 **Sustainable STEM: Overview**

**MIDDLE SCHOOL**

**Green Chemistry**

**Background and Overview:**

Beyond Benign is a non-profit organization that develops and disseminates green chemistry and sustainable science educational resources that empower educators, students and the community at large to practice sustainability through chemistry. Green chemistry is the science that provides tools at the beginning stages of design to create safer products.

Beyond Benign’s *Sustainable STEM* curriculum features a 6-lesson unit focusing on sustainable design. Students create their own cell phone case out of renewable mushroom material and see how the product aligns with the three criteria of green chemistry. The mushroom material was developed by [Ecovative](https://mushroompackaging.com/) as a Styrofoam replacement for packaging.

*Sustainable STEM* also features 3 stand-alone lessons. Fabulous Fabrics explores the differences between natural and synthetic fabrics. Polymer Properties allows students to discover how the properties of polymers change depending on how they link together. And Sharklet, showcases a technology that was developed after discovering the antibacterial properties of shark skin.

All of these lessons provide students with a look at how industry is incorporating sustainable design into their products. This curriculum will increase students’ awareness of sustainability and green chemistry through hands-on design challenges.

**Lesson Summaries:**

**Lesson 1: Beginning an Investigation by Gathering Evidence**

Time required: One or two 45- to 60-minute class periods

This lesson introduces the global problem of plastics and sets the stage for designing a biodegradable cell phone case made from renewable materials. Students will consider their own impact on the environment through their personal choices while exploring the scale of effect that one product can have

**Lesson 2: Using Engineering Design to Make a Prototype**

Time required: 45–60 minute (1 or 2 class periods)

Students will be introduced to the engineering design process, which they will use to design, construct, and evaluate a prototype for their cell phone case.

**Lesson 3: Life Cycle**

Time required: 45-minute class period

In this lesson, students will take part in a very important task typical of any scientist or engineer: reviewing and revising their experimental procedure. Together, their changes will highlight the three criteria important for green chemistry technology, which allows for discussion of the sustainability of their mycelium cell phone case.

**Lesson 4: Making Mushroom Material**

Time required: 10–15 days total\* Day 1: 45 minutes Days 2-14: 5 minutes Final day: 45 minutes

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

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.

**Lesson 5: Testing the Cell Phone Cases**

Time required: 45–60-minute class period

In this lesson, students will revise those procedures and use them to evaluate their mycelium cell phone cases. They will then use the information from their experiments to draw conclusions about their final product and choose one case to recommend.

**Lesson 6: Presenting a Sustainable Solution**

Time required: 45–60-minute class period

This lesson challenges students to consider the information they have gathered about the cost, safety and performance of their case and communicate the details of their final product in a presentation.

**Fabulous Fabrics**

Time required: Two 45-minute class periods

Students will consider the difference between natural and synthetic fibers and investigate the ways that a variety of fabrics will interact with both basic and acidic dyes.

**Polymer Properties**

Time required: 60-minute class period

In this lesson, students will explore the basics of polymer science, using pipe cleaners and colored penne to create models. Then, students will create two different slimes using chemical reactions and consider the difference between naturally derived and synthetic materials.

**Sharklet**

Time required: 45-minute class period

In this lesson, students will be introduced to biomimicry and Sharklet film. They will then investigate how Sharklet works through a hands-on experiment that simulates the accumulation of bacteria on surfaces with and without the pattern.

**Standards Met:**

***Lessons 1-6***

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

**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-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**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-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**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.

***Fabulous Fabrics***

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

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

***Polymer Properties***

**MS-PS1-1.** Develop models to describe the atomic composition of simple molecules and extended structures.

**MS-PS1-2.** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

**MS-PS1-3.** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

***Sharklet***

**MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.