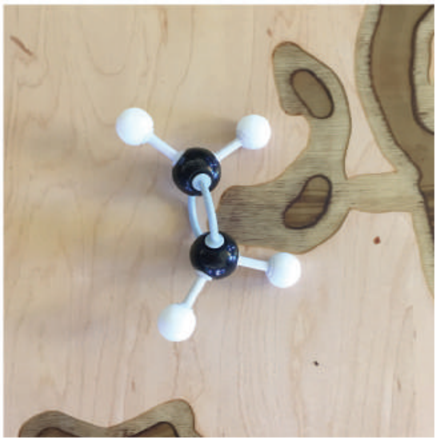
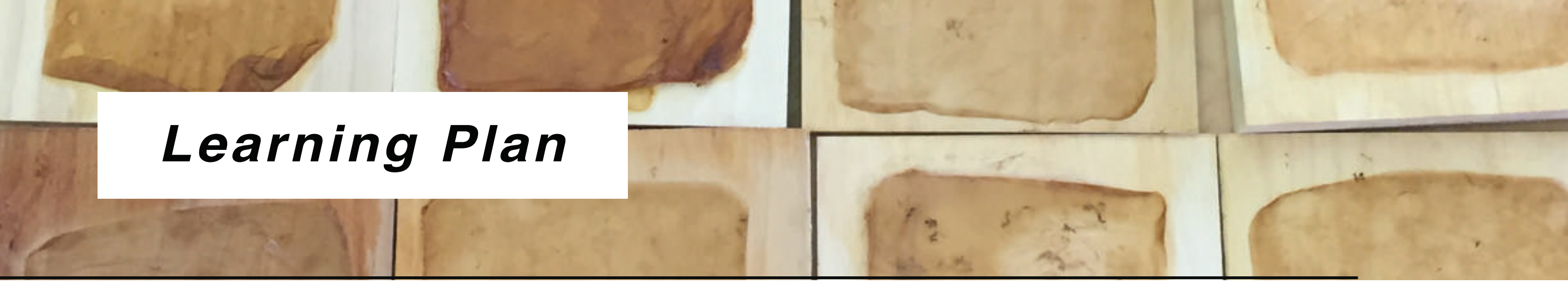


Image: Polymer model for students to manipulate.

Image: Students' bioplastic (which they dyed using a drop or two of food coloring) cools in trays by the window.

Image: Packed mycelium molds, inoculated and ready to grow over the following two weeks.



Learning Plan

3. Kombucha Leather and microscopic observation (lead by one teacher). Pour paper cups of kombucha so that interested students can try tasting it. Set up microscopes and slides up so bacteria, and yeast from the kombucha, and mushroom hyphae from the mycelium can be observed and drawn in notebooks (notice magnifications!). Students then combine the pre-made sweet tea (see recipe at the end of this PDF) and store-bought kombucha and pour mixture into glass pyrex or **plastic** take-out containers to grow a SCOBY over the next few weeks. Containers are labeled with each student's name and stored in a warm dark place. For more information about kombucha leather see the "Bio-materials" section of our webpage.

Image: Students kombucha in pyrex dishes, labelled and placed in a warm place to grow.

1. Five-Minute Journaling: Students clean up and return to tables to journal for five minutes. Teacher can pick one prompt for all students to respond to, or students can choose from three prompts. *(Writing: 5 minutes, if desired: 5 minute pair share or group share)*

- Make a drawing that explains how a monomer becomes a polymer. Imagine you had to show your drawing to someone who had never heard of a polymer, how would you explain it?
- In what ways do designers have the power to create change through design, if at all ? Why is this important? Write a paragraph.
- What are ways you can imagine using biomaterials in your everyday life? Could these materials be used to solve an everyday problem you encounter? Could these materials be used to lessen waste? Write or draw a response.

Image: Nametags for our students made out of bio-plastic.

2. "So what?" Lesson Recap. Ask students: What did we do today? Why is it important? Emphasize key ideas covered and larger context for today's learning—for example, "The materials we use and the impact they have on our planet isn't something that's out of our control—we can choose to use materials that have a smaller impact on the environment. We have the power and responsibility to understand the materials we use, how they will affect our planet, and the waste they will leave **behind.** Designers and scientists can further our understanding and use of materials that do not do further damage to our planet." *(5 Minutes)*

Image: Students' kombucha leather two weeks after this class, when their SCOBYs had grown and were dried on boards.

Bioplastic Recipe

Bioplastic – Flexible sheet, Potato Starch | Gelatine Recipe

Bioplastic is an alternative to synthetic plastic that can be easily made at home or in the classroom. It is biodegradable, and as such is a promising material in sustainable design.

Ingredients:

- 60 ml water
- 6 grams potato starch
- 6 grams gelatine
- 6 grams glycerine
- Food coloring (if desired)

Safety: please wear safety goggles and aprons, provided for you, and use caution around the hotplates.

Procedure:

1. Mix all ingredients well in 400 ml beaker, using glass stirring rod
2. Place on hotplate, set to heat level of 6 or 7
3. Continue stirring with glass stirring rod until mixture begins to turn whitish and thickens slightly. Add coloring (one or two drops) at this point if desired, and stir.
4. Turn off hotplate.
5. Carefully, using the beaker tongs, pour the liquid out into the tray provided
6. Tilt tray to make sure the liquid reaches all 4 corners, place on heat-proof surface
7. Make a label with your name on it, attach to tray.
8. Once cooled, wash out beaker and stirring rod using warm water.

Mycelium Recipe

Mycelium Material

Mycelium is the threadlike, vegetative part of a mushroom. Mycelium here acts as a bonding agent to hold together substrate particles in a matrix that can then be used as a styrofoam alternative, with a variety of applications including as a durable, flame-retardant, and lightweight packaging. It can form to any shape for which you are able to create a mold. Because fungi are decomposers, many types of substrate can be used, including agricultural waste. We use a commercially available product from grow.bio that uses flax or hemp fibers. Because other organisms will compete for this "food", it is important to clean all tools, surfaces and containers with alcohol to minimize potential for contamination.

First step: making molds

1. You will have a variety of materials to make molds from, including cardboard, paper, and plastic containers.
2. The mold must be waterproof, so the sides paper and cardboard in contact with the mycelium will need to be lined with plastic wrap.
3. All pieces touching the mycelium will need to be cleaned with alcohol.
4. Make sure your mold is made so that it's easy to get the mycelium out at the end!

Second step: packing molds

Ingredients:

• Pre-mixed starter with flax/hemp, fungal spores, wheat flour and water, grown out for 3+ days (follow package instructions).
• Wheat flour
• Molds
• Plastic wrap
• Toothpicks
• Post-it notes to label student work

Procedure:

1. With gloves on, sanitize your gloves, working area, and mixing bin with alcohol from the spray bottle. Make sure it's dry.
2. Remove the mushroom material from the bag and place it in the mixing bin.
3. Break up the material by hand until all of the particles are loose.
4. Add 4 Tablespoons (20g) of flour and mix thoroughly for one minute.
5. Sanitize your growing container(s) with rubbing alcohol and allow to dry.
6. Pack cavity with loose mycelium material.
7. Cover top surface with plastic wrap and secure with tape to keep the material from drying out.
8. Poke holes with clean toothpick 1 inch apart to allow for respiration. Label with your name!
9. Allow material to grow for one week.
10. Bake at 200F until their weight is reduced to 1/3 of original.
11. Remove from oven and cool.

Nature Lab

Kombucha Leather Recipe

Kombucha Leather Recipe

Kombucha leather is a biomaterial made from kombucha (a fermented drink made from sweet tea and **S**ymbiotic **C**olony **O**f **B**acteria and **Y**east or SCOBY) that is then dried to resemble leather. The final product is a tough but biodegradable material that acts a lot like real leather but without such an environmentally-taxing growing and tanning process.

Ingredients:

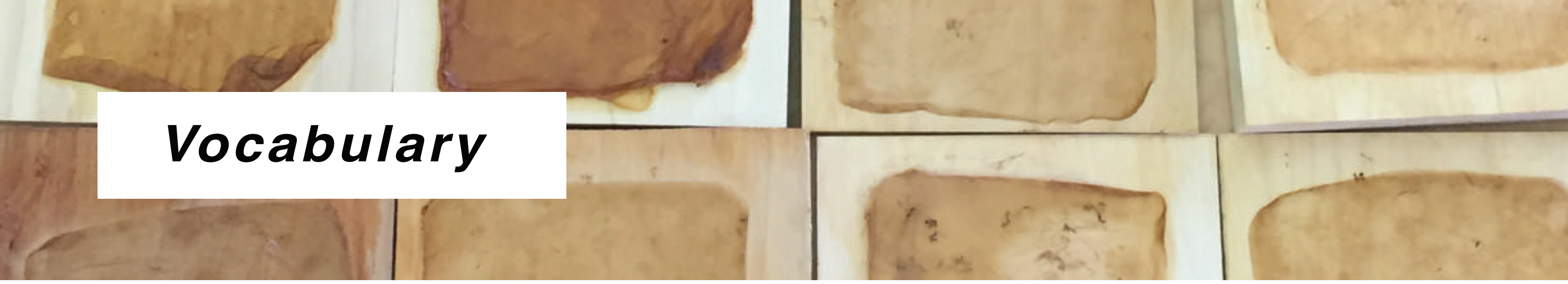
- Sweet tea, made with water, lipton tea bags and table sugar in a 7 cups water:4 teabags:1 cup sugar ratio
- Store-bought plain, raw, unfiltered kombucha

Procedure:

1. Clean a pyrex dish or takeout container and its cover with alcohol, making sure that all of the alcohol has dried thoroughly.
2. Add 300 ml sweet tea
3. Add 60 ml kombucha
4. Cover dish, attach label

Kombucha will be left in a clean, warm, dark place to grow for 2-4 weeks before harvesting and allowing to dry for one week on a wooden board. Growth can be sped up by placing grow pads, such as those used for seedlings, under the grow trays. Kombucha needs gas exchange, so either “burp” lids periodically, or leave a gap to allow for air flow.

Vocabulary



Terms:

Biomaterials: Materials that are either grown by organisms or formed through laboratory processes using a combination of grown starter ingredients.

Polymers: A chemical compound made by combining simple molecules (monomers) in a repeating pattern.

SCOBY: Symbiotic Culture Of Bacteria and Yeast. Makes kombucha from sweet tea.

Bioplastic: A type of biomaterial that can be molded into shape when first being made and dries into a rigid or pliable material.

Mycelium: The mass of filaments that make up most of the body of a fungus.

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