GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2204 | HUMONGOUS FUNGUS

THE FUNGUS AMONG US

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **fungal networks** in the city of Crystal Falls, MI to help students learn some of the science of the fungi kingdom. They will learn how fungi help plants to communicate with each other and contribute to everyday foods we enjoy. Learners will engage in experiments to investigate the factors that affect mold growth on bread, how temperature influences yeast growth, and create a model to explain fungal networks.

LESSON OBJECTIVES

- **Know** about the large fungal network in Crystal Falls
- **Understand** how fungi are involved in our everyday lives through foods and medicines that we enjoy
- **Be able to** investigate the factors that affect the rate at which bread goes moldy and how temperature affects yeast growth.

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

This lesson will explore the phenomenon of fungal networks in the city of Crystal Falls, MI to help students learn some of the science of the fungi kingdom.

They will learn how fungi help plants to communicate with each other and contribute to everyday foods we enjoy. Learners will engage in experiments to investigate the factors that affect mold growth on bread and experiment with how temperature affects yeast growth.

This lesson includes multiple activities, including lab experiments, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- Experimental design
- Data collection and analysis
- Phylogenetic classification of organisms
- Reporting findings from an experiment

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our full collection of lessons for more activities related to topics like these.

****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Fungal Networks

- MS-LS2-2
- 4-PS3-1
- SEP-7
- SEP-8
- SEP-1
- SEP-2
- SEP-3
- SEP-4

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit or activate prior knowledge
- Learning how cheese is made
- Teacher notes on fungi
- Close reading a **video** on the "Internet of Fungus"
- Watch a *Great Lakes Now* segment, the **humongous fungus of Crystal Falls**
- Class discussion to debrief video
- Read about a National Mushroom Festival in Northern Michigan
- Investigate the factors that affect the speed of mold growth on bread
- Investigate the effect of temperature on yeast growth
- Create a model to explain fungal networks

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at:
GreatLakesNow@DPTV.org

TEACHER BACKGROUND INFORMATION

by Great Lakes Now Contributor, Gary G. Abud, Jr.
**This information can be presented by the teacher as notes to students at the teacher's discretion.*

The **fungi kingdom** has many members—144,000 and counting to be exact. And while fungi come in many shapes and sizes, they are a distinct kingdom of organism from plants and animals. Unlike plants, fungi do not have typical structures like leaves, stems, roots, flowers, etc. Instead of roots, they have a branching system of filaments called **hyphae**; instead of cell walls made of cellulose like plants, the cell walls of fungi are made of **chitin**, which often makes up the exoskeletons of certain animals. Unlike plants, which produce their own food using photosynthesis, or animals which consume their food from living plants and other animals, fungi can be **decomposers** feeding off of dead organisms or **parasitic** feeding off of living ones, like plants. Several types of fungi, though not most numerous in the kingdom, are most commonly known: mushrooms, yeast, and mold.

Mushrooms*
Disgusting to some, yet a delicacy to others, mushrooms come in many varieties, from poisonous to portobello, but all share some common features aside from being the most widely-recognized fungus on earth. Every mushroom is a multicellular organism that has two main parts: a **mycelium**, or root-like system of hyphae underground, and a **fruit body**, or stem and cap above ground. Think of it like the torsos of the human body. The part of a mushroom we see and eat is actually the fruit body of the fungus.

Yeast
Unlike a mushroom which is a multicellular organism, yeast is a fungus that grows as a single cell, As with mushrooms, there are multiple kinds of yeast—and some are beneficial while others can be harmful. These tiny organisms consume sugar and produce carbon dioxide, water, and ethanol (alcohol). When used in baking, yeast produces the gas carbon dioxide that is responsible for making dough rise. People have some yeast that live naturally in our bodies—like *candida albicans* in our guts to help our digestive and immune systems keep healthy and do their jobs—but too high a level can cause a yeast infection.

Mold
Mold is a type of tiny fungus. There are thousands of different kinds. They are often seen in wet places. Unlike unicellular yeast, molds include all the species of microscopic multicellular fungi. Molds grow in a branching-out structure called hyphae and can grow on any organic matter (compounds that contain carbon), including clothing, walls, and food.

It is said that mold needs only three things to thrive: water, organic matter, and time. And, scientifically speaking, several factors affect mold growth, including the food source, temperature, and moisture level to name a few. Although some molds cause disease or food to spoil, molds are not always bad. For example, people can use them to make certain foods like bleu cheese and antibiotics such as penicillin. In fact, both bleu cheese and penicillin are made from the fungus Penicillium, which is non-toxic and safe to eat.

To keep foods such as baked goods from going moldy, you'll often see products like bread wrapped in a sealed plastic bag. Food labels on products like bakery items often have directions for preventing spoilage. Often these include keeping the food at low temperatures, for example in a refrigerator (or freezer for longer shelf life) or storing in an airtight container. That's because keeping food like bread in warm, moist conditions puts it at risk of mold growth, while cooler, dryer conditions cause mold growth to develop more slowly.

Many foods and baked goods you find at the store contain preservatives, such as calcium propionate, to slow the growth of mold. Calcium propionate is a naturally occurring organic salt formed by a reaction between calcium hydroxide and propionic acid. As a common food additive, called "E282," calcium propionate helps safeguard various food products, such as breads, muffins, and other pastries from rapid molding.

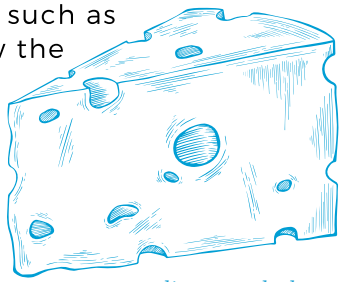
Image Credit: Gary Abud, Jr.

For further learning on fungi, mushrooms in particular, check out the PBS LearningMedia resource* ***The Secret Life of Mushrooms**.*

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities.

1. Before beginning the the warm up, have samples of food items out for students to observe: mushrooms, bleu cheese, bread.
2. Ask students to observe the items and discuss with a partner what they all have in common.
3. Now, ask students to share some of the ideas they came up with and generate a list for the whole group to see and copy down into their notebooks.
4. Ask for a show of hands as to how many students have ever baked bread before?
5. Invite some of those who raised their hand to share what was involved in the process, and list some of the steps that are relevant to this lesson (e.g., addition of yeast, allowing the bread to rise.)
6. If no hands are raised, ask how many have eaten mushrooms (e.g., on pizza, for example) or bleu cheese before. Then invite some of those who raised their hand to this question to comment on where those food items come from or what they might remember about how they tasted or smelled.
7. As this initial discussion concludes, draw students' attention to the overall commonality that all these foods share is fungus—a broad kingdom of living organisms.

B. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come:

1. Ask them to discuss with a partner how they think cheese is made. Some students may be familiar with the process already, while it may be brand new to others.
2. Invite a few students to share their ideas and list them out for all to see.
3. Show the NOVA video clip **What Lives in Cheese?** from PBS LearningMedia.
4. Afterward, have students discuss how their thinking has changed based on the video.
5. Invite students to share their ideas about cheese formation and fungi.

C. Close Reading a Video

Start by introducing that organisms belonging to the fungi kingdom come in many varieties and often are connected to other organisms in much the same way that computers connect to one another through the Internet. Ask for a couple of students to explain what they know about how the Internet works. Afterward, show the NOVA video clip about the **Wood Wide Web** and have students create and share diagrams explaining how fungal networks are similar to the Internet.

D. Background Information Notes

Explain that we are going to build on these ideas and experiment to learn more about fungi in this lesson. Then give the notes from the Teacher Background Information.

Image Credit: Great Lakes Now

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing one of the largest and oldest living organisms in the world—a fungus in the woods of Crystal Falls, MI. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm…** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2204 of *Great Lakes Now* called the **Humongous Fungus**.

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities about fungi.

How is what we saw in the video the related to what we discussed earlier in this lesson?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the giant fungal network in Crystal Falls and the Internet, as well as experiences they have with fungus in their food, from their own everyday lives.

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT THE NATIONAL MOREL FESTIVAL

This activity aims to provide students further understanding of the importance of fungi by spotlighting a festival that centers on a rare mushroom that people regard as a delicacy—the morel.

In this activity, students will use a **Think Pair Square Protocol** for discussing the two articles that they will read.

First, have students partner up and discuss whether they have ever eaten any type of mushroom before, what were the conditions, and how they liked it on a scale of 1-5 stars (like a restaurant rating). Proceed to distribute the article entitled: **Morel Season Begins in the Great Lakes** by Mary Ellen Geist from *Great Lakes Now* and allow time for students to individually read the article, and have them jot down three things they learned in the article.

Then, give students time after reading to discuss the article that they read with their partner. Have students share which three points they noted from the article and how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs.

Encourage them to come to a consensus about which point they found most important or interesting in the article.

Image Credit: Great Lakes Now

Last, have each group come up with a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that most important point with the whole group.

As student groups share out their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

After the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Based on the article, should you try eating morels, go hunting for them, or attend a festival about rare edible mushrooms?

After giving the groups some time to discuss this question, invite conversation from the entire class to see what consensus can be reached.

Further Learning: Want to know more about how people hunt for morels in Michigan? Visit michiganmorels.com to find out!

ACTIVITY 3: WHEN BREAD GOES BAD

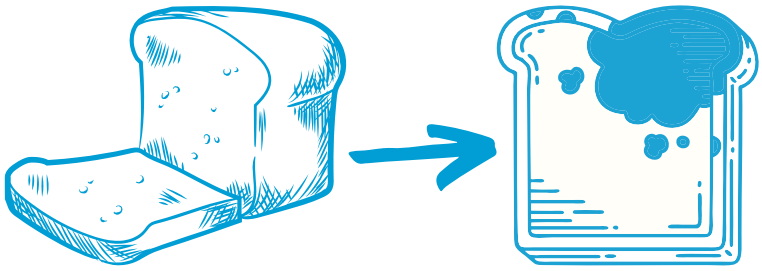

Image Credit: Gary Abud, Jr.

Many of us have encountered a moldy slice of bread, but what is going on when bread goes bad and what factors contribute to the molding of bread? The purpose of this experiment* is for students to investigate factors that affect mold growth on bread.

Do different kinds of bread mold at different rates? If you put bread in the fridge or freezer, as opposed to leaving it out on the counter for several days, will one mold faster than the other? What other factors are associated with faster molding of bread?

Possible Factors to Test:

- preservative vs. preservative-free bread
- temperature (fridge vs. out on the counter)
- types of bread (white, wheat, rye, etc.)
- surface area — loaf bread vs. sliced bread
- closed container (sealed bag) vs. open container (unsealed bag) vs. no container

Experimental Design & Setup:
First, explain to students that they are going to be researching the factors that affect the speed of mold growth using bread. Ask for a show of hands—how many have seen moldy bread before? Have them turn and talk with a partner about what happened, how long it took for the bread to mold, and what they noticed with the moldy bread they saw.

Then, elicit some student responses about their conversations and, through a group discussion. Generate a list of possible factors that may contribute to mold growth on bread. Guide them to consider all the **Possible Factors to Test** if they do not come up in discussion.

Next, have students choose with a partner which of these factors they think they could design an experiment to test and ask them to create a procedure for how to do so. Engage the group in a discussion to share some ideas of possible test steps that could be performed to see how different factors affect the speed of mold growth on bread. Encourage them to come up with a hypothesis before testing.

Last, support the students to conduct their experiments, over a number of days to take data, by providing supplies or equipment as needed and giving them time in class to plan and carry out their tests as well as collect data. Once experiments are done and data is collected, have students summarize their findings in a poster presentation (either using large dry erase boards, chart paper, or a digital slidedeck-making tool.) Provide time in class for students to share and discuss their results. Facilitate a group discussion to help the group arrive at consensus about which factors most affect the speed of mold growth on bread based on analysis of group results.

**Note: The structure of this experiment allows for an inquiry-based approach where students design their own experimental procedures and methods of data collection—with the support of the teacher—but could also be adapted to a more prescribed stepwise format of conducting the experiment (e.g., teacher-directed with procedure given) as needed.*

ACTIVITY 4: TEMPERATURE & YEAST GROWTH

Many bread recipes call for yeast to help the bread rise. The yeast consumes the sugars in the bread mixture and produce carbon dioxide, the same gas that people exhale, that gets trapped in the bread forming little bubbles and puffing up the bread, or helping it to rise.

Are there better conditions, such as an optimal temperature, for yeast to cause bread to rise? The purpose of this activity is for students to investigate the effect that temperature has on the growth of a single-celled fungi—yeast.

Begin by demonstrating to students that dry yeast, when mixed in a sugar-water solution, will eat the sugar and produce carbon dioxide. Have a container with dry yeast alone in it and another with yeast that has been in a warm sugar water solution for a while—but do not reveal the temperature of the water you used.

Materials Needed:

- Active dry yeast packets
- Beakers or tall, clear glass drinking cups
- Water
- Granulated sugar
- A heating element (e.g., a hot plate or microwave)
- Thermometer
- Ruler
- Stopwatch, clock with second hand, or timer

First, inform students that they will be working with a partner to test the effect of temperature on yeast growth.

Then, provide students the supplies they'll need to conduct the experiment. Explain that all groups will be testing the same factor—temperature—but each group will formulate their own hypothesis and choose three different temperatures to test on their yeast.

Next, give students time to plan out how they are going to test the effect of temperature on yeast growth. Guide them to consider choosing three different temperatures but the same amount of water, yeast, and sugar. When the yeast grows it will take the container's shape.

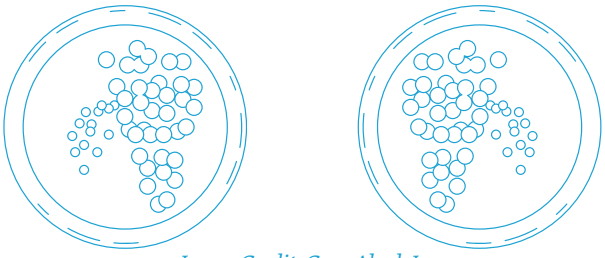

Image Credit: Gary Abud, Jr.

Because the containers are roughly the shape of a cylinder, help students to realize that one way to measure the growth of the yeast would be to compare the volume of yeast after a certain amount of time. They can estimate the volume of the yeast based on the height of the cylindrical column it forms using the cylinder volume formula:

$$V = \pi r^2 h$$

This would allow them to easily compare the amount of yeast growth between the containers of different water temperatures.

Last, have students organize their results in a data table, chart, or graph. The can display their findings and conclusions (e.g., did their data support their hypothesis or not) in a poster presentation using large dry erase boards, chart paper, or a digital slidedeck-making tool.

After the reports are finished, allow time in class for students to share and discuss their results with one another. Facilitate a group discussion to help the group arrive at consensus about what the ideal temperature might be to support yeast growth. Consider asking follow-up questions during the discussion to help students make further connections between their experiment and prior learning, such as:

- Could there be such a thing as too high a temperature for yeast? Why might that be?
- How might our findings here inform baking recipe procedures?
- What do the effects of temperature on yeast reinforce for us about the conditions that organisms need to live?
- Why does the yeast need to stay dry?

ACTIVITY 5: CREATE A FUNGAL NETWORK MODEL

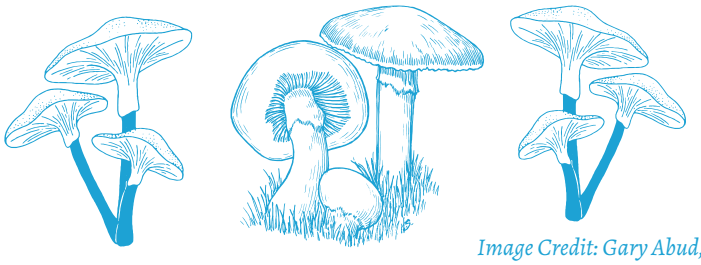

Image Credit: Gary Abud, Jr.

The purpose of this activity is for students to create a model that will communicate how fungal networks, like the one featured in the *Great Lakes Now* segment come about and function.

First, ask students to recall what they learned earlier in the lesson about how fungal networks can be compared to the Internet. Extend this discussion by asking how many students have ever heard of the IoT: the Internet of Things. Give students time to research and find model that depict the IoT and ask them to report back how the IoT works based on the models they found.

Image Credit: Gary Abud, Jr.

Then, inform students that they will be working in groups to create a fungal network model—essentially an Internet of Fungi (IoF)—that explains how fungal networks like the one in Crystal Falls occur and function in an ecosystem.

Elicit student suggestions about what makes for a good model (e.g., a visual representation that explains how something works) and what sorts of aspects of the fungal network should be included in the model.

Suggest to students that they creating a model of fungal networks that is similar to an IoT model, and that they might want to research what a model looks like to explain the Internet / IoT as inspiration.

Next, provide students with time to research and plan their models. They should sketch drafts of their models in their notebooks once they have a full idea of what they want to do. Monitor group activity as students work and provide feedback directly to students on their draft models.

Alternatively, create an opportunity for groups to pair up and trade drafts of the Internet of Fungus models to provide feedback to one another. Allow time for revisions and further research as needed until students have a final draft.

Provide students with chart paper and markers, large dry-erase boards and whiteboard markers, or a digital slidedeck-creation tool to construct their final drafts of their models.

Last, have students display all of their models next to each other along a wallspace so that everyone can see all of the models. Provide students time to do a gallery walk and examine each group's model before engaging them in a whole-group discussion about the models. Try to arrive at what an ideal fungal network model would look like based on the best features of all the group models. When finished, have students sketch the ideal model in their notebooks and take turns explaining it to a partner.

Conclude by inviting a couple students to compare and contrast the IoT to Internet of Fungus (IoF) in their fungal network models.

Image Credit: Great Lakes Now

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Compare and Connect

Initiate a discussion with students where you ask them to identify ways in which each activity connected to the other activities. This could be in terms of what was done, what was learned, or specific moments during the activities that corresponded with others.

Guide students to refer to each other's thinking by asking them to make connections between specific features of the activities and how they all connect to the big ideas of the lesson.

Make sure to invite students to connect other students' responses to their own ideas in the discussion.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

Image Credit: Great Lakes Now

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

NAME: _____

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: _____

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: _____

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed