**Shroomology 1010- Introduction to the Fascinating World of Fungi: A Lesson Plan for College Students**

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**Abstract (255 character limit for OER):** A lecture will be hosted by the educator. The first four sections cover factual information and in the activity students will draw conclusions about spore germination. The last section will highlight a scientist and current trends in mycology.

**Descriptive Abstract (no character limit):** A one-hour lecture will be hosted by the instructor. The topics covered include an introduction to mycology, mushrooms and mycelia, molds and slime molds, yeast and unicellular fungi, and a scientist spotlight. The first four sections cover fundamental concepts and information while the fifth section is meant to be updated and modified by an educator to reflect current trends in mycology. The target audience of this OER is first or second-year college students who are focused on a biological field. The lecture includes a think-pair-share activity where students discuss graphs and figures relating to lichens as bioindicators of air quality. A second class activity is also provided where students learn about spore germination conditions and how many spores become sporing bodies. This material was created for a Mycology Independent Study course at Worcester Polytechnic license with Professor Marja Bakermans and is distributed under the CC-BY-NC-SA 4.0 license.

**Before you present this lecture:**

* Fully read all resources provided- instructor lecture notes, conversational lecture notes, activity sheet, slides presentation, lecture evaluation survey, and initial presentation survey responses.
* Do research for colleges in your area and reach out to a graduate student or a college student studying mycology for the slides in section 5 “Scientist spotlight” class discussion.
* Print out activity sheets for each student in your classroom
* Optional: print survey sheets before the class and buy wooden mushrooms/dice for sporing bodies

**Learning Goals**

**Objectives**:

* Students will learn a basic background of mycology and why it is important to the global ecosystem
* Students will engage in an activity and learn about spore dispersal, and how many spores become sporing bodies
* Students will interpret the use of lichens as bioindicators of ecosystem health
* Students will describe the role of fungi in disease and technological advances

**Context for Use**

This is an introductory presentation and activity for college biology, horticulture, environmental science or agricultural science students.

**Subject:** Introductory Mycology

**Resource Type:** Lesson plan and in-class activity

**Grade Level:** First or second-year biology college students

**Material Type:** Activity, Lecture, Lecture Notes

**Description and Teaching Materials**

**Introduction**:

The guiding questions for this activity are:

1. Do a lot of spores from sporing bodies make it to an environment in which they can thrive?
2. How does water impact fungal growth?

**Materials**:

* Number generation for class activity
  + One 20-sided dice per student (42 pieces for $12, [link](https://www.amazon.com/AUSTOR-Pieces-Polyhedral-Assortment-Storage/dp/B0B4J745BB/ref=sr_1_7?keywords=20+sided+dice&qid=1680380992&sprefix=20+side%2Caps%2C85&sr=8-7)))
  + One 6-sided dice per student (42 pieces for $9, [link](https://www.amazon.com/AUSTOR-Pieces-Polyhedral-Assortment-Storage/dp/B0B4J7RNTD/ref=sr_1_7?keywords=20%2Bsided%2Bdice&qid=1680380992&sprefix=20%2Bside%2Caps%2C85&sr=8-7&th=1))
  + OR a free online dice roller- [website](https://rolladie.net/roll-a-d20-die)
* Sporing bodies for class activity
  + Wooden mushrooms, (30 pieces for $16, [link](https://www.amazon.com/Pllieay-Unfinished-Mushroom-Mushrooms-Decoration/dp/B09QXF1JYW/ref=sr_1_2_sspa?keywords=wooden%2Bmushrooms&qid=1680965172&sprefix=wooden%2Bmus%2Caps%2C83&sr=8-2-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExU1RZQkhLVDZJV0RTJmVuY3J5cHRlZElkPUEwNTM5NjcyMklJTUs0OEJPU0MwOCZlbmNyeXB0ZWRBZElkPUEwMzYxODczMUNUUEE4R0dFRjBSRSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1))
  + OR paper cutouts- see second page of “Spores Class Activity” document
* Optional: Lichen photo frame ($44.95, [link](https://www.forestry-suppliers.com/p/53969/431921/lichen-forms-riker-mount))

**Methods**:

* Give Lecture (powerpoint slides 1-42) reading off of the provided lecture notes to guide you. Take questions from the students after the lecture is over. Mycological topics that a teacher could further elaborate on can be seen on the appendix slide.
* Use the effectiveness survey after the class to evaluate student’s thoughts on the course.

**Suggested Lecture Notes**

***Bolded and italicized portions of these lecture notes are for the instructor to consider.***

**Slide 1** Hello class, I’m [Instructor name] and welcome to a one hour introductory mycology course.

**Slide 2**  Here is the outline of today’s lecture. The first four sections review basic factual information, and section 5 looks at a social context to what’s happening in mycology today.

**Slide 3**  This slide discusses the topic, material and audience of the OER. This slide could be kept in to show the students how open education resources are structured, or the slide could be cut out entirely.

**Slide 4**  So let’s begin! Section 1, a broad overview of the field.

**Slide 5**  Mycology is the study of fungi. There are three types of fungi- mushrooms, molds and yeasts. Humans have been using mushrooms for millenia- about 30 years ago, hikers found a glacial mummy with two types of fungi on its person, likely used for their beneficial health properties or fire starting. The mummy died more than 5,000 years ago on an alpine glacier (Peintner, 1998). The tinder fungus was one of the two types of mushrooms found on the mummy. It is a very flammable mushroom when dried and the picture on the right is of a tinder fungus.

S**lide 6** Why is mycology an important field of study? Fungi are essential for healthy ecosystems because they break down dead matter and recycle the carbon back into the environment. They are an important food source for humans and other animals. Many fungi are also useful in medicine and industrial purposes, and some are known for their psychedelic properties as seen here on the right.

Fungi are everywhere. There are 150,000 known fungi species today (Phukhamsakda et al., 2022) and it is estimated that there may be up to 3.8 million undescribed species around the globe. (Hawksworth & Lücking, 2017). Fungal spores, not unlike the seeds of a plant, are also everywhere. These spores are in the air we breathe- in every breath we take, we breathe in one to ten fungal spores. (Fröhlich-Nowoisky, 2009). This *coprinellus* mushroom (left) is found in Africa, and this *psilocybe* is from Australia (right).

**Slide 7** Let’s take a look at some fundamental biology concepts and refresh everyone’s knowledge of where fungi fall in a phylogenetic tree. Fungi are not plants! They have a kingdom of their own separate from plants. Fungi, like animals and plants, are eukaryotes. Fungi are more closely related to animals than they are to plants.

**Slide 8**  Now understanding that fungi have their own kingdom, let’s take a quick look at the different methods of fungal reproduction. First, some fungi are grouped into four divisions based on the shape and structure of the spore-making machinery, or sporangia, within the fungi (Berkely, n.d.). Most fungi reproduce by forming and releasing mass quantities of spores. These spores can be produced through asexual or sexual means of reproduction. Chytridiomycota here are aquatic fungi that produce flagellated spores that are able to move on their own, zygomycota are your bread molds, ascomycota include yeasts, and basidiomycota are filamentous fungi like mushrooms you may see on the forest floor or buy for cooking.

**Slide 9**  There are two other groups of fungi that prefer to remain outliers and not fall into any of the four categories we discussed in the previous slide. The first group here, Deuteromycota, which include molds, reproduce only asexually (Berkeley, n.d). Lichens, shown on the right, reproduce differently than the fungi on the last slide because they must associate with an algal partner before reproduction can occur.

**Slide 10**  Let’s do a deeper dive into lichens and this fungal-algal partnership. This partnership is a unique relationship among fungi in that the lichenized fungi requires association with an algae or cyanobacteria before growth can occur. The algae provides the sugars- the food source- from photosynthesis *to* the lichenized fungi, while the lichenized fungi give the algae a structure to grow on (Sheldrake, 2020; The British Lichen Society, n.d).These photos of lichen were taken on the island of Oahu in Hawaii. On the right we have *Parmeliella mariana*, a lichen found in the windward forests of Hawaii. The orange-red dots in the center of the lichen are what hold and disperse the spores. This picture on the left is of a lichen with a different morphology. ***If you, the instructor, bought the optional lichen frame, consider adding this to this slide: “I have an example of the differences between lichen structures up here in the front that anyone can check out after the lecture”. Alternatively, take a walk in your local park and gather some lichen samples off of the ground with different morphologies for students to observe.***

**Slide 11**  One major benefit of this fungal-algal partnership is the ability of lichen to measure pollutants in the air. This can be an effective tool in lichens as a bioindicator of air quality (National Park Service, n.d).

**Slide 12/13  *These two slides are an example of a “think-pair-share” activity. It’s also a great example of positive environmental change.*** In order to measure concentration of accumulated metals in a lichen, scientists typically dry up a lichen sample and run it through a machine called an atomic absorption spectrometer (Klimek et al., 2015). By taking multiple samples, scientists are able to see the concentration of metals that a lichen has absorbed during its lifetime on a tree or rock. Take a minute to look at this graph. The picture to the right of the graph is an image of the lichen species that the samples were collected from. Interpret the graph’s pattern, think about what underlying causes may have led to this pattern, and talk with each other for a moment or two if you care to. (US National Park Service, n.d)

**Class discussion and learning ensues!!**

The highest lead values were observed after the completion of a bridge that carried traffic over an island where this lichen was growing. Then, the graph declines at the same time when leaded gasoline was phased out. Subsequent measurements of lead concentrations in lichens declined sharply.

**Slide 14** That brings us to the end of section one; here are some other key historical points about fungi as a kingdom. Fungi have been on the planet for an estimated 1.5 billion years (Wang et al., 1999). Fungi have the ability to dissolve rock through secretions of enzymes and acids (Leeds, n.d). This millions of years long process of enzymatic breakdown of rocks and minerals, along with the flaking off of rock in a process called fungal weathering, allowed fungi to play an essential part in the creation of soil (Appalachian voices, n.d; Hall, 2021).

**Slide 15** That brings us to section two. This section discusses mushrooms, their structure, how they reproduce, how they interact in the soil, and their role in ecosystems as a whole.

**Slide 16**  Mushrooms each have 2 sections, a sporing body and the mycelium. The mycelium is the web-like network that extends from the sporing body, effectively functioning as roots, and gathering nutrients and water from its environment. The sporing body is the part of the mushroom that you’d typically see on a hike in the woods. Both the sporing body and mycelium are made up of the same material called hyphae, represented here with thin brown lines.

**Slide 17**  Let’s talk a bit more about how a mushroom reproduces. The top of this diagram reviews asexual reproduction, or “budding”. In budding, a cell replicates itself to create a genetically identical cell which then produces a genetically identical sporing body.

Asexual reproduction does not allow for much genetic diversity. This poses a disadvantage for asexually reproducing fungi in that a lack of genetic diversity leads to lower adaptability to changing environments. Asexually reproducing fungi may be unable to adapt to future environmental changes.

Sexual reproduction, covered on the bottom part of this diagram, allows for genetic diversity and opportunities for genetic recombination. This process is important because it allows for better species adaptation and higher survival rates in new or changed environments. In the “heterokaryotic stage” genetically different spores fuse their nuclei and create genetic diversity.

The common theme between both asexual and sexual reproduction is this “mycelium”, where fungal cells fuse together.

**Slide 18**  Mycelium is the web-like structure beneath the ground. On the right is a picture of some mycelial growth on a tree trunk. How this mycelial network came to be was that a spore landed in the middle of this central area when the conditions were right. These favorable conditions allowed the spore to send out hyphal “fingers”' in its search for water and nutrients. Mycelium is a hydraulic network, where water travels from one cell to another (Sheldrake, 2020). One cubic inch of soil can harbor eight miles of mycelium! (Stamets, 2005).

**Slide 19**  Mycelial networks grow after a spore lands in a favorable environment. Hyphal tips replicate and continue to extend the web in all directions until the network finds nutrients or water. Here is a cross section of hyphae, which shows all of the organelles within the cell. During this process, mycelium aids tremendously in creating soil structure by releasing a sticky substance called glomalin at its hyphal tips.

Glomalin is a protein that binds particulate matter together within the soil to create structural soil stability. This process of mycelial growth is like using eggs in a cake, where the eggs function to bring the mixture together (Sheldrake, 2020) The growth of mycelium provides a protection against erosion and also aids in carbon storage. A mycelial network is created through the relationship between a spore and its environment.

**Slide 20**  As the mycelial network interacts with plants, a different network is created. This network is called a mycorrhizal network. The mycorrhizal network is a fascinating and essential linkage between many plants and the mycelium that link them. The fibers in a mycorrhizal network connect plants to one another, knitting them together. Trees in mycorrhizal networks have been known to transmit nutrients to other trees that have less access to sun in order to keep the forest alive (National Forests, n.d). More than 90% of all plant species depend on a mycorrhizal network (Sheldrake, 2020).

This picture on the right is an example of mycorrhizal fungi. This photo was taken in a cave on Hawaii’s Big Island. The orange and tan roots belong to a plant above the surface of the cave. The roots extend into an underground cave, and this root is covered with the fuzzy and cottony mycorrhizae.

**Slide 21** Within a forest ecosystem, fungi operate at both ends of life. They create mushrooms through growth of sporing bodies and also function as decomposers, or the cleanup crew in an ecosystem. Fungi recycle carbon back into the environment by breaking down dead organisms and plant matter. Without decomposers, dead organisms and plant matter would accumulate and no carbon would be recycled back into the environment.

**Slide 22** Here are examples of gilled mushrooms with the spore-making structure, or sporangia, located on the gills under the cap. The spores drop from the gills when they mature and travel out into the air. The stipe, a stem-like structure, holds the cap up.

The photo on the right and in the middle of the slide are examples of fairy inkcap mushrooms. These pictures were also taken in a cave on Hawaii’s Big Island. Notice the fairy inkcaps are growing out of a piece of wood in a cave that lacked any other noticeable indication of life. You can see the immature mushrooms of the same species developing in the back.

**Slide 23** In more examples of mushroom variety, here we have mushrooms that grow directly on a tree. These mushrooms are called shelf mushrooms or polypores. Polypores lack a stipe since there is no cap to hold up. Spores from polypores are dispersed from the underside of the shelf structure.

**Slide 24** And here’s the last slide showcasing the morphological variety of mushrooms! (Point and talk about each mushroom on this slide).

**Slide 25** Now we’re going to take a break from the lecture content to do a class activity. ***Please refer to the “Instructor Activity Outline” portion of this document before running through the activity with your class.***

**Slide 26** On to section three- molds and slime molds. Molds are multicellular while slime molds are unicellular, and both germinate where moisture is present.

**Slide 27**  Mold gets a bad rap in the home, with its colorful and fuzzy appearance, but it has a lot of positive attributes; it’s in some foods we eat such as soy sauce and blue cheese (Ito et al. 2021). Adding molds to soy sauce and blue cheese gives foods new flavors or aromas. Certain molds are capable of making antibiotics like penicillin. Molds are important for the food industry and biotechnology applications, like antibiotics.

**Slide 28**  Slime molds, on the other hand, are not like the other molds- they're unicellular, and within their one large cell are many nuclei (Berkeley, n.d). Mushrooms, as you all know, have a body plan, a defined structure and shape. Slime molds, in effect, are one large organism that continues to grow without a body plan. Here you can see the slime mold running rampant on some branches on the forest floor.

**Slide 29**  Let’s talk some more about slime molds and their “intelligence”. A really intriguing characteristic of slime molds is that without a brain, slime molds appear to possess an innate ability to navigate an area to access a food source. Then, in order to transport nutrients through its network, the slime mold can prune its network to change and optimize how nutrients are transported through its own internal system (Tero et al., 2010).

This six part visual shows the growth progression of a slime mold over a 26 hour period. The yellow circle that transforms into an intricate web by the last panel in the lower right shows that the slime mold grew in the area that it was allowed to grow in with the goal of accessing each white dot. The white dots are the food source for the slime mold. After reaching all of the food dots, the slime mold then curates its internal web structure so that nutrients are carried to all areas of the slime mold. In doing so, the only pathways left from the slime mold’s initial position in panel 1 to each of the food sources end up being the shortest and most efficient pathway. (Tero et al., 2010)

The slime mold is such an efficient designer of its own internal network that transportation professionals and urban planners have taken note. In 2010, a team of researchers from Japan and the UK fed a slime mold with food sources laid out in the same pattern as the stations of the Tokyo subway system (Tero et al., 2010). The network that the slime mold created was remarkably similar to the Tokyo subway system. The Tokyo subway system was designed to have the most efficient paths from one station to another, and slime molds grow in a similar manner in search of food.

Subsequent research with slime molds has been conducted by creating computer models that simulate how slime molds fabricate their networks. These models were validated by comparing the computer models to those of a real slime mold grown in the lab.

**Slide 30**  Now we’ll take a look at yeast, another subset of unicellular fungi. Yeast, like slime molds that we just reviewed, are unicellular.

**Slide 31**  Humans have been using yeast for its molecular machinery in alcohol brewing since 7,000 BCE and in baking bread since 1500 BCE. (Bai et al., 2011; Samuel, 1996). This is the essence of biotechnology at work in its beginning years (Mattanovich, 2014). Harnessing that molecular machinery of organisms, like yeast, to create a new product, like alcohol, is an example of biotechnology. It’s a combination of function and science. By understanding the importance of this unicellular organism, yeast, the educator and student gain an appreciation for these fungal workhorses.

Yeast is also used in more advanced biotechnology areas of science like synthetic biology and genetic engineering. Yeast is a favorite model organism for biological research because of its ease to grow, similar to bacteria in a flask, and its structural similarity to animal cells. The first DNA sequence of a yeast genome was released in 2011, underscoring how important and popular yeast is as a research subject (Botstein et al., 1997).

**Slide 32**  In addition to being found in the air and in foods, yeast is present in our stomachs. The gut microbiome is a diverse environment that includes fungi, bacteria, viruses, and other organisms. Let’s talk about yeast in the gut microbiome environment. Yeast and bacteria have a delicate balance within the gut. When antibiotics or steroids are taken, stress is experienced, or when an individual has a weak or compromised immune system, the microbial population within the gut falls out of balance.

How this works is that when bacteria dies after, say, antibiotic use, it leaves open spaces and resources within the gut. This additional space and resources gives yeast the power to replicate exponentially. This then leads to a yeast infection or some type of other opportunistic fungal infection. (Cleveland Clinic, n.d.a; Cleveland Clinic, n.d.b) An opportunistic infection is when an organism that is normally present in a healthy person’s system overgrows and becomes a pathogen.

**Slide 33**  The next two slides review medical mycology, which is the study of fungal disease. Microbial imbalance within the body can trigger fungal disease. Health fungal issues include thrush, ringworm, fungal nail infections, and yeast infections. The images on the right show yeast on the left picture, and bacteria on the right picture. When either of these are out of balance, infection can occur (Center for Disease Control, 2021).

**Slide 34**  How do we treat these yeast and other fungal infections? It’s not easy. But why? Damage can occur to the human host cells from the antifungal drugs or treatments (Seneviratne et al., 2016). You can see on the slide the similarities between the structure of the animal cell and fungal cell. With treatments produced to target the fungal cell, human cells can also be impacted, causing side effects. This makes creating and developing novel antifungal drugs a difficult process, but highly profitable when successfully put out for large-scale consumer use (University of California-Davis, n.d).

**Slide 35**  In the last section, we highlight mycology focused scientists and discuss current trends in mycological research. ***Section five is designed this way to be modified by the educator based on what’s happening in the field.***

**Slide 36**  The creator of this OER met with their Biology and Biotechnology Department head, Dr. Reeta Rao. In the discussion, Professor Rao spoke about her research work in yeast biology when she was a doctoral student. Professor Rao continues to be a leader in this field through her teaching and research work. Some of her current research focuses on fungal pathogens under grant funding from the National Institutes of Health. One of her achievements involved the factors that influence fungal infection of macrophages.

**Slide 37**  The creator of this OER also spoke to a PhD candidate at Duke studying mycology in a lichen-focused lab named Ian Medieros. Ian discussed his research where he compares lichen samples collected in the 1800s with lichen samples collected today. An overarching goal of his research using historical lichen samples is to inform current lichenology diversity.

**Slide 38**  We conclude section 5 with some discussion about how fungi are playing an important role today and into the future with helping our environment heal from the negative impacts of human engagement and interference.

This quote is from the book *Entangled Life: How Fungi Make Our Worlds, Change Our Minds & Shape Our Futures* by Merlin Sheldrake. It’s currently the number 1 best seller in the Environmental Science category on Amazon. It’s a great book for both experienced and amateur readers in the mycology field.

“The algal partner in a lichen can’t make a living on bare rock without striking up a relationship with a fungus. Might it be that we can’t adjust to life on a damaged planet without cultivating new fungal relationships?” (Sheldrake, 2020)

As we’ve discussed so far in this lecture, scientific literature points to how important fungi and mycology are to understanding, working with, and creating solutions for some of the problems and challenges facing the planet today.

**Slide 39**  This slide shows examples of mycorestoration, an umbrella term that refers to the use of fungi to help a degraded environment (Stamets, 2005).

Mycofiltration is the use of fungal mycelium, the stringy web that we covered earlier, as a biological filter for removing contaminants out of a water source.

Mycoforestry is the use of a mycorrhizal network to improve forest health. As a refresher, mycorrhizal networks use the mycelial web to connect plants together within a forest ecosystem. This mycorrhizal web is the agent that can improve plant immunity, increase plant access to nutrients due to the extended reach of the web, and improve overall forest health.

***For an example of mycoforestry in action, the educator would turn to an example like the following:***

***In an experiment with cedar and fir trees, half of the trees were dipped in a mycorrhizae rich solution before planting, and the other half received no such treatment. Another variable was that a certain amount of trees had wood chips and some did not for moisture retention. After 10 months of growth, the trees that were dipped in the mycorrhizal solution were eight percent taller and seven percent thicker than the non dipped trees. This research is critical for forest managers to help restore forests and clear cut areas. (Stamets, 2005)***

Mycoremediation is the use of fungal mycelium in a soil environment to degrade or isolate contaminants like bacteria, heavy metals, or chemicals.

The photo on this slide shows an ongoing mycoremediation experiment where researchers placed contaminated soil and fungi in containers and waited to observe the fungi isolating the soil contaminants (K’allampero, 2008).

Lastly, Mycopesticides are pesticides in which the main active ingredient is a fungus. These Mycopesticides function as a biological control for pests such as insects or nematodes. They can be a more sustainable supplement or alternative to chemical pesticides.

**Slide 40** ***This slide is a catch-all of suggested topics that an educator might want to incorporate in a future lecture or to use as an add-on to this lecture.***

**Slide 41** ***This slide was an acknowledgments slide for the creator of this OER and can be removed prior to presenting to the class.***

**Slide 42** ***This slide was a final slide for the creator of this OER and can be removed prior to presenting to the class.***

***Here are some other online mycology courses:***

1. [***https://continuingstudies.uvic.ca/science-and-the-environment/courses/introduction-to-mycology/***](https://continuingstudies.uvic.ca/science-and-the-environment/courses/introduction-to-mycology/)
2. [***https://continue.utah.edu/lifelong/class/llhg\_477\_mycology\_for\_beginners***](https://continue.utah.edu/lifelong/class/llhg_477_mycology_for_beginners)

***Classes in mycology are rare but they may become more requested in the future. This online lecture demonstrates that others are creating these courses as well.***

**Instructor Activity Outline**

***The purpose of this activity is to demonstrate the idea that most spores do not make it to ideal germination conditions using probability and dice. This activity is meant to be flexible for different educator budgets and resource access. Buying the wooden mushrooms is optional- if an educator would rather a lower-cost option, The second page of the activity sheet has some mushroom drawings that students can cut out to use as sporing bodies. An alternative to buying dice is a random number generator that only selects values between one and twenty or one and six.***

***In the first part of the activity, students roll a 20 sided dice. Rolling one on the dice means that a student would receive a wooden mushroom, indicating that their spore has landed in favorable conditions and germinated into a sporing body. The probability of rolling a one with a 20-sided dice is low.***

***In the second half of the activity, students receive a six-sided dice. Students are more likely to roll a one if they are rolling six-sided and 20-sided dice at the same time. The six-sided dice represents a “rainy season” where spores are more likely to germinate- moisture is an important factor in spore germination.***

1. Every student gets a 20 sided dice.
2. **Goal:** roll a 1 and accumulate as many mushrooms as possible.
   1. Rolling a 1 indicates that the spore has landed in a wet environment = mushroom/sporing body created
3. **Activity begins:** Students begin rolling their 20 sided dice and fill in Table 1 on the class worksheet. Each student rolls their dice 20 times.
4. The first student to roll a 1 is given a wooden mushroom
5. The wooden mushroom indicates that a spore has landed in ideal conditions for growth.
6. **Activity takeaway #1:** With all students rolling at the same time and very few succeeding in rolling a 1, students can see and sense how few spores actually become sporing bodies.
7. **Activity continues:** All students continue rolling the dice to try to roll a 1.
8. After students fill Table 1, the educator tells the students that a weather event has occurred and that the rainy season has begun.
9. With the start of the rainy season, each student is given a 6 sided dice to roll along with the 20 sided dice.
10. The students roll both the 6 and 20 sided dice.
11. The goal remains to roll a 1 with either dice.
12. The students that roll 1s are given wooden mushrooms- meaning a spore has landed in ideal conditions.
13. **Activity takeaway #2**: Probabilities indicate that it would take less time to roll a 1 with the 6 sided dice than the 20 sided dice. With the start of the rainy season, the rolling of the 6 sided dice will result in more 1 results, showing that the wet conditions result in higher spore germination.
14. **Activity Bottom Line**: The educator informs the students that a six sided dice has a ⅙ chance of a 1; the 20 sided dice has a 1/20 chance of a 1; and mushrooms release over 1 billion spores per day. (Dressaire et al, 2016)

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