**Part 2 of the project will allow students to engineer and test a product that has a closed-loop lifecycle. It is divided into two lessons and will take between 14 and 17 days. NOTE - not all days will be “active” as the mushroom materials take several days to grow and dry.**

**After designing and testing the alternative mushroom material product in comparison to a traditional polystyrene product of similar design and use, students will write and present a summary assignment in the form of a lab report or poster presentation that will link back to the 12 Principles of Green Chemistry through a green chemistry connection prompt.**

**Teacher Prep before Day 1:**

**IMPORTANT NOTE - Teachers will need to purchase Grow-It-Yourself materials from the Ecovative Design website** <https://shop.ecovativedesign.com/collections/grow-it-yourself>.

Kits come with instructions. Materials need to be re-activated, fabricated, grown, and dried, requiring a total of 11 to 13 days until products are ready to be tested, according to the timeline below:

* Order and receive the materials (varies by location)
* Activate the materials (follow instructions in kit, then the process takes 5 days for pre-molding growth)
* Create the molds, then they will sit and grow for 5-6 days
* Remove from molds and dry for 1-2 days, then bake for 30 minutes

**The following videos will set the stage for Part 2 of the PBL.**

It is suggested that the teacher pre-read the information on TED.com about William McDonough and his Cradle to Cradle design. Cradle to Cradle designs a closed-loop lifecycle for products in comparison to the traditional Cradle to Grave design that ends with products in an open-loop lifecycle. Additionally, teachers may watch the entire 20-minute TED talk.

<https://www.ted.com/speakers/william_mcdonough>

Alternatively, here is a link to a video that summarizes Cradle to Cradle design in just over four minutes.

 <https://www.youtube.com/watch?v=fP8PRA-OajU>

As the teacher, you will decide which video or segments of the videos will be most effective to use with your students to teach them about Cradle to Cradle design.

**Next, these videos explain the vision and development of Ecovative, a company that uses renewable feedstocks to design polystyrene-replacement products. It is suggested that the teacher pre-read the information on TED.com about Eben Bayer and Ecovative. Ecovative uses locally-sourced agricultural waste as a structural foundation for mushroom mycelium to grow into a product that can be used in place of polystyrene.**

 <https://www.ted.com/speakers/eben_bayer>

You should also explore the Ecovative website where you will find in-depth information about the process and the current collaborative projects that are ongoing.

 <https://ecovativedesign.com/>

These videos also demonstrate mycelium growth in a time lapse

 <https://www.youtube.com/watch?v=c6JRjVBYijs>

 <https://www.youtube.com/watch?v=FqIygiViJRw>

**PBL lesson outline:**

**Lesson 1** is developed so that the teacher may decide how much or how little time to spend on presenting the background information on Ecovative materials. Additionally, there are several suggested formats for the summative evaluation.

The lesson is written so that students will select their own polystyrene product to study and test; however, if the teacher so desired, the selection of polystyrene product could be assigned individually by the teacher, or the entire class could research the same product.

**Lesson 1: Background of Ecovative Design and the use of mushroom materials as a polystyrene alternative.**

This lesson may take one or two days, depending on how many of the videos suggested above the teacher decides to show students.

Referring back to the open-loop and closed-loop slides from PBL Part 1 that demonstrate the differences between closed-loop mushroom materials and open-loop, traditional petroleum-based polystyrene, lead students in small- or whole-group discussions to compare and contrast these two alternatives.

**Lesson 2: Engineer and test a polystyrene-alternative product.**

**Day 1**: Students will conduct online research to identify uses for polystyrene products. Examples include packing materials and insulating materials. Appropriate uses for Ecovative products are also suggested in the Eben Bayer TED Talk. Students may use the Product Design handout to guide their decision on what type of product they will engineer. See handout 8 Product Design Lesson

**Day 2**: Develop an experimental protocol. Students will use the Experimental Design handout to guide this process. See handout 9 Experimental Design

**Day 3**: Students use Grow-It-Yourself materials to create their products. Follow instructions on the packaging.

**Days 4-8:** Mycelium growth occurs in molds. Students may check on a daily basis, if desired.

**Days 4-10**: Students should create a flow-chart to use during the product testing phase on one of these days while waiting for the fabricated product to grow. See handout 10 for a simple flow chart example (perhaps we want to direct teachers to more in-depth online resources about flow chart? This came out of the Dec. 12 meeting discussion)

**Day 11**: Test products, gather data on flow-chart.

**Day 12**: Students will analyze data by first organizing it into data tables. Depending on the test conducted students might complete calculations, create graphs, etc. Students should be sure to make comparisons of the efficacy of both Ecovative mycelium fabricated products and traditional polystyrene.

**Day 13-15:** Students will create and present final analysis presentations. These may take the form of a lab report, poster presentation, slides, or other type of oral or written format. Refer to handout 11 Ecovative Assessment Checklist for suggested assessment/rubric components