

green, neutral red, toluidine blue, basic fuchsin, safranin, aniline yellow, methyl violet, janus green B. Newer techniques (fluorescent stains) are also successfully used with protists, and many details are available in links from the *Nelson Science Web site*. It is important to note that many stains are extremely toxic and some are both carcinogens and mutagens.

CAREER CONNECTION

Biological technicians and technologists may work independently or provide technical support and services to scientists, engineers, and other professionals working in fields of agriculture, resource management, plant and animal biology, microbiology, cell and molecular biology, and health sciences. According to the HRDC National Occupational Classification, the duties of biological technicians and technologists are as follows:

Biological Technicians	Biological Technologists
<ul style="list-style-type: none"> – assist in conducting biological, microbiological, and biochemical tests and laboratory analyses – perform limited range of technical functions in support of agriculture, plant breeding, animal husbandry, biology, biochemical, or biomedical experimental research – assist in conducting field research and surveys to collect data and samples of water, soil, plant and animal populations – assist in analysis of data and preparation of reports – assist in enforcing regulations regarding wildlife and fisheries habitat and population protection 	<ul style="list-style-type: none"> – conduct biological, microbiological, and biochemical tests and laboratory analyses in support of quality control in food production, sanitation, pharmaceutical production, and other fields – perform experimental procedures in agriculture, plant breeding, animal husbandry, biology, biochemical, and biomedical research – conduct field research and surveys to collect data and samples of water, soil, plant and animal populations – assist in analysis of data and preparation of reports – conduct or supervise operational programs such as fish hatchery, greenhouse, and livestock production programs – enforce regulations regarding wildlife and fisheries habitat and population protection

Job titles include: Agricultural Technician, Agricultural Technologist, Agronomy Technician, Aquaculture Technician, Bacteriology Technician, Biological Laboratory Technologist, Botanical Technician, Dairy Products Technician, Fish Hatchery Technician, Fisheries Technician, Habitat Management Technician, Microbiology Technologist, Microbiology Quality Control, Plant Breeding Technician, Seed Technologist, Wildlife Technician.

Diploma programs in this field are available in many colleges across Canada. Information is available on the *Nelson Science Web site*.

2.15 FUNGI

TRY THIS ACTIVITY: COLLECTING AND EXAMINING LICHENS

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- (a) Students will classify lichen into three categories: crustose, foliose, and fruticose.
- (b) The photosynthetic partner in the lichen will contain chlorophyll, the fungus will not.

SECTION 2.15 QUESTIONS

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Understanding Concepts

1. Fungi are heterotrophs (consumers) and lack the structures and ability to produce food.
2. The following criteria are used to classify fungi: often have many nuclei per cell; have few or no storage molecules; have no roots; often have chitin in their cell walls; are heterotrophs; do not reproduce by seed.
3.
 - (a) mycelium: branching filament that makes up the part of a fungus not involved in sexual reproduction; nutrient absorption takes place here
 - (b) spore: a reproductive cell that has a haploid number of chromosomes; all fungi produce spores as part of the reproductive cycle
 - (c) hypha: one of the filaments of the mycelium; hyphae develop enlargements which form buttons, stalk, cap, gills, and eventually, spores
 - (d) sporangia: the reproductive structures in which spores are produced

4. Haploid spores form in specialized reproductive structures called sporangia. Inside the gill there is a tangled network of hyphae. The formation of dikaryotic extensions (two haploid nuclei) is an asexual process, as is the fusion of two haploid nuclei into one diploid nucleus. The next stage—meiosis of the diploid nucleus into four haploid spores—is a sexual process.
5. There are several species of *Amanita* mushrooms, all of them potentially fatal if eaten. Symptoms from the neurotoxin range from abdominal pain, cramps, and vomiting to hallucinations, disorientation, coma, and death. Eating only store-bought mushrooms avoids the risk of *Amanita* poisoning.
6. (a) Mycorrhizae are a symbiotic relationship between the hyphae of a fungus and the roots of a plant. In mycorrhizae, fungal hyphae help the plant absorb nutrients such as phosphorus.
(b) Lichens represent a form of symbiotic relationship between green algae or cyanobacteria and a fungus. The fungus provides the photosynthetic cells of the plant with carbon dioxide and water. The fungus also provides structural support.
7. Reindeer moss and British soldiers are both examples of fruticose lichen.

Applying Inquiry Skills

8. Commercially made bread contains preservatives and mould retardants to extend shelf life.
9. Directions for making spore prints are outlined in the Teacher’s Resource. Sample data from a white button mushroom:

Characteristic	Observations
colour	creamy white
odour	slight fungus smell
surface	dry; smooth (like bread dough) or fine wrinkles
structure	cap 5–12 cm diameter; gills free; pinkish brown becoming purple-brown then blackish-brown stalk (“stipe”) 2–5 cm tall; 1.5–2.5 cm thick; slightly bulbous at base; white turning brown
spore print	blackish-brown
identification	<i>Agaricus bisporus</i>

Ninety percent of the commercial mushroom production in North America is *Agaricus bisporus*. Two brown strains (portobello and cremini) also belong to the species. Portobello (sometimes spelled as portabella or portabello) is a more flavourful brown strain of *Agaricus bisporus* that is allowed to open to expose the mature gills with brown spores. Cremini is the same brown strain that is not allowed to open before it is harvested.

Making Connections

10. Molson Brewery has developed its own in-house brewer training program. Candidates come to Molson with an education in engineering, biology, or chemistry. Formal training is given at Molson and each brewer is partnered with a mentor brewmaster with many years of experience. It is a two-year apprenticeship program, covering every aspect of the brewing business, from handling raw materials to making deliveries. Apprentices perform nearly every job in the brewery, continuing to the next step only when their mentors decide they are ready. Along with hands-on training, there is a rigorous study program to learn the more technical aspects of brewing. Some apprentices are sent to specialized brewing schools located in the U.S., Germany, and England. Brewers rotate through various brewery positions to gain practical knowledge and experience after their apprenticeships. Continued on-the-job learning prepares them to mentor the next generation of Molson brewers. Similar in-house training programs are available with other commercial breweries and microbreweries across Canada. Other information is available on the *Nelson Science Web site*.
11. Impact of fungi on our lives:

Impact	
social	Mycotoxins have been used in the rituals of some cultures to alter mental states.
economic	Fungi are food sources (mushrooms, truffles) and are also used in the production of food (e.g., cheese).
environmental	Fungi recycle nutrients back into the soil by decomposing dead organic matter; this makes nutrients available for plants to absorb through their roots. Fungi are used in bioremediation—they decompose harmful pollutants and hazardous chemicals. Symbiotic relationships (mycorrhizae and lichen) are beneficial in many ways.
medical	Fungi are used in the production of antibiotics (e.g., penicillin).

12. Possible steps to ensure a spore-free living environment (students may have others):
- Keep leftover food well protected to prevent mould growth.
 - Have the air filter in the furnace changed regularly.
 - Have furnace ducts cleaned to prevent the spread of spores when the furnace is running.
 - Keep windows and doors closed as much as possible to prevent outside spores from entering the house.
13. The *Nelson Science* Web site has complete information available on the following topics:
- (a) the Irish potato blight of 1845–1847
Phytophthora infestans was responsible for the Irish potato famine in the 1840s that resulted in about 1 million deaths and the emigration of about 1.5 million people to other parts of the world. There are now varieties of potatoes that are resistant to most strains of *P. infestans*, and fungicides can be applied to combat this organism. However, potato blight still occurs in certain parts of the world where people cannot afford the fungicides and where it has been able to overcome the resistant potato varieties. Russia is the world's second-largest producer of potatoes after China, and in 2000, late potato blight destroyed more than 15% of the country's total crop. Worldwide, annual losses and fungicide costs amount to about US\$3 billion.
- (b) the use of fungi in the production of antibiotics
 In 1929, Alexander Fleming noted that a fungal colony had grown as a contaminant on an agar plate streaked with the bacterium *Staphylococcus aureus* and that no bacteria grew near the fungus. The contaminant was identified as *Penicillium notatum*, and the antibiotic produced from this culture was named penicillin. Other antibiotic substances were soon cultivated from soil bacteria (e.g., streptomycin from *Streptomyces griseus*—the species responsible for most of the antibiotics used in clinical medicine today). Other antibiotics from fungi include the cephalosporins and griseofulvin (from *Penicillium griseofulvum* and related species), which is used to treat athlete's foot and related fungal skin infections. Hundreds of antibiotic-like compounds have been isolated from microorganisms but few are useful because of their selective toxicity. Antibiotics must be highly effective against a microorganism but have minimal toxicity to humans.
- (c) the physiological effects of poisonous fungi on the human body (listed by genus)
Amanita: The death cap (*Amanita phalloides*) and the destroying angel (*A. virosa*) cause body cell damage and are normally fatal. The fly agaric (*A. muscaria*) and the panther (*A. pantherina*) cause severe poisoning. *Boletus*: Devil's boletus (*Boletus satanas*) causes digestive system irritation even when taken in small amounts, as does bitter bolete (*Tylopilus felleus*), peppery bolete (*Chalciporus piperatus*), and *Boletus clopus*, all of which have an unpleasant peppery or bitter taste. *Coprinus*: The common ink cap (*Coprinus aramentarius*) contains coprine, which causes nausea, headaches, palpitations, and collapse if consumed with alcohol. It is known as the “antabuse effect.” Related species such as the magpie ink cap (*C. picaceus*), *C. auminatus*, and *C. romagnesianus* are also thought to have a similar effect. *Cortinarius*: *Cortinarius oellanooides* and *C. oellanus* are deadly poisonous. Because very little is known about edibility in this large genus, it should be avoided. *Inocybes*: Red-staining inocybe (*Inocybes ptouillardii*) causes death by heart failure or asphyxiation. The straw-coloured inocybe (*I. fastigiata*) contains the chemical muscarine, which induces sweating and can also lead to death. *Psilocybe*: The liberty cap or magic mushroom affects sensory perception. It has hallucinogenic properties and when dried this fungus becomes an illegal drug. *Scleroderma*: The common earthball (*Scleroderma citrinum*) causes gastric upsets. Smooth earthball (*S. verrucosum*) can cause a bad case of diarrhea. Earthballs are often confused with edible puffballs. *Entoloma*: The livid entoloma (*Entoloma lividum*) causes gastric upsets and possible liver damage. Many other species are considered deadly.

2.16 INVESTIGATION: MONITORING BREAD-MOULD GROWTH

(Pages 141–142)

Prediction

- (a) Students will use previous knowledge to make this prediction. The growth of mould on bread is favoured by moisture, darkness, and warmth.

Procedure

- (b) Bread types will vary. If bread is purchased for this Investigation, ensure that it is free of preservatives. Homemade bread is a more reliable choice.
- (c) Qualitative and quantitative observations vary so much that a sample table is not helpful. It is possible that there will be no mould growth on anything but Sample 2 (warm, wet, dark) and that growth may be restricted to *Rhizopus* or *Penicillium*. If many mould spores were present when the investigation began, there may be some growth on all experimental cubes.