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Natural Sciences Education

WEB LESSONS AND LEARNING ACTIVITIES

# Mycology in the agriscience classroom: A curriculum based on wild foraged mushroom certification

**Carley Kratz**[1] | **Aaron McKim**[2] | **Gregory Bonito**[3]

[1]Lenawee Intermediate School District, Center for a Sustainable Future, Adrian, Michigan, USA

[2]Department of Community Sustainability, Michigan State University, East Lansing, Michigan, USA

[3]Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, Michigan, USA

**Correspondence**
Carley Kratz, Lenawee Intermediate School District, Center for a Sustainable Future, 1372 N. Main St., Adrian, MI 49221, USA.
Email: carley.kratz@lisd.us

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**Abstract**

The overarching goal of this impact project is to make mycology accessible to more agriscience educators and students. Lesson plans were prepared to link core competencies and science standards to the Wild-Foraged Mushroom certification. Incorporating mycology into the classroom has many benefits, including discussions on food safety and regulation, the role of ecology in agroecosystems, and taxonomic identification skills. Fungi also play many different roles in the ecosystem, including decomposers, mutualists, and parasites. Lesson plans in three topic areas were produced: mushroom identification and fungal ecology, mushroom growth and food safety, and mushrooms as a renewable resource. Examples of hands-on learning and connections to the Wild-Foraged Mushroom certification are provided. This certification is available in the state of Michigan; however, lessons could be adapted for use in other regions of the United States. Looking at taxonomy, ecology, food science, and economics through the lens of mycology is an engaging way to motivate students while potentially helping them earn a certification.

## 1 | INTRODUCTION

Fungi play many important ecological roles, including parasites, decomposers, and mutualists, yet the field of mycology is often overlooked in science curricula (Irga et al., 2020; Moore et al., 2005; Rambold et al., 2013). The overarching goal of this impact project is to bring fungi to the forefront of lesson plans designed for the agriscience classroom at the secondary level. The curriculum presented here can be adapted to many regions of the United States; however, it is focused on the State of Michigan. Part of the impetus for designing these lessons was to help students identify the macrofungi highlighted in the Midwestern American Mycological Information (2024) Wild-Foraged Mushroom Certification exam, which is overseen by the Michigan Department of Agriculture and Rural Development (2024). The Michigan Department of Education has approved this credential through the Perkins V legislation, which aims to increase certification opportunities for secondary education students through the Career to Pathways Grant (Michigan Department of Education, 2024b). Although the primary audience for the curriculum is Michigan science teacher, lessons could be implemented in a broader geographic region with minor adjustments.

Teaching students about science using the lens of mycology may peak their interest in other scientific pursuits. Three lessons are presented here to accomplish that goal. Using the identification lesson can be a great way to introduce students to the field of taxonomy with skills that can be applied to other living organisms. The lesson on food safety includes important points on cottage food law that can be applied to other products. The final lesson includes information on sustainability and renewable resources, which are something we all must consider as we seek solutions to problems on a local, national, and global scale. I hope these lesson plans will be easily accessible, flexible, and engaging enough that more educators feel comfortable including fungi in their curriculum.

## 2 | PURPOSE AND OBJECTIVES

The primary objective of this impact project is to present lesson plans related to the Perkins V Core Competencies for the 03.0000 Natural Resources & Conservation CIP Code that are related to the Wild-Foraged Mushroom Certification (Michigan Department of Education, 2024a). Twelve of the 17 competency codes can be addressed in relation to the certification and mycology. This includes all four Perkins Courses in the Perkins V Core Competencies. Lesson plans were also aligned with the Michigan K-12 Science Standards, which are based on the National Next Generation Science Standards (Michigan Department of Education, 2015). A secondary goal of this impact project is to prepare students for the Wild-Foraged Mushroom Certification class and exam. This will be achieved by focusing on mushroom identification, harvesting and storage, and poisonous look-alikes.

## 3 | NEED

The State of Michigan's 60 by 30 goal aims to have 60% of working-age adults obtain a certification or college degree by 2030 (State of Michigan, 2024). This will give Michigan residents more skills, knowledge, and opportunities to enhance their livelihoods. Wild-foraged mushrooms are now being sold more frequently at farmer's markets and online, which legally requires the Wild-Foraged Mushroom Certification in the State of Michigan (Michigan Department of Agriculture & Rural Development, 2024). In Michigan, certified wild-foraged mushroom hunters earn $1000 annually on average from morel sales alone, with more potential income from other mushroom species (Malone et al., 2022). Professional wild-foraged mushroom harvesters of various species have an income of 5% above average in rural populations in Finland (Cai et al., 2011). The Department of Education has approved the Wild-Foraged Mushroom Certification for the Natural Resources and Conservation CIP code as a certification for secondary students in the Agriculture, Food, & Natural Resources career pathway (Michigan Department of Education, 2024a). Some of the online resources for mycological education, such as the North American Mycological Association (2024) or the Mycological Society of America (n.d.), provide links to ideas for lessons on fungi; however, these can be difficult to synthesize into a cohesive curriculum. An easily accessible curriculum related to mycology that meets the new Perkins V Core Competencies has not been developed. The lessons presented here will meet this need by developing mycology lessons aligned with both the Perkins V Competencies and the Wild-Foraged Mushroom Certification.

**Core Ideas**

- Fungi can be used to teach students about ecology, food science, and renewable resources.
- Mycology lessons are linked to core competencies and science standards.
- Lesson plans include learning objectives, standards, pacing, Google Slides lectures, worksheets, and activities.
- Lessons were built to be flexible so that they can be adapted to different grade levels and class structures.
- Students can be engaged in hands-on learning about ecology, taxonomy, food safety, and economics using fungi.

## 4 | LITERATURE REVIEW

The main objectives for this impact project were to design a curriculum related to the Perkins V Core Competencies and to prepare students for the Wild-Foraged Mushroom Certification exam. An underlying goal was to make mycology more accessible for educators and students. Mycology is a field that is notorious for being difficult to study. Albeit unintentional, there is some degree of gatekeeping in the mycological community. It was difficult to simplistically synthesize the copious amounts of information to describe, classify, and cultivate mushrooms. I have carefully balanced technical terms with more common language, kept lectures brief, and designed engaging student activities to build excitement around fungi. Countless other fungi-related topics can be applied in the agriscience classroom, such as mycofiltration and water quality, food, medicine, and nutrition, biofuel production, and coarse woody debris and forestry.

Mycology has proven to be important in agriculture, food systems, and natural resources. Fungi are present in nearly every environment, which makes them accessible to study. In agriculture, we often focus on fungi as parasites or plant pathogens, but they can also be mutualists, such as mycorrhizal fungi. Understanding fungal interactions with our crop plants allows us to design strategies to enhance yields and lower costs, making farming more sustainable (Rambold et al., 2013). Fungi also produces many economically important secondary metabolites, including antibiotics and enzymes related to biofuel production.

Despite the economic and environmental relevance of fungi, mycology is not often a focus in educational settings (Irga et al., 2020; Moore et al., 2005; Rambold et al., 2013). Many secondary students have misconceptions related to the classification and ecological role of the kingdom of fungi, often confusing them with plants (Karakaya et al., 2023). Irga et al. (2020) reviewed the course offerings at 11 universities and found only one course focused on mycology, and this course was related to the field of medical mycology. Most curriculums incorporate an overview of mycology into a unit on botany or ecology, but very few offer dedicated classes on the topic. One barrier to including fungi in the curriculum may be that teachers need to become more familiar with how the fungal kingdom relates to the field of biology (Moore et al., 2005). Finding reputable sources for information related to fungi can be a challenge. It is important to be cautious about online information related to fungi, particularly when students are involved. Some social media posts may give out incorrect information or may be focused on psilocybin mushrooms and their psychedelic properties (Irga et al., 2020). This project aims to provide succinct lesson plans to address this gap in the curriculum and make mycology more accessible to all.

Many advances in DNA technology are now available to detect fungi in the environment, but mushrooms are accessible to everyone without the need for advanced laboratory equipment for identification. Martin and Watling (2016) suggest that teachers start by taking students into a nearby outdoor area for a foray (or field collection) of fungi and then bring samples indoors for spore prints and microscopy. Students learn proper documentation skills and how to make thorough observations during fieldwork (Martin & Watling, 2016). These are skills that can be applied to many different areas of science. It is important to demonstrate proper collection techniques by carefully digging up the mushroom, storing it in a separately labeled paper or foil container, and preserving it with refrigeration or drying (Martin & Watling, 2016). Michael Kuo (2024) presents a detailed guide to studying mushrooms on his website (mushroomexpert.com), but this may be too detailed for a simple introduction in class. The Fungi Foundation (n.d.) has a protocol for students to observe, photograph, collect, and preserve mushrooms. This protocol includes a reference label card for record keeping, which has been modified for student use. This website also offers a demonstration video on proper documentation during collection.

Following the foray, students can share their collections by displaying them in the classroom and organizing them based on their morphology or ecology (Martin & Watling, 2016). Morphological identification of fungi often requires background knowledge that is not easily accessible to the general public. Dichotomous keys, such as David Arora's (1986) Mushrooms Demystified, may be considered the gold standard for mushroom identification; however, they are complicated by a lot of terminology for the beginner to use. The identification wheels presented in the Fungi of Temperate Europe (Læssøe & Petersen, 2019) provide a concise way to graphically view the key features of the groups and families with visual representations of essential features such as gill or spore shape. These wheel guides are freely available at mycokey.com. The keys presented at mushroomexpert.com (Kuo, 2024) are simple enough to be used effectively in the classroom with a small amount of background knowledge of morphological terminology. This website contains excellent information on identification with photos of key characteristics.

The diversity of fungi collected from a foray can be measured in different ways, including morphology and ecological roles. The MycoDiversity Game can incentivize students with a competition to see who can get the most diverse collection during a foray. It can also be adapted to discuss ecological clades of fungi (Hibbett, 2009). For more advanced students, this game can be used to show relations between taxa using phylogenetic trees while also studying morphological identification. One way to gamify a mushroom-collecting foray would be to have students compete to find as many different ecological roles as possible, such as litter decay, wood decay, mycorrhizal, lichen, and parasites (Hibbett, 2009). Fungi play many different roles in our ecosystems and easily lend themselves to discussions on ecological interactions between species. Something as simple as lichens growing on a rock may be a way to demonstrate the abstract idea of commensalism to students. Competition of belowground mycelium is nearly impossible to see, but the competition between two fungi on a Petri dish can be measured easily in a classroom. Martin and Watling (2016) describe how cultures of soil fungi or spores can be prepared for classroom use.

Giving students an outside audience to validate their work is essential in many models of teaching and learning (The Buck Institute, n.d.; Crandall et al., 2022; McKim et al., 2019). Students can be assigned to a type of fungus and prepare a short presentation related to its identification and role in the ecosystem and everyday life. This will help students learn about fungal diversity and build leadership skills by providing an opportunity to practice public speaking. Tom Volk's Fungus of the Month (2010) can be used to assign students a fungus related to their birth month and also includes fungi related to various holidays. Citizen or community science is one way students can enhance their identification skills and share their data with the global community. Online platforms, such as iNaturalist (2024), allow students to contribute data on mushroom identification in an area during a foray, which can help monitor the biodiversity of that area by crowdsourcing data (Irga et al., 2020). iNaturalist (2024) can also be used to confirm mushroom identification since mycologists across the world verify data, although it is important that students use other resources to verify identifications. Making students aware of fungi, getting them in an outdoor environment, and allowing them to contribute in meaningful ways to the body of scientific knowledge will bolster student confidence and interest in mycology.

## 5 | LESSON PLAN DESCRIPTIONS

The curriculum has three focus topics: mushroom identification and ecology, mushroom growth and food safety, and mushrooms as renewable resources. Lesson plans related to each of these topic areas were developed. This includes general directions for activities, alignment to standards, links to Google Slides presentations, handouts, and links to helpful online resources. In Lesson 1, mushroom identification and fungal ecology were combined into a larger lesson plan, taking 5–8 h, as both topics benefit from a mushroom-collecting foray, which can be time consuming. This lesson will introduce students to fungi and prepare them for the skills needed for the Wild-Foraged Mushroom Certification exam. Lesson 2 focuses on mushroom growth and food safety. This lesson includes directions to grow mushrooms indoors, preparation of mushrooms as food, basics of cottage food law, and common toxic mushrooms found in the US Midwest. Two to three hours should be dedicated to Lesson 2. Lesson 3 focuses on mushrooms as a renewable resource. This lesson introduces students to laws related to foraging for wild mushrooms, sustainability, and the product lifecycle analysis. This lesson should take approximately 2–3 h.

## 6 | LESSON 1

### 6.1 | Mushroom Identification and fungal ecology

#### 6.1.1 | Scope and sequence

This lesson was designed for high school students enrolled in an agriscience class. It is best done in the fall due to the higher diversity of mushrooms, but it could be done in the late spring. The mushroom foray could be used as a team building exercise early in the school year so that students work together while learning content related to identification skills and ecology.

The lesson includes an introductory lecture in a Google Slides format. This lecture covers basic terminology related to mushroom identification and fungal ecology. A handout from the Fungi Foundation on scientific collection protocols and an accompanying video are recommended before taking students outdoors for the foray. This background information and foray should take approximately 2–3 h of class time. Fungal identification, scoring of the MycoDiversity Game, and reporting to iNaturalist (2024) should take an additional 3–5 h of class time. The lesson includes some extension activities if more time can be dedicated to fungi in the curriculum or for students interested in learning more.

#### 6.1.2 | Perkins V core competencies

A4. Identify and describe plants, wildlife, rocks/minerals, and soil.
B1. Keep accurate records by obtaining and analyzing data and producing technical reports.
B2. Monitor and record soil and water quality, populations of plants, wildlife, and pathogens.
D1. Analyze and explain the nutrient cycles in relation to biotic and abiotic components within the environment.
D2. Analyze and explain how species interact in the environment, including native, exotic, and invasive species, and human impact.

#### 6.1.3 | Next Generation Science Standards of focus

1. HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
2. HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
3. HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
4. HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

#### 6.1.4 | Objectives

The objective of this lesson is to familiarize students with the kingdom of fungi. This includes basic mushroom identification and the various ecological roles that fungi play. Proper record-keeping skills for sample collection and documentation will also be learned.

#### 6.1.5 | Materials needed and suggested resources

Required materials are as follows: Student computers, copies of reference labels for collection, pens, wax paper, or aluminum foil for collection, and see the following suggested sources for reference: Lecture on Mushroom ID and Fungal Ecology (https://docs.google.com/presentation/d/1Va0v8tVe6kgY8irSgAG3NAkp-gZvMN5wOkHNizRKJig/edit#slide=id.g273d4ee1fa7_0_1), Fungi Foundation Collection Protocol (https://www.ffungi.org/campaign/what-you-see-matters) and Reference Labels (https://docs.google.com/document/d/1CoDh5-yeAlpFoYOSz2VI2931zrYTXALH09ro1_4PP64/edit?tab=t.0), MycoKey Fungi of Temperate Europe Identification Wheels (https://www.mycokey.com/), Mushroom Expert Online Dichotomous Key (https://www.mushroomexpert.com/major_groups.html), and Simplified MycoDiversity Game Directions (https://docs.google.com/document/d/19chJhhV6cmuI27xQSQrJY2jku8RTpNPMtkQM5QcfSlU/edit?tab=t.0).

Optional materials are as follows: iNaturalist (2024) app with Seek, microscope, paper or glass slides for spore prints, student phones, or cameras.

### 6.1.6 | Engagement activities

*Part 1 (2–3 h)*
A short video by National Geographic, "You didn't know mushrooms could do all this" (https://www.youtube.com/watch?v=BlcKBKJ8uro), can be played to get students' attention. Next, the lecture on Mushroom ID and Fungal Ecology (see above) is presented. This lecture can be broken up into different sections as needed, depending on the length of the class periods or topic of focus. This lecture should be available to students for future reference. The Fungi Foundation Collection Protocol (see above) should be discussed with students, and the video from their website can be played to show proper documentation. It is recommended that no >1 h be spent on this background portion.

The second hour of class time is spent on the collection foray. Students should be cautioned about the dangers of poisonous mushrooms prior to the foray. Mushrooms should not be tasted under any circumstances, unless express permission is granted by the teacher. While handling mushrooms alone will not cause poisoning, some mushrooms are fatal if ingested. Additionally, students should be prepared with a safety talk including staying in groups, bringing water and first aid supplies, poison ivy identification, and knife skills. While a knife can be a helpful tool, it is not required. To prepare for the foray Reference Labels (see above), pens, and wax paper or aluminum foil should be distributed to students. Students should be grouped in teams of 3–5. It is suggested that each student fill out their own reference label, and the group work together to find and collect one unique fungus sample per student during the foray. Students should be reminded to look for fungi of various textures and sizes during the collection foray. Teams will compete to find the most diverse fungal collection based on identification and ecological role.

Optionally, students can download the Seek app available through iNaturalist (2024) to aid in identification. Observations can be submitted to the iNaturalist (2024) database. To make a spore print (optional, but helpful for identification on day 2), mushrooms should be set out with the hymenium (gills or pores) facing down on paper or glass slides overnight in the classroom.

*Part 2 (3–5 h)*
Identifications can be confirmed using reference materials such as Mushrooms Demystified, MycoKey Fungi of Temperate Europe Identification Wheels (see above), or Mushroom Expert Online Dichotomous Key (see above). The iNaturalist (2024) Seek app works fairly well for fresh samples, but will not work as well on dried specimens. While this app is fairly reliable and backed by expert taxonomists in many fields, it is sometimes lacking for fungal identification because fungi are notoriously difficult to identify, so the app should not be relied on as the only source of information for identification for mushrooms. It is also good practice for students to confirm identifications using reference materials in addition to the app. Identification to order or family level is recommended before proceeding with the MycoDiversity Game. If spore prints were made, the color can help with identification. Spores can be made into a wet mount to view under the microscope. Approximately 2–2.3 h should be spent on identification.

The Simplified MycoDiversity Game Directions (see above) include two versions of the game that can be played to see which team has the most diverse collection. Teams should score their collection based on the rules for the MorphoDiversity Game first, then the EcoDiversity Game second. Results and rankings can be shared with the class, and all students can view the combined collection. This should take 1–2 h.

### 6.1.7 | Assessment

This lesson is designed as an introductory activity to the Kingdom Fungi; therefore, suggested assessments are formative rather than summative. Formative assessments could include examining student reference labels for completeness, the ability to use information presented on mushroom identification to correctly identify samples collected, the use of vocabulary to describe mushroom morphology, and correctly determining the ecological role of samples.

### 6.1.8 | Differentiation (support and extension)

Before beginning this lesson, students may need to be introduced to dichotomous keys. If so, each student group could make a key based on the 3–5 fungi they collected. This artificial key should not include "not as above" answers and give distinctive characteristics for each fungus. This could be done as a warm-up activity before the foray the following day using teacher-collected specimens. This activity could also be done using the specimens collected during the foray instead of the MycoDiversity Game.

It may be helpful for the teacher to demonstrate proper collection and documentation techniques in the field before students begin the foray independently with team members. Teachers should monitor the foray activities and help struggling students locate fungi as needed.

Using iNaturalist (2024) requires users to download an app and share their location, which may or may not be something students choose to do on their personal cell phones. The Seek app can be used separately from iNaturalist (2024) and does not require sharing personal information. It is suggested that the teacher submit some observations to iNaturalist (2024) to show students the citizen/community science process. These observations could be taken prior to the foray. The map of observations can be viewed as a class following the foray.

If time permits, the video Fantastic Fungi could be played and discussed. The student version of the video is accessible from the website of Fungi Foundation Education (https://fungieducation.thinkific.com/). It also contains a curriculum that could be used to generate questions related to the video.

The full version of the MycoDiversity Game Directions (https://hibbettlablog.wordpress.com/wp-content/uploads/2018/10/game-rules.pdf) includes many versions of the game that can be played to see which team has the most diverse collection. The basic game uses phylogenetic trees and requires identification to the genus level. This is suggested for more advanced students.

If it is not possible to have a foray outdoors, then flashcards could be used to mimic a foray. Flashcards could be hidden throughout the classroom or school, and students could find them. The flashcards could have a photo of the mushroom on the front and description on the back. The Mycology Club at the University of Minnesota (2024) has a set of flashcards freely available on their website that would work well for this purpose.

# 7 | LESSON 2

## 7.1 | Mushroom growth and food safety lesson plan

### 7.1.1 | Scope and sequence

This lesson was designed for high school students enrolled in an agriscience class. It can be done anytime during the school year, including winter. It is suggested that mushroom grow kits, such as oyster mushrooms, be ordered a week or two in advance so that mushrooms are available for cooking and processing. It is not recommended that wild-foraged mushrooms be prepared in class without a certified expert to identify mushrooms and parental permission for liability purposes. This lesson would be best done following a lesson on mushroom identification and ecology (see Lesson 1).

The lesson includes an introductory lecture in a Google Slides format. This lecture is divided into two parts: general food safety and MDARD regulations for selling wild-foraged mushrooms and common mushroom toxins. This background information, cooking mushrooms grown in class, and transferring mycelium to grow new mushrooms should take approximately 1–2 h of class time.

### 7.1.2 | Perkins V core competencies

A1. Examine and summarize health, safety, and environmental regulations in AFNR organizations.

A2. Develop and practice plans to handle emergencies and common hazards.

C5. Describe how natural resources are harvested, processed, and turned into final products, and how this can be done sustainably.

### 7.1.3 | Next Generation Science Standards of focus

1. 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.
2. HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

### 7.1.4 | Objectives

The objective of this lesson is to familiarize students with the Michigan modified food code as it relates to processing and selling wild-foraged mushrooms, common toxins found in wild mushrooms, and how to grow and cook cultivated mushrooms.

### 7.1.5 | Materials needed and suggested resources

The required materials are as follows:

1. Mushroom grow kits (Back to the Roots or North Spore are reliable kits on Amazon), toilet paper rolls, plastic bags,

hot water (from pot or hotpot), extra trays or tote to handle hot material (see lecture on Michigan mushroom sale laws and fungal toxins [https://docs.google.com/presentation/d/1bI2GPFo1aK71uAE09Rkt5j0ei9JppYtQUFCpWAncZD4/edit#slide=id.g273e1711b11_0_91]).
2. Saucepan, heat source, butter or oil, utensils (see video on oyster mushroom growing with toilet paper [https://www.youtube.com/watch?v=IHWL2x-EXTc&t=12s]).
3. Kahoot game review (https://create.kahoot.it/share/michigan-mushroom-laws-and-toxins/aa5002b6-5281-44cf-a9c1-cfa1311dfa6f) and student computers.

Optional materials are as follows: Pressure cooker, autoclave bags, straw or wood pellets for substrate, 70% rubbing alcohol, gloves, and Martha tent.

#### 7.1.6 | Engagement activities

Students should help to prepare mushroom grow kits 1–2 weeks before the lesson. This involves soaking them overnight in water and then misting them daily. Two grow kits should be plenty to produce mushrooms for approximately 30 students to sample. This lesson should be done when the mushrooms have fully fruited. On the day of the lesson, the lecture on Michigan mushroom sale laws and fungal toxins (see above) is presented to the students. This lecture should take approximately 20–30 min. Discussion and questions should be encouraged at the teacher's discretion.

Students can help to process and cook the mushrooms by carefully slicing them from the block of substrate and cooking them in the saucepan with butter or oil (or the teacher can demonstrate this). All proper food safety protocols should be followed; the area should be disinfected with a food-safe cleaner, and hands should be washed. The difference between the cultivated mushrooms prepared here and wild-foraged mushrooms can be discussed. While the mushrooms are cooking, the Kahoot game review (see above) can be played. Mushrooms must be thoroughly cooked for at least 15–20 min. Water should also be boiled at this time for mushroom cultivation using toilet paper (a hot pot works for this).

The substrate block from the mushroom kit can be broken up into smaller chunks either with a knife or by tearing pieces off with clean hands. Students can place a toilet paper roll in a plastic shopping bag, and then place the bag in or on a tote or tray. Hot water is poured into the bag to soak the toilet paper roll. The tote or tray helps students to move the bag around the room and not burn themselves. The toilet paper roll should be saturated without having extra water in the bag. A small handful of substrates from the mushroom grow kit will be added to the toilet paper roll once it is warm to the touch. The bag can then be tied shut and kept in a dark location. The bag should be checked once a week to view the white growth of mycelium and to check for contamination (usually green mold). Bags with contamination should be discarded. Setting up the new mushroom toilet paper growth bags will take approximately 20–30 min, depending on the size of the class. Cooked mushrooms can also be sampled during this time.

#### 7.1.7 | Assessment

This is designed as an introductory activity to the Michigan modified food code, mushroom toxins, and cooking and growing cultivated mushrooms. Therefore, suggested assessments are formative rather than summative. Formative assessments could include class discussion and the ability of students to follow directions to process and grow fungus. The review Kahoot game is meant to be a formative assessment but could be adapted into a summative assessment.

#### 7.1.8 | Differentiation (support and extension)

Students should be encouraged to sample the mushrooms cooked as a class, but student allergies and mycophobia should be considered.

The optional list of materials includes supplies for students to grow mushrooms in a way that is more closely aligned to industry while still using accessible materials in the classroom. This is why a pressure cooker is suggested to sterilize bags and media instead of an autoclave. Keep in mind that the sterilization setting on a pressure cooker may take 1–2 h, so substrate may need to be transferred the following day, or substrate bags can be sterilized in advance. Surfaces, tools, and gloves should be disinfected using 70% ethanol or isopropyl alcohol. These materials will cost more than the method using toilet paper but are less likely to encounter contamination and may produce more yield. Students can continue growing new batches of mushrooms as long as the mycelium is not contaminated. Contamination will often look like green mold (*Trichoderma* spp.).

If the Kahoot game is made into a summative assessment, then accommodations should be made as necessary to support students with IEP or 504 plans.

## 8 | LESSON 3

### 8.1 | Mushrooms as a renewable resource lesson plan

#### 8.1.1 | Scope and sequence

This lesson was designed for high school students enrolled in an agriscience class. This lesson is not weather dependent and could easily be done in the winter months. It could be done independently of the lessons on mushroom ecology, identification, and growth (see Lessons 1 and 2).

The lesson includes a Google Slides presentation on laws and regulations related to the collection of wild mushrooms, how to forage sustainably, and how mushrooms are a renewable resource. A renewable resource is considered to be something that can grow back in a relatively short time frame (<100 years), and fungal mycelium are included as examples in this lesson. Fungi can be used for building materials, fabrics, packaging, food, medicine, and much more. The Google Slides presentation ends with an introduction to life-cycle assessments for products. This introduction ties to the second portion of the lesson, in which students research a product made from fungal mycelium and compare it to a traditional product, listing the pros and cons in a life cycle analysis. The lecture and activity should take 1–2 h of class time.

### 8.1.2 | Perkins V core competencies

C2. Analyze and describe laws related to natural resource management and protection.
C4. Analyze and explain how issues, trends, technologies, and public policies impact society, the economy, and the environment.
C6. Analyze and explain the pros and cons of renewable versus non-renewable energy products.
D3. Apply scientific principles to natural resource stewardship and management activities to enhance the quality of an ecosystem.

### 8.1.3 | Next Generation Science Standards of focus

1. HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
2. HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
3. HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
4. HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
5. HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
6. HS-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.

### 8.1.4 | Objectives

The objectives for this lesson include familiarizing students with basic laws and best practices related to wild mushroom foraging, the concepts of sustainability and renewable versus non-renewable resources, and product life cycle assessments.

### 8.1.5 | Materials needed and suggested resources

The materials used are student computers along with the following suggested sources: mushroom foraging laws and economics (https://docs.google.com/presentation/d/187VSEOaZyfaGRe9lKDAiW3xPOINvIWbsxevnhw6NuhQ/edit#slide=id.g273d4ee1fa7_0_1) and mushroom product life cycle analysis worksheet (https://docs.google.com/document/d/17SsaL-aWLcF8oAC_04yafCuVstVd-B5AKxVDiMCFDEs/edit?tab=t.0).

### 8.1.6 | Engagement activities

To begin this lesson, students should brainstorm keywords related to sustainability or renewable resources. These keywords can be written down individually on scrap paper for 1–2 min, then shared aloud with the class and written on the whiteboard. These keywords should be referenced during the lecture. Next, the lecture on mushroom foraging laws and economics (see above) can be presented to students. This lecture ends with an introduction to life cycle assessment for products. This portion of the lesson should take about 30 min.

Next, students should be split into small groups (three to five) to conduct research on the mushroom product life cycle analysis worksheet (see above). Each group can be assigned a different product (building materials, packaging, or clothing). It should be made clear to students that life cycle assessments are very complex and require a lot of research by a company. Therefore, each student should thoroughly research the pros and cons of their products for each category of the life cycle analysis (resource recovery, manufacturing, packaging and distribution, use, and end of use). There is no single correct answer, but more information will help them present their results to the class. Students should be given 30 min to 1 h to research their products and fill out the table on the worksheet. Students will then present their results to the whole class. This could be done verbally, using student worksheets under a document viewer, or with students writing out their pros and cons on the whiteboard. Student presentations should be given

30 min. This portion of the lesson will take 1–1.5 h, depending on how much time is allocated for student research and the number of groups for presentations.

#### 8.1.7 | Assessment

This lesson was designed as an introductory activity to sustainable foraging, mushrooms as a renewable resource, and life cycle analyses of products. Assessments were designed to be formative rather than summative. Formative assessments could include class brainstorming of keywords and connections made during class discussion and lecture. The mushroom product life cycle analysis worksheet is meant to be a formative assessment but could be adapted into a summative assessment. As a formative assessment, it can be used to see how thoroughly students answer the questions and consider the pros and cons of each portion of the table. Some questions may be challenging to answer as some mushroom-based products are still being developed for commercial use. If it is made into a summative assessment, then clear expectations should be set for students.

#### 8.1.8 | Differentiation (support and extension)

Student grouping should be carefully considered for the active participation of all group members. Each group member could be assigned to one of the five life cycle assessment categories to help ensure equal distribution of group work. The teacher can assist struggling students by suggesting keywords to look for as they search for background information to fill out the table.

Additional products such as biofuels, nutritional supplements, or mycofiltration could be added to the life cycle analysis. These may be more challenging topics to research. An alternative way to assign groups could be to split the class and have half research the mushroom-based products and the other half research the traditional product. Results could then be compared in a debate-type format where each group defends their product type based on the five stages of the life cycle analysis.

## 9 | FUTURE WORK

I suggest three improvements to this curriculum: creating summative assessments, incorporating industry connections, and studying for the Wild-Foraged Mushroom Certification exam. Additionally, this curriculum was written with a focus on the US Midwest and the state of Michigan, in particular. Future work could include adapting lessons for other regions. The formative assessments in these lessons could be adapted to create summative assessments, but due to the introductory nature of the lesson plans. I did not include official summative tests here. There are many ways to build connections with industry partners, such as visiting local mushroom farms or inviting guest lecturers into the classroom. Many Michigan-based companies are on the cutting edge of mycological research and are willing to share their knowledge. This includes Myconaut, which was recently awarded a grant to examine ways fungi can clean up water contamination, and Midnight Harvest, which is exploring ways to grow morel mushrooms in cultivation. The Michigan Mushroom Hunters Club also offers public forays where students and educators can learn from experts. Lastly, if students aim to pass the Wild-Foraged Mushroom Certification exam, they should register and begin studying early. Passing the exam will require some studying outside of the classroom. Exams are offered throughout the year in various locations in Michigan throughout the year (Midwest American Mycological Information, 2024).

## 10 | GLOSSARY

**Aborted** (form): A mushroom whose growth was terminated prior to maturity, resulting in a stunted, deformed, or transformed fruiting body. Typically occurs from inadequate environmental conditions and/or mycoparasitism.

**Agaricales**: An order of Basidiomycota mushrooms with a cap, stipe, and hymenium of gills from which basidiospores are produced.

**Annulus**: Ring- or collar-like tissue, sometimes found around the stipe of some mushroom species; it is the remnants of the partial veil, which covered the spore-bearing surface of the mushroom (commonly referred to as "Ring").

**Apex** (of stipe): The top of the stipe and point of connection to the cap.

**Apothecium**: A spore-bearing structure consisting of asci found in cupped-shaped fruiting bodies of Ascomycetes.

**Arbuscular mycorrhizal**: A distinctive symbiotic relationship forming between an ancient and single lineage of fungi in the Glomeromycotina that associate with the roots of plants in which the fungus penetrates the cells of the plant for nutrient exchange. Although common mutualists in the roots of most plant species, arbuscular mycorrhizal fungi do not produce large fleshy fruiting bodies (compared to ectomycorrhizal fungi).

**Areolate**: A mushroom, especially the cap portion, which has a "cracked" appearance; typically, as the mushroom ages.

**Asci (plural)**: Sac-like structures where ascospores are produced in mushrooms in the Ascomycota phylum (singular ascus).

**Ascocarp**: The name given to a sexually produced fruiting body in the phylum Ascomycota.

**Ascomycete**: A taxonomic class of fungi whose spores develop in sacs called asci.

**Ascomycota**: One of the two mushroom-forming phyla with sexually produced spores that develop in a sac-like structure called an ascus. Often these mushroom structures are cups or truffles (compared to Basidiomycota).

**Ascospores**: The sexually produced (products of meiosis) spores within the ascus of ascomycete fungi.

**Basal bulb**: The lower part of the stipe of a mushroom.

**Basidia**: Club-shaped structures where spores are produced (and released) in mushrooms in the phylum Basidiomycota (singular Basidium).

**Basodiomycete**: A class of fungi whose spores develop in basidia.

**Basidiomycota**: One of two mushroom phyla with sexually produced basidiospores develop on a club-like structure called basidium, which is the more traditional mushroom shape (compared to Ascomycota).

**Bolete**: A common name that refers to a group of mushrooms, which have a cap, stipe, and pore surface instead of gills or spines under the cap. Collectively refers to many genera and species of mushrooms.

**Bracket fungus**: A fungus growing laterally (sideways) from its substrate. For example, mushrooms of *Ganoderma* (synonym: shelf fungus).

**Brown Rot**: Decay of wood in which the mycelia of certain fungi, such as *Laetiporus* species, breaks down the cellulose of wood, leaving brown, corky, and chunky lignin-rich remains (compared to white rot).

**Bruise (stain)**: Any color change of the flesh of a mushroom when handled or damaged, typically when cut open.

**Butt rot**: Decay of trees in which the mycelia of certain fungi, such as *Grifola frondosa*, attack trees through their root system, producing decay and weakening in the trees' root system and heartwood. The mushroom is almost always positioned at, or near, the base or root buttresses of the tree.

**Button**: The name given to the immature stage of a fruiting body during fungal development. At this stage, mycelia swells to form these often spherical or egg-shaped "buttons," which emerge through the surface of substrate.

**Cap**: The top of a mushroom in the Agaricales (see Agaricales). Also called the pileus.

**Carcinogen**: Any substance or organism capable of causing cancer in living animal tissues.

**Cespitose**: Mushroom growth habit in which the mushrooms grow in dense clusters; the bases of the stems may be fused together or packed tightly.

**Chambered**: A description sometimes used to describe the inner area of a mushroom, which is seemingly hollow but broken into multiple, enclosed spaces. This may be observable in the entire fruiting body or only in the stipe.

**Clade**: Grouping of organisms sharing a common ancestor.

**Conk**: A general term for the fruiting body of polypore's growing on the face of, or from the base of, a tree.

**Cortina**: A partial veil that has a "cob-web like" appearance and functions as protective tissue covering the gills of some mushrooms during maturation. The young fruiting bodies of *Cortinarius* typically have cortinas.

**Cottage Food Law**: MDARD enacted this law in 2010 allowing individuals to manufacture and store certain types of foods in an unlicensed home kitchen. For the purposes of the Wild-foraged Mushroom Certification program, the end product must be sold directly to the consumer.

**Cross-venation**: Ridges that run longitudinally between the pits/ridges, gills, or pseudo-gills in some mushrooms. They can create ladder-like or net-like appearance on the spore-bearing surface.

**Cultivated**: Fungi that have been intentionally grown indoors, or outdoors, from spawn.

**Decurrent**: A description for when the gills, pores, spines/teeth extend from the cap, and starting to extend down the stipe of a mushroom.

**Deliquesce**: Dissolving into liquid; the process by which some mushrooms, especially species of *Coprinus*, release their spores.

**Detritus**: Dead, organic material produced by decomposition.

**Ectomycorrhizal**: A symbiotic relationship forming between a fungus and the roots of plants and/or trees in which the fungus forms an exterior structure on the roots for nutrient exchange. Most ectomycorrhizal fungi associate with and are mutually dependent on temperate forest tree hosts, and many produce fleshy fungi, some of which are edible and prized (compared to arbuscular mycorrhizal fungi).

**Egg stage**: An early developmental stage in the fruiting of species in the Amanitaceae or Volvariaceae; the term used to describe the immature form of a mushroom, which is covered completely by a universal veil (thin membrane), making it appear to look like an egg.

**Ellipsoid spore**: A spore, which is not a perfect circle but is stretched in an oval shape (also referred to as ellipsoid, ovate, or elliptical).

**Emesis**: Vomiting.

**Endophyte**: A fungus that occupies the spaces in between a plant's cells; inside any part of a plant (leaves, stems, roots, etc.) but does not necessarily change/effect cellular structure, play a role in nutrient exchange or cause disease.

**Eukaryote**: An organism whose cells contain a nucleus with genetic material in the form of chromosomes. All animals, plants, fungi, and several unicellular organisms are eukaryotes (compared to prokaryote).

**Exotic species**: Any organism intentionally or unintentionally introduced by human activity into habitats outside their native range or distribution. Also known as non-native species (compared to invasive species).

**Fairy Ring**: A pattern of fruiting in which a mushroom colony fruits to produce a ring or arc of mushrooms, usually from an evenly composed substrate. Perhaps most prevalent in Agaricales.

**False Morel**: A common name given to group of mushrooms in the genera *Gyromitra* and *Verpa*, which may resemble members of the genus *Morchella, some of which contain known toxins* (compared to True Morel).

**Fungi**: A kingdom of life; these eukaryotic organisms disperse by spores and feed on organic matter. Fungi are distinct from plants and animals. Forms of fungi include yeasts, molds, and mushrooms (singular fungus).

**Genus**: The taxonomic classification spans below family and above species. In binomial nomenclature, it is always capitalized and italicized (plural genera; compared to phylum and species).

**Gills**: Blade-like or plate-like structures making up the fertile tissue (hymenium) underside of some mushrooms' caps of the order Basidiomycota. Spore-producing reproductive structures called basidia are located on gills. Also known as the hymenium, lamella, or lamellae.

**Glandular dots**: Tiny, granular pieces of tissue on the stipe of a mushroom, typically a different color than the stipe making, the stipe appear dotted. Much smaller than a scaber (see scaber).

**Gleba**: The enclosed, spore bearing inner tissue of some fungi, especially puffballs and truffles.

**Globose**: A term used to describe the ball-like or globe-like shape of a spore.

**Gregarious**: Describes the growth habit of some mushrooms; loosely clustered or spread out as a loosely organized community but never cespitose.

**Hardwood**: A tree described as having broad leaves and whose seeds are enclosed in fruits or nuts.

**Heartwood**: The inner, central part of a tree or woody plant, which is nonliving, usually darker, and denser.

**Humus**: Organic compound of soil formed as leaves and other plant material decompose.

**Hygraphanous**: A color change of a mushroom, usually the cap, caused by absorbing or losing moisture and a ring effect. When the cap is wetter, it is more transparent. When the cap is drier, it tends to be more solid and not so transparent.

**Hymenium**: The fertile surface of a mushroom consisting of the spore-bearing structures. Often referred to as gills in the Agaricales.

**Hypha** (singular): Fungal cells; filaments or strands, which branch out to create the mycelial network (plural hyphae).

**Hypogeous**: Growing or living below the surface of the ground, such as the fruiting habit of truffle fungi.

**Invasive species**: A nonnative species, usually introduced intentionally or unintentionally through human activity, which has an adverse effect on native ecosystems (compared to exotic, nonnative species).

**Knot**: During the life cycle of a mushroom, this is the first stage of growth for a mushroom fruiting body. Hyphae bunch together to form a bulge, which then gives rise to a pinhead, that develops into a button, and then a mushroom.

**Laccate**: A mushroom with a lacquered, varnished, and/or shiny appearance, especially in bracket fungi. Also known as lacquered.

**Lacrimation**: Shedding tears, or shedding more tears than normal in response to an injury, irritant, or ingestion of toxin.

**Latent period**: The time period between exposure/ingestion of a toxin and the time symptoms start to appear.

**Latex**: Liquid that exudes when mushroom flesh or gills are cut; clear, milky, or colored. Especially in the genus *Lactarius*.

**Lichen**: a mutualism between algae or cyanobacteria living symbiotically among filaments of multiple fungal species and sometimes yeast.

**Loupe**: A small magnifying glass, set in an eyepiece, used by jewelers, mycologists, coin collectors, etc.

**Macroscopic**: Features that are visible to the naked eye and can be observed without magnification.

**Margin**: The outermost edge of the cap of a mushroom.

**MDARD** (Michigan Department of Agriculture and Rural Development): The State of Michigan Department, which certifies people who have attended a Midwestern Association of Mycological Information (MAMI) workshop and successfully passed a certification exam. Also, the State of Michigan Department is responsible for food handling regulations and food inspections.

**Microscopic**: Features so small, on the micron scale, such that a microscope is needed to observe them.

**Morphology**: Describing the physical (morphologic) features and structural characteristics of organisms (compared to taxonomy).

**Mushroom**: The common name given to the reproductive body, or fruiting body, of some fungi belonging to Basidiomycota.

**Mutualism**: A symbiotic relationship between two organisms in which both organisms benefit positively from the interaction.

**Mycelium**: The mass of hyphal tissue that makes up the vegetative and fruiting bodies of a fungus.

**Mycorrhiza**: Fungus growing in a symbiotic, often mutualistic, relationship with the roots of a plant or tree (plural: mycorrhizae, adjective: mycorrhizal).

**Mycology**: The scientific study of fungal biology.

**Mycoparasite**: A parasitic fungus that parasitizes another fungus.

**Mycophagy**: The practice of eating mushrooms.

**Mycophile**: A common name describing a mushroom or fungal enthusiast, especially a forager of wild mushrooms.

**Mycoremediation**: A branch of bioremediation focused on using fungi to degrade or decompose contaminants in the environment.

**National Forest**: A forest or natural area managed by the US Forest Service, emphasizing resource preservation but also providing multiple services and commodities such as timber, recreation, and grazing.

**National Park**: A pristine area preserving natural or historically significant features managed by the National Park Service; the focus is to protect natural and historic resources "unimpaired for future generations."

**Naturalize**: A species introduced into an ecosystem other than its own and has established a self-sustaining population.

**Nonnative species**: A species occurring in an area outside of its native range, introduced as a result of accidental or deliberate human activity, which may or may not adversely impact the ecosystem it occupies.

**Ornamentation**: Physical decorations, often used to characterize spore walls that may be "decorated" with spines, ridges, or other visual features.

**Ovoid**: The shape of a spore that is oval or egg-shaped.

**Parasite**: An organism living in or on another organism (host) and benefitting from it at the host's expense.

**Partial veil**: Protective tissue covering immature gills or pores of some gilled mushrooms and some boletes (compared to universal veil).

**Pathogenic**: A medical term describing viruses, bacteria, fungi, and other types of germs causing disease to their host.

**Peridium**: The outer layer of the fruit body of certain fungi enclosing the spores and spore-bearing structure. Commonly used when describing truffles, puffballs, and other sequestrate fungi.

**Pileus**: The top of a mushroom in the Agaricales (see Agaricales). Also called the cap.

**Pinheads**: The growth phase of the fruiting body of a mushroom in which the hyphal knot expands into the first observable fruiting body, which resembles a tiny pin-like structure that continues to develop into mushrooms.

**Pithy**: Description for a soft, coarse, sponge-like texture of the interior flesh of a mushroom.

**Polypore**: Specifically, "many pores." A group of fungi that have pores on the underside of the cap. Especially bracket fungi and boletes.

**Pores**: The opening of the tube in polypores.

**Primordia**: The immature stage of a mushroom's life cycle in between knots/pinheads and a mature fruiting body.

**Prokaryote**: An organism whose cells do not contain a nucleus or other membrane-bound organelles. Bacteria and Archaea are Eukaryote (compared to prokaryote).

**Pseudogills**: "False gills" that differ from true gills by being blunt or ridge-like. Commonly used to describe the hymenium, chanterelles, and allies.

**Pubescence**: Tiny, minute hairs or "fuzz" on the cap surface, stipe, or peridium of fungal fruiting bodies.

**Resupinate**: A fruiting body appearing to be inverted and growing upside-down; the "back" is attached to the surface while the fertile surface faces upward.

**Reticulation**: Raised tissue on the stipe of some mushrooms, which create a net-like pattern on the stipe. Commonly found in boletes.

**Rhizomorph**: A thick, cord-like strand of mycelium for transporting water and nutrients long distances. Particularly common in *Armillaria*, but also *Stropharia* and other fungi.

**Ring**: A common reference to the collar-like tissue, sometimes found around the stipe of some mushroom species; it is the remnants of the partial veil, which covered the spore-bearing surface of the mushroom after the veil ruptured (formally known as "Annulus").

**Ring Zone**: The area on a mushroom stipe where the partial veil deteriorated and left behind remnants or discoloration.

**Saprotroph**: Fungi which feed on dead organic matter.

**Sapwood**: The secondary wood of trees between the heartwood and bark, which contains the living, vascular tissue.

**Scabers**: Small scab or scale-like pieces of tissues on the stipe of some mushrooms, typically a different color than the stipe; generally larger than glandular dots (see glandular dots).

**Scales**: Small, plate-like pieces found on the cap and, occasionally, on the stipe where the flesh of the mushroom has peeled upward.

**Scattered**: A group of single mushrooms, which appear apart but may be located within the same general area.

**Sclerotia**: A compact mass of hardened mycelium occurring in some fungal species serving as a reproductive resting state or protection during adverse environmental conditions.

**Sessile**: A mushroom, which has a cap but not a stipe.

**Solitary**: Growing alone, singly.

**sp**: Abbreviation for species; used when referring to a single, unspecified species within a genus.

**spp**: Abbreviation for species; used when referring to more than one unspecified species within a genus.

**Species**: The basic taxonomic classification of an organism or biological unit, which ranks below genus in taxonomic ranking. In binomial nomenclature, it is always lowercase and italicized (compared to genus).

**Specialty mushroom**: In mushroom economics, specialty mushrooms are considered any mushrooms other than the "button mushroom," *Agaricus bisporus*.

**Spines/teeth**: The fertile surface of some mushrooms in which conical, "teeth-like" structures bearing basidia hang from the underside of a cap. In *Hericium* species, the entire mushroom hymenium is an arrangement of spines/teeth.

**Spore**: Microscopic, single-celled dispersal units in the fungal reproductive cycle. Spores are to mushrooms as seeds are to plants.

**Sporulate**: To produce spores.

**State Forest**: Lands managed by the Michigan Department of Natural Resources.

**Stem**: Part of a mushroom; the portion between the cap and the base. Also called the stipe.

**Stipe**: The stem of a mushroom; the portion between the cap and the base. Also called the stem.

**Stipitate**: Having a stipe.

**Striation**: Vertical lines that extend from the margin of the cap of some mushrooms to the top of the cap.

**Substrate**: The material from which mycelium derives its nutrients.

**Symbiosis**: A relationship between two organisms where both organisms physically interact in time and space.

**Taxonomy**: The science of naming living organisms. Hierarchical groups such as genera and species are called taxa.

**Terrestrial**: Fungus that grows in, or on, the soil, as opposed to aquatic (relating to water).

**Toxic**: A substance that is harmful to cell function and is capable of causing death or serious debilitation.

**True Morel**: Species of mushrooms belonging to the genus *Morchella* (compared to False Morel)

**Truncated**: The shape of an ellipsoid spore where one end has been blunted or flattened.

**Unaborted form**: The natural, primary fruiting body of a fungus prior to any alteration from a mycoparasite. Commonly used to reform to a species of Entoloma (compared to aborted form).

**Universal veil**: Protective tissue that completely encloses some species of mushrooms during their immature phase (compared to partial veil).

**Veil**: Protective tissue that covers a mushroom during its immature growth phase (compared to partial veil and universal veil).

**Venation**: Raised ridges, oftentimes pseudo gills, which have vein-like arrangements or patterns.

**Viscid**: A mushroom cap that might be sticky or appear to have a gelatin-like covering.

**Volatile toxin**: A toxic compound that easily vaporizes in air or is easily soluble in water.

**Volva**: A sac-like cup at the base of some mushrooms, left from the universal veil rupturing as the mushroom expands during growth.

**Warts**: Tufts of tissue from the universal veil, which stick to the cap of a mushroom after the universal veil has ruptured (also known as Patches).

**White rot fungi**: Fungi that degrade the lignin of wood, resulting in soft whitish, stringy strands that remain (compared to brown rot).

**Wild-foraged**: Mushrooms that are collected from the wild and not cultivated.

**Zones**: Distinct, differently colored and/or textured bands or concentric rings observable on the cap and/or stipe of a mushroom.

## AUTHOR CONTRIBUTIONS

**Carley Kratz**: Conceptualization; data curation; investigation; methodology; visualization; writing—original draft. **Aaron McKim**: Writing—review and editing. **Gregory Bonito**: Writing—review and editing.

## ORCID

*Carley Kratz* https://orcid.org/0000-0002-3212-8135
*Aaron McKim* https://orcid.org/0000-0002-0600-3611

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