Why Teach Mycelium:
Teacher's Introduction to Grow It Yourself™ materials and biology lessons

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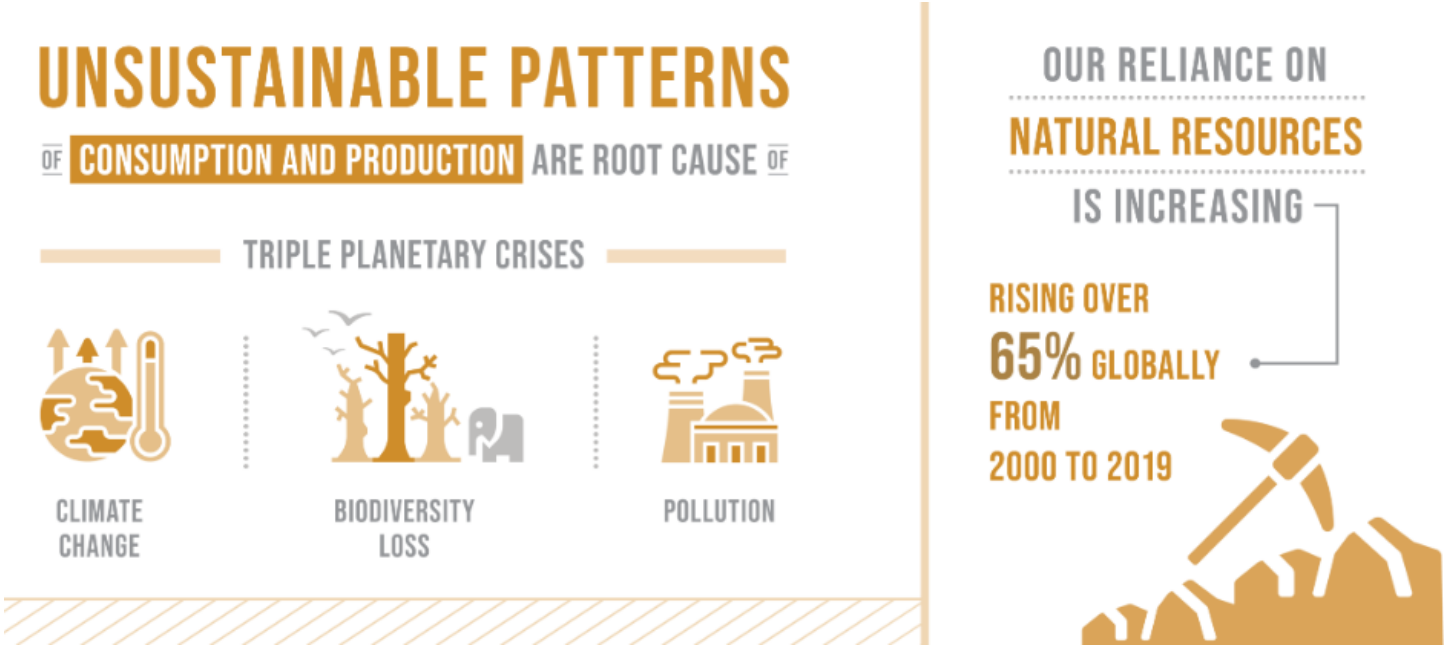
Do you want to instill a passion for sustainability with your students? Do you want to provide a hands-on, problem-based learning experience that will empower students to think critically and be creative?

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]*



Infographic Source

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 CO_2 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 food, electronics and other household 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 the agricultural products I use, like 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. 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.

Continue reading and watch a video for more on Ecovative's "Why Mycelium" page.

Try out Grow.bio's Grow It Yourself™ mycelium material

Ready to get your students working with mycelium? Order our Grow It Yourself™ material for use in your classroom.

Follow along with the Grow.bio instructions here.

Use the Biology curriculum alongside the GIY material

Teachers, lose the stress of incorporating something new to your classroom! The Biology unit consists of 10 lessons that students can move through alongside growing their own mycelium. It is the perfect companion to grow engagement and deep understanding of the GIY material. We recommend completing at least Lesson 1 before starting the GIY material. As you wait for your mycelium to grow, you can continue the sequence in the most convenient way for you. Short on time? No worries. Every lesson is stand-alone and can be used without doing the whole unit. Pick out what works for your classroom and get excited about mycelium!

Every lesson fosters active learning, where students co-create their own knowledge as they move through the activity. They contain:

- A *problem-based learning model* where students are first introduced to biofabrication and continue the unit until they have successfully made their own mycelium product.
- *Downloadable manipulatives* that the teacher can print and reuse
- *Kinesthetic activities* where students can move and collaborate with others

The biology curricular companion is appropriate for life science, grades 7-12, and incorporates the following topics:

- Recycling nutrients in the ecosystem
- Kingdoms of life
- Cell structure
- Protein synthesis
- Food webs
- Cell respiration
- Data interpretation

NGSS & Common Core Standards	
Lesson 1: Introduction to fungi	Lesson 2: Fungi life cycle
NGSS.SEP.8 - Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. CCSS.RI.9-10.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. CCSS.RI.9-10.2. Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text. CCSS.SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. CCSS.SL.9-10.1d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. CCSS.L.9-10.4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 9–10 reading and content, choosing flexibly from a range of strategies.	NGSS.CCC.5 - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. NGSS.CCC.5 - Energy drives the cycling of matter within and between systems. CCSS.RH.6-8.7. Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.
Lesson 3: Fungi protein synthesis	Lesson 4: Being multicellular
NGSS.HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. NGSS.MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.	NGSS.MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. NGSS.MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
Lesson 5: The food chain	Lesson 6: Feed the fungi
NGSS.CCC.5 - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. NGSS.CCC.5 - Energy drives the cycling of matter within and between systems.	NGSS.MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. NGSS.CCC.6 - Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Lesson 7: Cell respiration in fungi	Lesson 8: Problem with plastic
NGSS.HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. NGSS.CCC.1 - Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. NGSS.SEP.2 - Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. NGSS.SEP.3 - Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. NGSS.SEP.3 - Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.	NGSS.SEP.4 - Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. NGSS.SEP.7 - Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. NGSS.SEP.7 - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. CCSS.SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. CCSS.SL.9-10.1c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.
Lesson 9: Mycelium alternative	Lesson 10: Show what you know
NGSS-MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. NGSS-HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	NGSS.SEP.1 - Ask questions to clarify and refine a model, an explanation, or an engineering problem. NGSS.SEP.6 - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. NGSS.SEP.6 - Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. NGSS.SEP.7 - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Take a sneak peek at our future subjects!

Use mycelium as a STEAM learning tool! Want to host a science or design fair around a centralized sustainability theme? Incorporate thematic teaching among different subject areas? Check out our future subjects that will be available to download and use alongside GIY material.

Biology Extended	• Evaluate the use of animals in the current food system. • Evaluate the nutritional benefits of mycelium as a meat alternative. • Transpiration and translocation in fungi
Scientific Method	• Test the effect of substrates on the density of mycelium products. • Test the effect of various temperatures on the decomposition of the mycelium products. • Test the tensile strength of mycelium products.
Chemistry	• Observe the hydrophobicity of mycelium products. • Test the flame retardant properties of mycelium products. • Create a plastic and natural glue using everyday materials. • Evaluate mycelium as a plastic and resin alternative.
Engineering Design	• Design and 3D print a mycelium mold for a specific purpose using CAD software. • What makes good packaging? Evaluate the use of mycelium bricks as a building material. • Create a smaller scale structure from history using mycelium bricks. Attempt to make it as strong as possible.
Math	• Create a mathematical abstraction to help conceptualize the scale of the packaging industry. • Design a package to safely deliver a product. • Calculate your agricultural footprint, or plastic footprint.
Business	• Create a marketing campaign for mycelium products. • Conduct market research on biofabrication. • Create an advertisement for a mycelium product. • Consider the environmental responsibilities of a business.
Art & Design	• Evaluate the benefits of mycelium as a sculptural material. • Design a 3-dimensional art piece using mycelium. • Explore the industrial and artistic uses of mycelium around the world.