2.15 Fungi

BACKGROUND INFORMATION

More than 100 000 species of fungi exist. Fungi are usually classified in four divisions: the Chytridiomycota (chytrids), Zygomycota (bread moulds), Ascomycota (yeasts and sac fungi), and the Basidiomycota (club fungi). Placement into a division is determined by the way in which the fungus sexually reproduces. The most useful characteristic for identifying these major groups is the shape and internal structure of the sporangia. Endings used for levels of taxa in kingdom Fungi are as follows: phylum (-mycota), class (-mycetes), order (-ales), and family (-aceae).

When people think of mushrooms, they are probably thinking of the fruit of club fungi (Basidiomycota). All the 25 000 species in this phylum produce spores on a club-like structure called the basidium. The basidium may grow free or be attached to a surface called the hymenium. Among the more famous in this phylum are *Agaricus* (the common supermarket button mushrooms); *Amanita* (species that are deadly, delicious, or hallucinogenic); *Boletus* (called porcini in Italy and cèpe in France); and *Cantherellus* (the delicious and beautiful chanterelle). Toadstools, shelf fungi, puffballs, rust, and smuts are other examples.

Ascomycota, or sac fungi, produce their spores in special pods or sac-like structures called asci. The prized morel and truffle are included among the 25 000 species of this phylum, as is *Saccharomyces cerevisiae* (brewer's, baker's, and nutritional yeast), which is used to produce beer and bread.

Around 25 000 additional fungal species are grouped as imperfect fungi (phylum Deuteromycota). These "leftovers" do not fit well into any of the other groups. They reproduce asexually by spores only, and their name implies that the sexual stage is lost or not yet discovered. For this reason, they cannot be assigned to either the sac or club fungi. Members include *Trichophyton* (athlete's foot), *Penicillium* (the antibiotic penicillin), and *Candida albicans* ("yeast" infections).

There are around 600 species of conjugation fungi (phylum Zygomycota). The most common example is the black bread mould *Rhizopus stolonifer*. Zygomycota means "paired" or "yoked" fungi because when two different hyphae join for sexual reproduction, they form a swollen, thick-walled structure (zygospore) that links the hyphae together. Fertilization takes place inside the zygospore when nuclei from the two hyphae fuse. Some researchers describe zygomycote sex as an orgy because so many nuclei are brought together and fuse at the same time.

Lichens (Mycophycophyta) are no longer considered a phylum. Scientists have identified around 25 000 species of these symbionts.

Misconceptions

When students see mushrooms growing on trees, they may think that the only advantage of this relationship is the nutritional benefit the fungi receive. Rather, the advantages in this commensal relationship are also phototactic (one organism uses another to gain a better position in shady environments like rain forests) and reproductive (some fungi climb trees and vines to release their spores from as high a perch as possible).

Related Background Resources

- Fungi: http://tolweb.org/tree?group=Fungi&contgroup=Eukaryotes
- Mushrooms: http://www.ansci.cornell.edu/plants/toxicagents/amanita/amanita.html
- Lichens of North America: http://www.lichen.com
- The Fungal Web: http://helios.bto.ed.ac.uk/bto/microbes/fungalwe.htm#crest
- University of California Museum of Paleontology: http://www.ucmp.berkeley.edu/museum/museum.html

ASSESSMENT PLANNING

Overall Skills Expectations

SIS.02
SIS.04
SIS.05
SIS.06
SIS.07
SIS.08
SIS.10

Overall Expectations

M.01
M.02
M.03

Specific Expectations

M1.01 compare the structure and properties of the genetic material of viruses and bacteria with those of eukaryotic cells

M1.02 illustrate the differences between representative bacteria (including Eubacteria and Archaebacteria), protists, viruses, and fungi by comparing their shape, motility, ecological role, and connection to human diseases

M1.03 analyse and explain the different methods of reproduction in various types of viruses, monera, and fungi

M1.04 describe the anatomy and physiology of representative organisms from monera, protists, fungi, and viruses

M1.05 demonstrate an understanding of the vital role microorganisms play in symbiotic relationships

M2.01 identify specimens of monera, protists, and fungi by using prepared slides or wet mounts

M3.01 evaluate the impact of viral, bacterial, and fungal infections on the health of host organisms, and on humans in particular

M3.05 describe some beneficial functions of microorganisms in an ecosystem

Achievement Chart Categories	Assessment/Evaluation Opportunities (Evidence)	Assessment Tools
Knowledge/Understanding	Understanding Concepts, q. 1–7 M1.01–M1.05	Rubric 1: Knowledge/Understanding

Achievement Chart Categories	Assessment/Evaluation Opportunities (Evidence)	Assessment Tools
Inquiry	Try This Activity Applying Inquiry Skills, q. 8, 9 M2.01	Rubric 2: Inquiry
Communication	Making Connections, q. 13 M1.02, M3.05	Rubric 3: Communication Rubric 6: Research Skills Self-Assessment Checklist 2: Research Skills
Making Connections	Making Connections, q. 10–13 M1.02, M3.05	Rubric 4: Making Connections

Assessment Opportunities

Knowledge/Understanding Collect student answers to Understanding Concepts questions 1 to 7 and compare to answers provided in the Solutions Manual. To determine their level of achievement, use *Assessment Rubric 1: Knowledge/Understanding* assessment criteria:
- Understanding of concepts, principles, laws, and theories (identifying assumptions, communicating misconceptions, providing explanations)
- Knowledge of facts and terms
- Understanding of relationships among concepts

Inquiry Observe students during the Try This Activity to assess their inquiry skills. To determine their level of achievement, use *Assessment Rubric 2: Inquiry* assessment criteria:
- Performing and recording
- Analyzing and interpreting

Communication Collect student work for Making Connections question 13. To determine their level of achievement, use *Assessment Rubric 3: Communication* assessment criteria:
- Communication of information and ideas
- Use of scientific terminology, symbols, conventions, and standard (SI) units
- Use of various forms of communication (e.g., reports, essays)
- Use of information technology for scientific purposes (e.g., specialized databases)

Assessment Rubric 6: Research Skills (all criteria) and *Self-Assessment Checklist 2: Research Skills* may also be used with this task.

Making Connections Collect student work for Making Connections questions 10 to 13. To determine their level of achievement, use *Assessment Rubric 4: Making Connections* assessment criteria:
- Understanding (making) connections among science, technology, society, and the environment
- Analysis of social and economic issues involving science and technology
- Assessment of impacts of science and technology on the environment
- Proposing courses of practical action in relation to science- and technology-based problems

INSTRUCTIONAL PLANNING

Suggested Time

Narrative/Section Questions—60 min
Try This Activity—collection as homework, 30 min class time to complete the activity

Materials and Equipment

Material/Equipment	Quantity per station	Quantity for 16 stations
plastic bags	3 per student	3 per student
ruler	1	16
hand lens	1	16
compound light microscope	1	16
prepared slides of lichen	1 set for class	1 set for class

- Students can provide their own plastic bags and rulers.

Safety and Disposal

- Students can dispose of lichen and plastic bags in the garbage.

TEACHING SUGGESTIONS

- Build a dung chamber as an attention grabber for the content in this section. Take a hike in a field, forest, or park to find some fresh dung from a vegetarian animal (e.g., deer). Dung from the most likely vegetarian animals (e.g., deer, rabbit) will be recognized by its pellet form. An excellent Web site is http://www.hiddenforest.co.nz/fungi/fun/dung.htm. Put this dung in a petri dish. Sprinkle the dung with a little water then cover the dish with the lid. After a few days, determine how many different types of fungal fruiting bodies are growing on the dung. Start about four days before this lesson so that students can see some real-life examples of the fungi as they proceed through section content.
- Remind students that the older classification systems included fungi in the plant kingdom. Recent molecular evidence suggests that fungi may be more closely related to animals than to plants or protists. After discussing the Venn diagram (Figure 1 on p. 136 of the Student Text), divide students into groups and have them draw two other Venn diagrams on (1) the similarities and differences between fungi and protists, and (2) the similarities and differences between fungi and animals. Compare the results as a class and use this opportunity to review basic classification (Section 2.1, Table 2).
- Fungi do not have roots. Students may have examined onion root tips under the microscope in Grade 9 Science, so you can make the analogy: mycelia are to roots as hyphae are to root hairs.
- Where are the digestive organelles in a fungus? Explain that fungi digest food outside their bodies: they release enzymes into the surrounding environment to break down organic matter into a form that they can absorb. Compare this with digestion in protists (e.g., phagocytosis in *Amoeba* and digestive vacuoles in *Paramecium*).
- Review with students the alternation of diploid and haploid stages in the life cycles of organisms in Figure 5 (p. 138 of the Student Text). As an extension project, a creative student could illustrate this cycle in baker's clay or polymer clay and display the model in the classroom. It will be helpful for students to realize that a "mushroom" is the fruit of the fungus.

Just as the fruit of a plant releases seeds, the mushroom fruit releases spores into the air and the wind carries these off to start the next generation.

- Ask students what ringworm or athlete's foot is and how you can get each. Make a list on the board of what conditions promote fungal growth. These will be expanded and tested in Investigation 2.16.
- Emphasize that many fungi are toxic and that it is difficult to identify safe fungi. A poster project on the *Amanita* genus, which contains some of the most poisonous types of fungi, could be assigned as an extension.
- Saprophytes recycle dead organic matter into useful nutrients. Sometimes the fungus doesn't wait for the substrate to die, in which case the fungus is called a parasite. Many plants, however, depend on the fungus to get their own nutrients. Plants also benefit in this mycorrhizal association by absorbing materials digested by the fungi growing among plant roots. Students will differentiate between types of symbioses in Section 2.17.
- Ask students to list the characteristics of algae and fungi. Consider the difficulties that algae would face living in a terrestrial habitat. List the advantages to both organisms in their association as lichen. Use **LSM 2.15-1: Collecting and Examining Lichens** to extend the Try This Activity. The lichen Web site http://www.lichen.com has a wealth of information to stimulate interest and help students with identification. Remind students that lichens grow very slowly. As the lichens will not be returned to their habitat after the activity, encourage students to harvest only what they need for their research.
- As students go through the headings in this section, they can take notes using **Workbook 2.15 Additional Practice: All about Fungi**. Completing this study sheet will help students answer the section questions.
- While completing the summary table, refer students back to **LSM 2.3-1: Additional Practice: Structure of Representative Organisms**. They can label the fungus diagram now, which completes the structural comparison of the four major groups of microorganisms.
- Question 9 directs students to make a spore print. Demonstrate this technique. Holding the mushroom with the cap facing down, take the stalk between thumb and forefinger, twist gently, and carefully remove the cap without disturbing the gills. Place the cap on a sheet of white paper with the gills touching the paper. Place a beaker upside down over the cap and put it in a safe place overnight. The next day, carefully remove the beaker and the cap. The paper will show where the spores fell from the gills. These are the spore "prints." Black or coloured paper can also be used. Display the prints from different mushrooms. Have students observe a wet mount from a spore under the microscope and drawn this image as an insert on the spore print page.
- Students may have eaten mushrooms but have probably never looked at mushroom structure in detail. **Workbook 2.15 Activity: The Anatomy of a Commercial Mushroom** investigates the features of the common commercial mushroom *Agaricus bisporus.* The activity reinforces section content; assign all or part of it or have a student complete it for extra credit and present the findings to the class.
- As described in the Unit Opener, yeast is a very busy fungus in the fields of nutrition, medicine, biotechnology, and agriculture. If students did not have the opportunity to complete **Workbook Getting Started Activity: Dead or Alive?**, use it here and as an introduction to the bread mould growth experiment in Section 2.16.