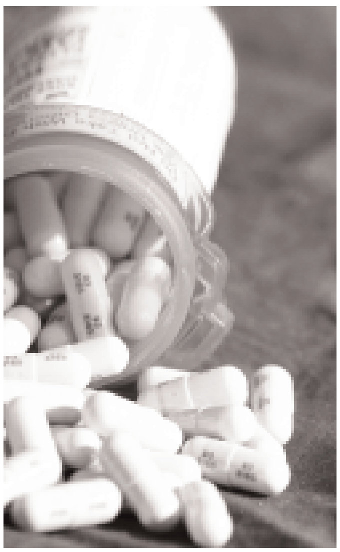
SCIENCE

Fungus Among Us

by Constace Anders

Overview

Students will:
- **Learn basic characteristics of the Fungus Kingdom.**
- **Identify the presence or absence of scientific methodology in published material.**
- **Understand antibiotic resistance as a microevolutionary event.**



Terrain Article: "Got Milk," Fall 2005, pages 10-13.

Introduction

In 1928, Alexander Fleming made a chance discovery. He had been working with cultured bacteria and noticed that several of his cultures had become contaminated by a mold. Fleming was stunned to see that the bacteria located near the mold had burst and died. Could the fungal mold have secreted a substance that could kill bacteria?

Fleming began investigating this possibility. He brewed a broth of fungal chemicals and tested them on a variety of bacterium. The testing showed the broth to be lethal for a wide spectrum of bacteria. Next Fleming injected the active ingredient from the broth into mice to see if his concoction was lethal to mammals as well as bacteria. The mice lived! The possibilities for fighting infection were staggering.

Fleming had discovered a substance that could kill disease germs without hurting patients. The identity of the fungal mold that contaminated Fleming's bacterial cultures was *Penicillium notatum*. The antibiotic he had discovered was named penicillin. Unfortunately, Fleming found penicillin difficult to extract and purify, so he abandoned this line of research.

Fast forward to 1940. World War II is raging. Researchers Howard Florey and Ernst Chain of Oxford University are frantically working on a miracle drug that could cure infections and save the troops. They decide to investigate penicillin and through repetition of Fleming's work are able to extract some of the active ingredient. To test the drug's potency, they inject eight mice with deadly amounts of **streptococcal** bacteria. One hour later, they inject only half of the mice with penicillin. Within 24 hours, the mice given the **strep** germ alone are dead and the four mice given the additional penicillin are alive!

But time is running out. Most of Europe has fallen to Hitler. The Oxford researchers destroy their lab and escape with the precious *P. notatum* spores rubbed into their clothes. The Allied Powers set up a safe lab in Peoria, Illinois and this vital effort continues. Production that had once been done on the liter scale now increases to industrial levels. In order to find more productive mold species, military pilots collect soil samples from around the globe. Scientists establish new fermentation techniques for the purpose of increasing production. *Penicillium chrysogenum* replaces *P. notatum* as a better source of penicillin. This new drug is tested on mice, then humans. By D-day, 1944, there is enough penicillin produced to help every Allied soldier survive. Thousands upon thousands of soldiers' lives are saved by the wonder drug. Alexander Fleming, Howard Florey, and Ernst Chain are awarded a Nobel Prize for their work.

Penicillin has been used for over 60 years. Many other antibiotics have since been developed and used. No longer do people die of infected cuts or **TB** or **pneumonia** — or do they? **Antibiotic resistant** bacteria have evolved. How did this happen? And what does it mean for the future?

CA SCIENCE CONTENT STANDARDS GRADES 9-12: I Cell Biology 1. c. Students know how prokaryotic cells, eukaryotic cells, and viruses differ in complexity and general structure. Evolution 7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time. d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions. Evolution 8. Evolution is the result of genetic changes that occur in constantly changing environments. a. Students know how natural selection determines the differential survival of groups of organisms. b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment. Investigation and Experimentation 1. Scientific progress is made by asking meaningful questions and conducting careful investigations.

Put the Learning in Context

Introductory Activity

Students will collect their own fungus samples and create a spore print.

Teacher Directions

1. Two days before beginning this lesson, ask students to bring in samples of moldy bread or "furry" food from an old Tupperware container in the back of the fridge for the later microscope activity.
2. Augment this supply by picking up (with permission) fungi in backyards, woods, parks, or grocery stores. Place in zip lock bags for safekeeping.
3. Attain 10-15 fresh mushrooms, a packet of dark paper, 10-15 plastic containers, and a dropper filled with water.

Student Directions

Cut off the stem and place the cap gill side down on dark paper. Don't move the cap once you have placed it. Cover with a container to keep environment moist. If you suspect that your mushrooms are not fresh, put a few drops of water on the cap before covering with the container. Leave your mushroom untouched until the next class. Mature spores will be released from the gills and fall on the paper, producing a spore print.

Note: most mushrooms will have white spores. Some, however, have dark spores, and their prints will show up better on light paper. Gill color is not related to spore color. If the cap has dried out, a print may not form.

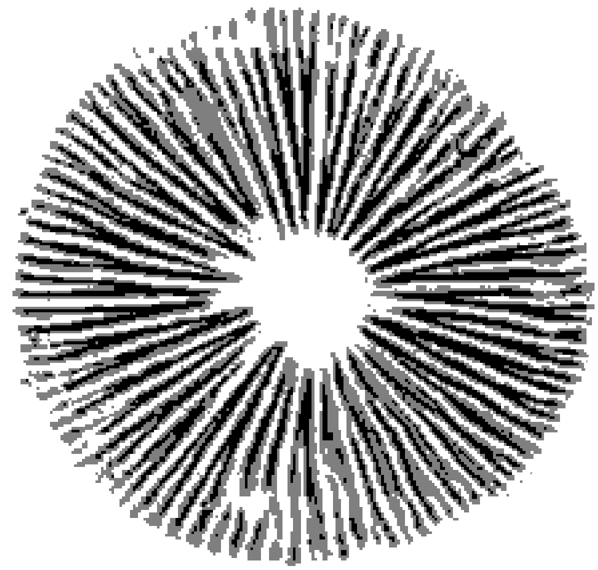


Image: spore print of mushroom
source: www.anbg.gov.au/fungi/spore-prints.html

Glossary of Terms

Antibiotic resistance: The ability of some bacterium to live in the presence of lethal doses of antibiotics.

Bacterial cell wall: A rigid structure at the periphery of the cell containing a material called peptidoglycan.

Binary fission: Asexual reproduction. (Simple cell division.)

Cell membrane: A plasma membrane that defines a cell as a distinct entity. It is made up of double phosolipid embedded with proteins.

Eukaryotic: Possessing a nucleus.

Fitness: Ability to survive and reproduce.

Genes: Hereditary material responsible for traits.

Heterotroph: Organism that must ingest food. It does not make its own food.

Hyphae: Slender filament that makes up fungal structure.

Microevolution: Mutations in a gene that lead to changes in the characteristics of a population.

Mutualism: A relationship between two organisms in which both benefit.

Mutation: Change in genes.

Mycelium: Group of hyphae.

Pathogenic bacteria: Bacteria that cause disease.

Penicillium crysogenum: Genus and species of the fungus that produces the penicillin used today.

Penicillium notatum: Genus and species of the fungus that produced the first penicillin.

Pneumonia: A lung disease.

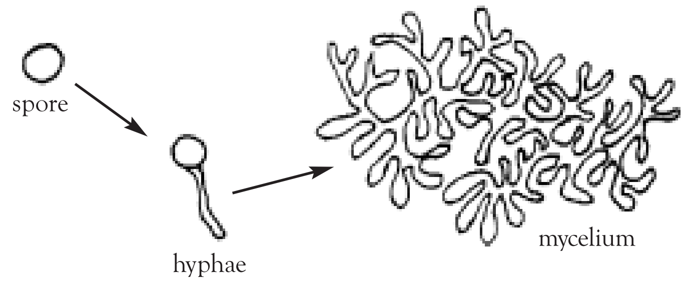
Spore: An asexual reproductive cell.

Streptococcal bacteria (strep): A disease-causing germ.

TB: Tuberculosis, a lung disease.

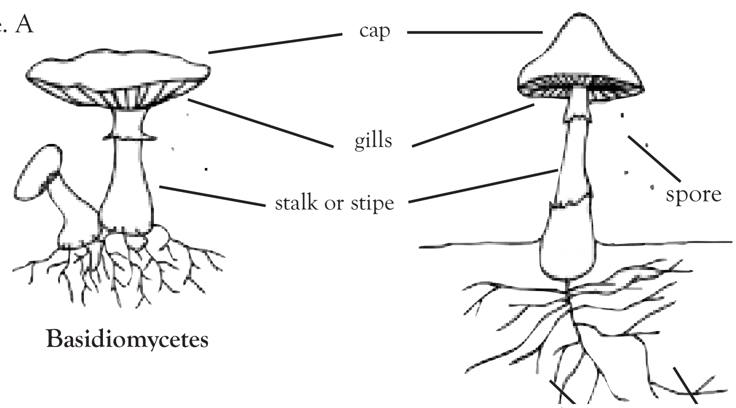
Fungus Kingdom Fact Sheet

Characteristics
All fungi are eukaryotic heterotrophs. This means that fungi posses a true nucleus and feed off other organisms, rather than photosynthesizing. In order to eat, fungi use extra-cellular digestion. They actually spew digestive enzyme onto their food before they absorb it.



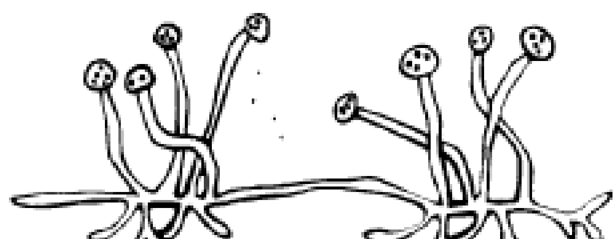
Role in Nature and Society
Some fungi are decomposers. They break down dead material through mildew, dry rot, and food spoilage. Others cause diseases like yeast infections and athletes' foot. Still others are responsible for bread, cheese, beer, and wine. A few very important fungi act medicinally as antibiotics.

General Structure
With the exception of yeast, all fungi -- from the microscopic to the very large -- are multi-cellular and made up of tube-like filaments called hyphae. A branching network of hyphae is called a mycelium. The gills, cap and stalk (or stipe) of a large mushroom are made up of millions of hyphae. Microscopic penicillium fungus is made up of only a few.



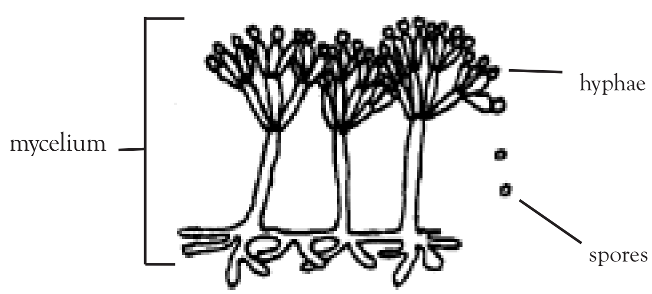
Basidiomycetes **Basidiomycetes**

Reproduction
Fungi have a sexual and then an asexual life stage. (In some fungi, the sexual stage has not yet been identified.) Spores are asexual structures, which can grow into new organisms without first fusing with other reproductive cells. Fungal spores disperse in the air and develop into a new mycelium if conditions are suitable.

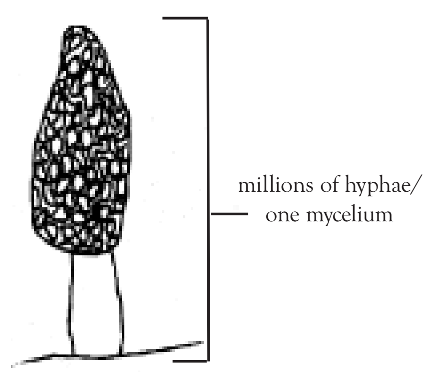


Zygomycetes
(bread mold)

Types of Fungus
Basidiomycetes: also called club fungus because the spore producing structure looks like a club. Examples: mushrooms or rust.
Ascomycetes: also called cup fungus because the above ground structure looks like a cup or group of cups. Examples: yeast, powdery mildew, or morel mushrooms.
Zygomycetes: bread molds.
Imperfect fungus: mold.



Ascomycetes
(penicillium)



Ascomycetes
(cup fungus/morel mushroom)

Fungus: A Closer Look

Microscope Lab

Students will examine fungi under a microscope.

List of materials

- Microscopes
- Prepared slides of fungus from biological supply house
- Clean slides and cover slips
- Tooth picks
- Beaker of water and dropper
- Dissecting scope
- One mushroom cap gill side up
- A selection of molds students brought

Student Directions

1. View 2 different prepared slides under low and high power. In the boxes below, draw the field of view and label with the total magnification, name of organism, and the following structures, if present: hyphae, mycelium, and spore.

Prepared Slide #1: Name of fungus: _______________

Low Power: ______ High Power: _____

Prepared Slide #2: Name of fungus: _________________

Low Power: ______ High Power: _____

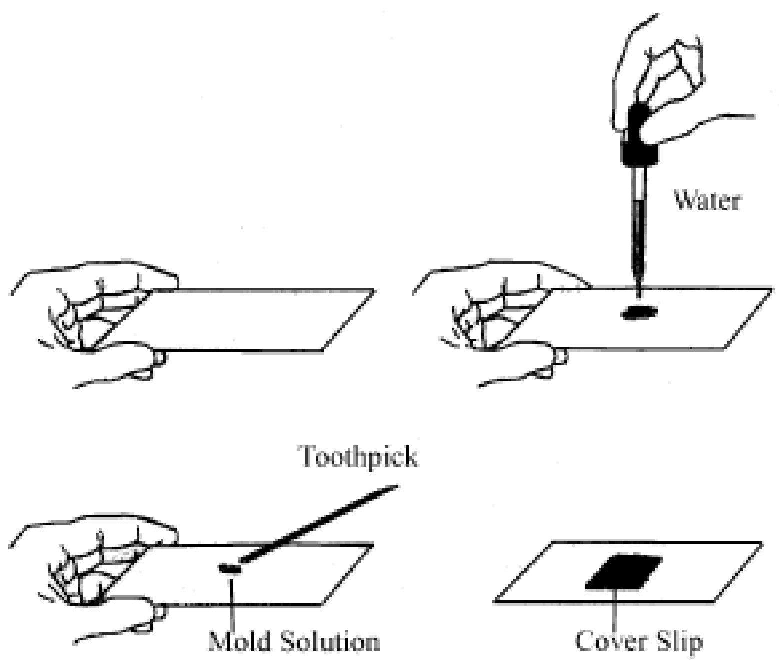
2. Make 2 wet mounts from mold material provided. To do this, place a drop of water on the slide, take a clean tooth pick and touch it to the mold source, dab the moldy end into the water drop, and cover with a cover slip. Do not attempt to put a lot of material on the slide — to do so prevents the cover slip from lying flat. View under low and high power. Label with total magnification and terms hyphae, mycelium, and spore.

Wet Mount #1

Low Power: _____ High Power: _____

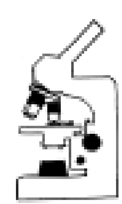
Wet Mount #2

Low Power: _____ High Power: _____



3. Draw a picture of the mushroom cap as viewed under the dissecting scope. Label cap, gill, and spore. Using your notes, name this type of fungus.

Name of fungus: _______________



Tabloid Science: Science Literacy

Reading Activity

Students will examine articles that deal with science for scientific methodology.

The Five Basics of Scientific Method

1. Observation
(A scientist observes something.)
2. Question
(Scientist asks a specific question about what he/she has seen.)
3. Hypothesis
(Scientist predicts the answer to the question.)
4. Controlled Experiment
(Scientist creates an experiment in which one control group does not have the same test variable.)
5. Conclusion
(Scientist decides whether the experiment supported the hypothesis or not.)

Materials needed

- Student copies of "scientific articles" cut out from the tabloids (i.e. *Star*, *Weekly World News*, *Enquirer*). Some actual examples from past additions include such all time favorites as "Cucumbers Cure Aids" and "Mad Human Disease."
- Student copies of the introduction on page 6.
- Student copies of Terrain article, "Got Milk"

Teacher Directions

1. Divide students into groups of 2 or 3. Pass out a different tabloid article to each group.
2. Write on the board and review the steps of scientific method.
3. Ask the groups to read the articles and critique them on the basis of the presence or absence of scientific methodology. Groups must also make suggestions to correct any errors in scientific method they see.
4. Have each group informally present (call out) their findings to the class to encourage discussion.
5. Pass out copies of the introduction from page 6. As a class, read it out loud and explain any terms to the students that they may not understand. Once it has been read, give students five minutes to independently write down the scientific method steps that are present.
6. Pass out the Terrain article. Give the students a little while to read and write down whether scientific method is present.

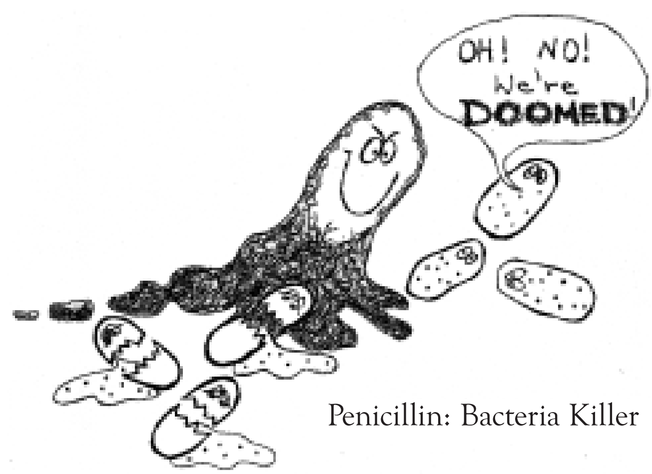
Putting It Together: Antibiotic Resistance

Bacteria

Characteristics
All bacteria are small prokaryotic single-celled organisms. In other words, these tiny organisms possess no nucleus. Unique to bacteria is a cell wall containing peptidoglycan.

Reproduction
Bacteria only reproduce asexually through a process called binary fission.

Mutualism
Not all bacteria are pathogenic (disease causing). Many bacteria are beneficial to us. For example, a healthy digestive tract contains bacteria, which help in the absorption of food.



Penicillin: Bacteria Killer

Antibiotics
Penicillin kills bacteria while leaving us unharmed. This happens because penicillin binds to the enzyme that helps construct the cell wall. When the bacterium divides, it can no longer make a cell wall, so it ruptures and dies. Since we do not have cell walls, we are unharmed by penicillin.

Penicillin Antibiotic Resistance
Antibiotic resistance is a mutation that allows a bacteria enzyme to break down penicillin rendering it harmless.

Resistance Wrap-Up

Quiz

In this assessment activity, students will explain what antibiotics do, what antibiotic resistance is, and what they can do to improve the situation.

Teacher Directions

1. Make copies and pass out the "Rest of the Story" below as an in-class or homework reading assignment.
2. Lead a class discussion to check for understanding. (Let the students know that a quiz will follow the discussion but do not tell them it is open book.)
3. Write the following quiz question on the board:

   Explain in your own words what antibiotics do to bacteria, what antibiotic resistance is, why it is dangerous to us, and what you can do to help the situation.

The Rest of the Story...

Penicillin, the original "wonder drug," and other antibiotics have ceased being effective against some strains of bacteria because of antibiotic resistance. Now, TB, pneumonia and other serious illnesses are becoming hard to cure. Do you know how this happens and what it may mean for the future?

To answer these questions, it is necessary to understand how resistance develops. Mutations (changes in genetic material) occur in every population. The faster a population multiplies the greater the mutation impact. Bacteria multiply approximately every 20 minutes. As a result, mutations enter bacterial population at a high rate. If a mutation confers fitness on a bacterium, it continues to reproduce and pass on its genes to the next generation. If the bacterium is unfit for the current environment, it will die out. In terms of bacteria verses antibiotics, the environment can be likened to an arms race. The antibiotics attempt to kill all of the germ invaders. Some germs adapt via chance mutation and this adaptation allows them to survive the antibiotic chemical weapons. Over time, the surviving bacteria reproduce and pass on their resistant genes to the next generation. This is natural and expected.

Poor medical practice has caused antibiotic resistance to develop at an accelerated rate. How did this happen? When doctors prescribe antibiotics for illnesses that are not bacterial, the body and the germs it contains are bathed in unnecessary antibiotics. Under these conditions, the constantly mutating bacteria have chance after chance of hitting the resistance jackpot. The greater the exposure to non-lethal levels of antibiotic, the greater the odds of adaptive traits arising. The common practice of giving antibiotics for virus-based flus (organisms which simply can't be killed by antibiotics) only encourages the development of antibiotic resistance. The patient also plays a role in resistance development. When a patient is told to take an antibiotic for two weeks and only takes it until she feels better, she has succeeded in knocking back the bacterial population but not killing it entirely—again giving it a chance to adapt. Another area of concern is the use of antibiotics in animal feed. This widespread practice exposes bacteria in farm animals to constant low levels of antibiotics. The same principles of microevolution occur in all populations, and so it is logical to assume that bacteria in cows, pigs, and chickens are becoming antibiotic resistant.

What does this mean to us? We don't want TB resistant bacteria or super anthrax to spread. Scientists are working on new weapons with which to fight these and other diseases. In the mean time, doctors need to follow correct medical practice, patients need to take the full course of antibiotics as prescribed, and agriculture science needs to explore non-antibiotic means for maintaining healthy herds and flocks.