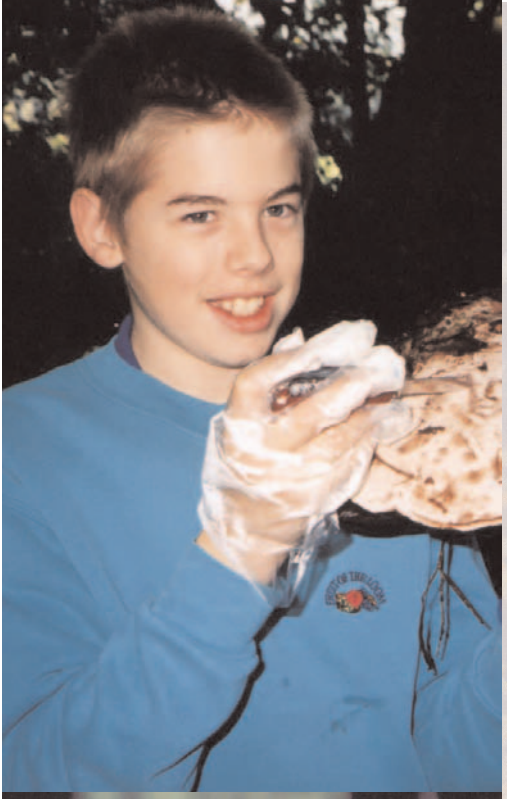


# HOW THE MUSHROOM GOT ITS SPOTS

## AN EXPLAINERS' GUIDE TO FUNGI


**Sue Assinder & Gordon Rutter**

**British Mycological Society Education Committee**



bms British Mycological Society promoting fungal science

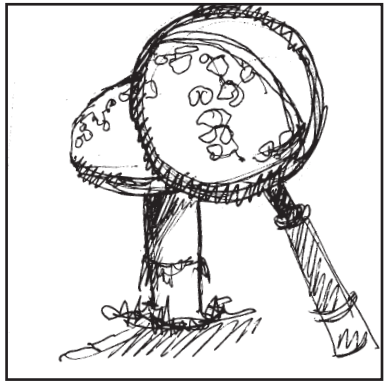
bbsrc biotechnology and biological sciences research council


# Contents



*Amanita muscaria* (Fly agaric)
(Roy Anderson)

*Lactarius vietus*
(Grey Milk Cap)
(Gordon Dickson)



# Introduction

## Background

The idea for this booklet came at a weekend workshop in York, which was organised by the Education Group of the British Mycological Society (BMS) for members of Local Fungus Recording Groups. These Groups identify and record the fungi present in their local area and promote their conservation. They also try to encourage an interest in the importance of fungi in everyday life, through forays, talks and workshops. The aim of the weekend was to share ideas (and hopefully think of new ones) of how to promote the public understanding and appreciation of fungi. This booklet is the result of those deliberations.

## Who can use this book?

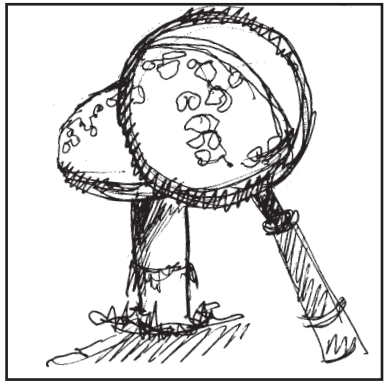
The booklet is aimed at anyone faced with the prospect of talking about fungi, whether to a school class, science club, local wildlife group or any other non-specialist audience. If you are a novice in this field, we aim to share a few tips to help you convey some basic facts about this important group of organisms. If you are a skilled practitioner, we hope that you will still find some new ideas to try.

## A special note to schoolteachers

We know that teachers may not have the time or freedom to explore novel topics. However, one of the great things about fungi is that they can be used to illustrate a whole range of basic biological principles. So if you are looking for a novel way to explain some aspect of biology, look at the workshop exercises and see if fungi could do the job. To help you, we have indicated how these can be integrated into the National Curriculum for Science (England, Wales and Northern Ireland). Further information, and details of the relevance to the curriculum in Scotland, can be found in Appendix III.

British Mycological Society promoting fungal science

bbsrc biotechnology and biological sciences research council



# How to use this Booklet

## Layout

The booklet is in three parts. The first part reviews the topics that you may wish to cover, highlights the important "take-home" messages and refers you to the relevant worksheets. The worksheets can be found in the second part of the booklet, and may be photocopied to use as handouts, OHP transparencies or merely as a memory aid for yourself. Finally, at the back of the book there are a number of appendices, which give important background information, safety advice and contact details for useful organisations and suppliers.
Most of the exercises require no more than a basic grasp of mycology - page 4 gives some essential material which you may find helpful if your background is limited. There is no rigid sequence in which to use the activities - the idea is to mix and match according to your audience and interests. Experiment and, above all, enjoy!

## Additional material

Additional material, updates and support can be found on the web pages of the BMS (Appendix I) and the Biotechnology and Biological Sciences Research Council (BBSRC) (Appendix II). The BMS site at www.fungi4schools.org offers a very wide range of teaching resources for free download.


## Acknowledgements

Thanks are due to the BMS and the BBSRC for financial support for the initial brainstorming weekend and for the publication costs of this booklet. We are indebted to the villagers of Heddon-on-the-Wall for being willing guinea pigs, to the Local Fungus Recording Groups for their helpful suggestions, and particularly to the participants of the weekend retreat - Hubert Fuller, Liz Holden, Richard Illiffe, Neil Mahler, Gerry Shannon and Marysia Stamm. Special thanks to Dariel Burdass, Maggie Hadley, Liz Holden, Janet Hurst, Royall Moore, John Tranter and Margaret Whalley for invaluable comments on the draft booklet.


## Health and Safety

**The two most important safety rules are:**

- **NEVER eat a fungus unless you are absolutely sure that it is safe - Get help from an expert and IF IN DOUBT, DON'T EAT IT!**
- **ALWAYS wash your hands after touching fungi.**

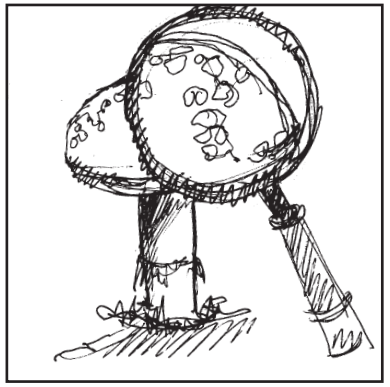
**Appendix VII gives more advice on safety and good practice for handling fungi in the field and classroom, and directs you to other sources of information. Teachers are advised to conduct a risk assessment before carrying out any of the activities in this booklet.**

# Fungi - the Essential Facts

Fungi used to be regarded as plants but they are now placed in their own kingdom. They range from single-celled **yeasts** that can only be seen with a microscope through to the largest living organism. They can be found everywhere, from deserts to the Arctic Circle, and were even a hazard on the Russian Space Station Mir. Nearly 100,000 different fungal species are known to date and it is estimated that there are over a million left to be discovered.

Most fungi grow in the form of microscopic filaments called **hyphae** that extend and branch to form a vast network or **mycelium**. The cell walls of fungi are made of chitin - the same material found in an insect's exoskeleton. What we normally think of as fungi - **mushrooms** and **toadstools** - are the **fruit bodies** that arise from the mycelial network, although some fruit bodies do not have the characteristic mushroom shape at all (e.g. puffballs, earthstars and fairy clubs). To exploit new **habitats**, fungi produce millions of **spores**. The fruit body is essentially a device to spread the spores at certain times of the year. A fruit body may exist for only a few days before rotting away but the mycelium that produces it may live for years and some individuals are known to be hundreds of years old.

This booklet concentrates on the macroscopic fungi that are most likely to be found in the field. These are divided into two groups. Most are **basidiomycetes** in which the spores develop on the outside of specialised club-shaped cells (**basidia**) and drop from these when mature to be wind-dispersed. This is a very diverse group, including gill fungi, boletes, jelly fungi, brackets, puffballs and stinkhorns. Others, such as the cup fungi, are **ascomycetes**, in which the spores are formed in a sac-like cell called an **ascus** and shot out under pressure.



Fungi do not possess the green pigment chlorophyll found in plants, so they have to gain their food from other sources in much the same way that an animal does. Many are **saprotrophs**, living on dead organic matter such as leaf litter, whilst others are **parasites** and may in extreme cases kill the host. Fungi play a vital role in recycling by breaking down lignin. Without this action, all the nutrients locked in plants would remain there, nutrient cycles would stop and plants would not have enough raw materials to survive. **Mycorrhizal** fungi form **symbiotic** associations with trees, extending the root system and assisting in the uptake of water and nutrients. Over 90% of plants have a fungus associated with their roots and many would not survive without their fungal partner. Fungi may also form **symbiotic** relationships with algae, known as lichens.

Fungi are used by humans for a variety of processes - from alcohol and bread production (with yeast) to genetic engineering and biotechnology. Fungal fermentation has been harnessed to manufacture important therapeutic compounds, such as antibiotics, and enzymes for use in the food, textile and other manufacturing industries.

(Terms in **bold** are defined in the Glossary on page 44.)

## WORKSHEETS

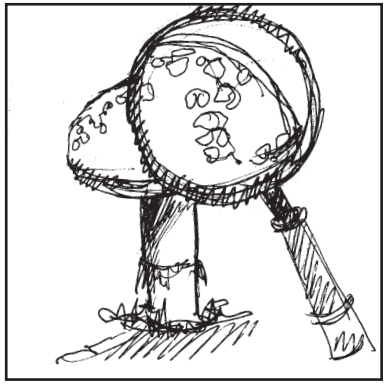
***Worksheet 1:***
*Top Fungal Facts*

***Worksheet 2:***
*Kinds of fungi*

***Worksheet 3:***
*Parts of a mushroom*

***Worksheet 4:***
*Why study fungi?*

***Worksheet 5:***
*Supermarket challenge*



# EXPLAINING THE BASICS

Most people are familiar with mushrooms from their local supermarket, but that is often where their knowledge of fungi begins and ends. When faced with such an audience, the last thing you want to do is bombard them with facts and figures. There is a danger that they will quickly decide that fungi are "difficult" or (even worse) "boring"! **Worksheets 1, 2** and **3** are "essential fungal facts" for people with no knowledge of fungi - they can be used as OHP transparencies or handouts, or can be adapted as quizzes for a review session.

There is a potentially confusing issue over terminology that is best dispensed with early on in the proceedings. The term 'fungus' includes all members of the kingdom. 'Mushroom' and 'toadstool' are normally used interchangeably to describe those fungi with a fleshy fruit body with a cap and stem. It is important to make clear that no inferences can be made about the edibility of a fungus from its name. The word 'toadstool' is popularly associated with inedible or poisonous fungi. However, the classification has no scientific basis and several species called 'mushroom' are poisonous. The only safe way to distinguish between edible and poisonous species is to learn to identify them accurately.

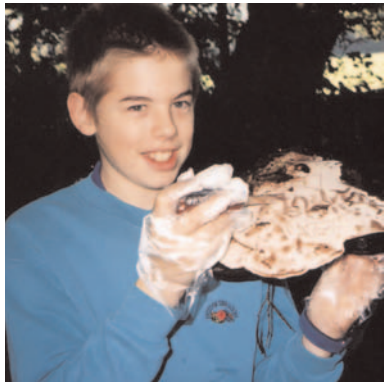
It is also important to convey why we study fungi, since many people regard them as curiosities with little interest beyond their possible edibility. Fungi have an impact (both positive and negative) on many aspects of everyday life. You can illustrate this using **Worksheet 4**, either as a transparency or as a handout to which examples and/or illustrations can be added.

If you want to open children's eyes to the many ways that humans use fungi, just send them to the local supermarket with the task of identifying as many products as possible of fungal origin (**Worksheet 5**). Alternatively, bring the supermarket to the classroom. Present a selection of items, some that have a connection with fungi and others that do not. Obvious things to include are mushrooms (fresh and dried), processed foods (e.g. pies, soups), Quorn products, alcohol, blue cheese and bread. Less obvious but good topics for discussion are chocolate and coffee (both involving fermentations), washing powder (often contains fungal enzymes), tofu and soy sauce (derived from mould action on soya beans). Additional resources dealing with these topics can be downloaded (free) from www.fungi4schools.org

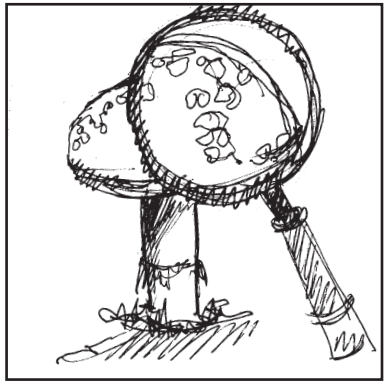
Links to the National Curriculum
Sc2 Life processes and living things. 5. Living things in their environment.
KS2 (f) Beneficial and harmful properties of micro-organisms.
KS4 (f) Micro-organisms in decomposition and recycling.

## WORKSHEETS

***Worksheet 6:***
*Recording Sheet*



Bracket fungus at Heddon-on-the-Wall, 2000 (Sue Assinder)



# LOOKING AT FUNGI IN THE FIELD

The best way to demonstrate the diversity within the fungal kingdom is to take out your audience to look at fungi in their natural environment. It is up to you whether this includes collecting, or just observing. Autumn is the best time of year for seeing fungi in the UK, although they can be found all year round if you look carefully and are particularly prolific after a few days of rain. Publications mentioned in Appendix V contain further information about which fungi you might expect to encounter in the field, with illustrations of some common species.

A fungal foray is an excellent way of introducing the key scientific skills of observation and record-keeping. **Worksheet 6** is an example of the sort of recording sheets you might use for KS2/3. As much information as possible should be recorded, including what the fungus looked like, when it was found, what it was growing on and details of nearby vegetation. If fungi are being collected, it is important to dig up the whole specimen (using a blunt knife if necessary) because features at the base of the stem can be important for identification. Once collected, store in an open basket or plastic container (e.g. an old margarine tub), not in plastic bags as this will speed up decomposition. Note than when collecting fungi, it is important to follow 'The Wild Mushroom Pickers' Code of Conduct' (Appendix VIII).

Safety is a prime consideration when taking any group into the field (see Appendix VII). Some hints and advice on organising and leading forays are given in Appendix VIII. If you feel that you do not have the experience to lead a foray yourself, a Local Fungus Recording Group may be able to help (Appendix IV).

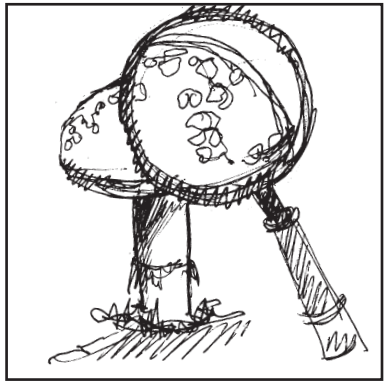
Links to the National Curriculum
Sc 1 Scientific enquiry.
All key stages; investigative skills; obtaining and presenting evidence.

## WORKSHEETS

***Worksheet 2:***
*Kinds of fungi*

***Worksheet 7:***
*A close look at mushrooms*

Making a "habitat collage"
Heddon-on-the-Wall, 2001
(Sue Assinder) - see p.10.



# LOOKING AT FUNGI IN THE CLASSROOM

If a foray is not practical (30 ten-year-olds let loose in the woods may be too much of a challenge for even the most experienced teacher!), a good collection of field samples still looks impressive back in the classroom, and has the obvious advantage that you can restrict the display to non-poisonous varieties. Alternatively, you can use supermarket specimens, although this will give a less varied range of shapes, colours and textures. **Worksheet 2** can be used to identify the major groups to which each of the specimens belongs, and **Worksheet 7** details some of the key features to consider when looking specifically at mushrooms. Check with the Local Education Authority before bringing wild fungi into the classroom as local guidelines vary. If there is concern about children handling the fungi, dental mirrors are useful tools for carrying out close examinations (see Appendix IV for supplier).

Encourage attention to all of the characteristics of a fungus, including shape, colour, smell and size. It is also useful to demonstrate some of the practical tests that are often used as aids in identification -

- Are the gills brittle and crumbly? (*Russula*)
- Does it produce milk when cut? (*Lactarius* - milk cap)
- Does it bruise when you press on the cap? (Some bolete species)

An alternative way of seeing live specimens is to buy a "grow-your-own" kit (See Appendix IV for suppliers). These are inexpensive and have the added excitement of being able to watch the fungi appear, a novel classroom alternative to growing mustard and cress!

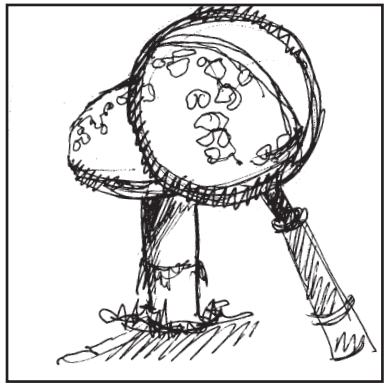
Links to the National Curriculum
Sc 1 Scientific enquiry.
All key stages; investigative skills; obtaining and presenting evidence.
Sc2 Life processes and living things. 5. Living things in their environment.
KS2 (f) Beneficial and harmful properties of micro-organisms.
KS4 (f) Micro-organisms in decomposition and recycling.

## WORKSHEETS

***Worksheet 8:***
*Dyeing wool with fungi*

***Worksheet 9:***
*Making paper with fungi*

**You can find further information on fungi in the school curriculum in Appendix III and a list of books and web-based educational resources in Appendices V and VI**



# EXPERIMENTING WITH FUNGI

Fungi offer many opportunities for experimental science and project work at all levels. A simple idea for primary age children is to examine the conditions necessary for the growth of fungi in a "mould garden". This is an excellent way of introducing the ideas of a fair test and controlling variables. Note that primary schools can only culture microorganisms on substances where they grow naturally and must not incubate above ambient temperature. Place identically sized pieces of bread or soft fruit in clear jars with the lids loosely fitted or in closed plastic bags punctured by a few pinpricks. Vary the conditions within the containers (e.g. by adding additional water or a desiccant such as silica gel) and place them in a variety of locations (e.g. on a sunny windowsill, in the dark etc). Examine the contents periodically (do NOT open the containers) and record the appearance. Note that at the end of the experiment, the contents must be disposed of by autoclaving or disinfecting (Appendix VII), not thrown in the bin!

In secondary schools, fungi can be grown in Petri dishes on malt agar (available from scientific suppliers). The Microbiology On-line web site (Appendix VI) carries a useful list of fungi that can be safely used in schools, together with their growth requirements and educational interest. It is also possible to take a more investigative approach, such as comparing fungal growth from different water or soil samples. During incubation, the lid and base of the Petri dish should be taped together with 2-4 short strips of adhesive tape as a protection against accidental opening. Do not seal around the circumference of the dish as this would create anaerobic conditions. "Environmental" samples must also be taped around the seals after incubation before pupils look at them because of the possibility of growing harmful microorganisms. Note that agar cultures must always be disposed of by autoclaving (Appendix VII).

Yeast is a useful and safe fungus for work with both primary and secondary school children and features in the schemes of work for KS2 (unit 6b Microbes) and KS3 (unit 8c Microbes and Disease) (www.standards.dfee.gov.uk/schemes). The Society for General Microbiology (SGM) has produced a resource pack for KS1/2, with activity sheets for experiments with yeast that are downloadable from the Microbiology On-line web site.

The activities in **Worksheets 8** and **9** are more suitable for post-16 project work (or for younger children as demonstrations). Note that teachers must complete a risk assessment before carrying out these experiments (e.g. use of knives, boiling water, safe collection/disposal of fungi).

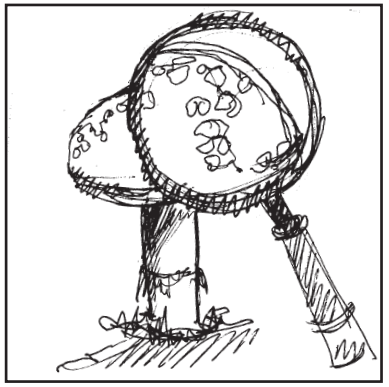
**Links to the National Curriculum**
Sc 1 Scientific enquiry.
All key stages; investigative skills; obtaining and presenting evidence.
Sc2 Life processes and living things. 5. Living things in their environment.
KS2 (f) Beneficial and harmful properties of micro-organisms.
KS4 (f) Micro-organisms in decomposition and recycling.

## WORKSHEETS

***Worksheet 10:***
*How to make a spore print*

***Worksheet 11:***
*How the mushroom got its spots*

*Oudemansiella mucida*
(Gordon Dickson)



# HOW DO FUNGI GROW?

An important message is that there is much more to fungi than meets the eye. Many people do not realise that when they look at a mushroom, they are seeing only a very small part of the fungal life cycle ("fruit body"). The real body of the fungus (mycelium) is present the whole year round, either underground or hidden in the food substrate depending on the particular fungus. The fruit body is responsible for spreading the spores. These are like tiny plant seeds but they do not have the food reserves that a seed contains. **Worksheet 10** explains how to make a spore print, an attractive way of illustrating the process of spore dispersal.

A classic image of a fungus is that stalwart of fairy tales, the fly agaric (*Amanita muscaria*), its red cap resplendent with vivid white spots. The spots are the remnants of the universal veil, a protective structure that ruptures as the fruit body matures. **Worksheet 11** provides a simple but effective way of explaining this process, and is a firm favourite with children who can produce their own mushroom memento to take away. The activity also nicely illustrates the importance of water for growth, not just for fungi but for all living things.

"How the mushroom got its spots" Heddon-on-the-Wall, 2000
(Sue Assinder)

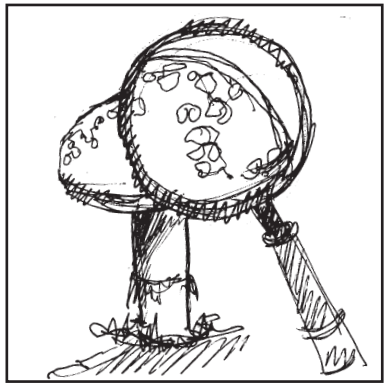
Links to the National Curriculum
Sc2 Life processes and living things. 5. Living things in their environment.
KS2 (f) Beneficial and harmful properties of micro-organisms.
KS4 (f) Micro-organisms in decomposition and recycling.

## WORKSHEETS

***Worksheet 12:***
*Build a tree*

***Worksheet 13:***
*Mushroom Murder Mystery*

"Building a tree" (Worksheet 12) Heddon-on-the-Wall, 2000 (Sue Assinder)



# WHERE DO FUNGI GROW?

Fungi live in a variety of habitats and exhibit many different lifestyles. **Worksheets 12** and **13** explain the three roles that fungi can play in nature, and are fun to use with all age-groups. Fungi can have beneficial roles as mycorrhizal partners gathering extra food for the tree and as decomposers of dead wood and leaves, which recycles nutrients to the soil. Parasitic fungi are harmful to the individual tree, but still can be seen as having a positive effect for the forest by providing new deadwood habitats for insects and other organisms and allowing sunlight to reach the forest floor for re-growth. **Worksheet 12** explores these concepts from the viewpoint of an individual tree, whilst **Worksheet 13** expands these themes to the forest as a whole.

A good way of reinforcing these ideas with a younger group is to make a "habitat collage". This works particularly well on a "drop-in" basis when there are several other activities running in parallel. Ask participants to draw a picture of their favourite fungus or prepare some simple outlines that they can colour in. Using their knowledge from a foray they have been on, or by consulting simple field guides, the children stick the pictures on the appropriate part of a background showing a range of habitats (e.g. coniferous and deciduous woodland). For a 3D effect, add to the foreground some models of fungi made from a modelling clay like plasticine or some fly agarics using **Worksheet 11.**

Links to the National Curriculum
Sc2 Life processes and living things 5. Living things in the environment
KS2 (b) Different habitats (d) Feeding relationships in habitats
KS3 (b) Habitats support a diversity of interdependent organisms
KS4 (f) Micro-organisms in decomposition and recycling.

## WORKSHEETS

***Worksheet 14:***
*A simple key to fungi*

***Worksheet 15:***
*What's in a name?*

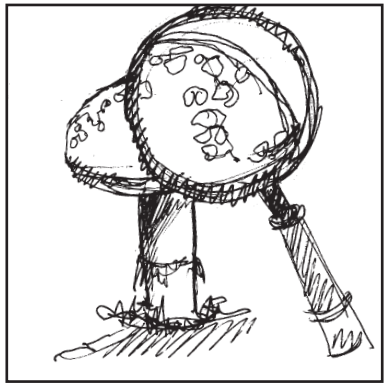
***Worksheet 16:***
*Odd one out*

***Worksheet 18:***
*Answers to puzzles and quizzes*

# WHAT'S IN A NAME?

It is entirely possible to appreciate the beauty and diversity of fungi without identifying each species collected. Precise identification requires considerable experience and a range of skills that are outside the scope of this book. However, if your audience wishes to put names to their prized specimens, you can set them on the right track by instilling a basic understanding of the use of identification keys. Fungi are actually an ideal group of organisms with which to illustrate the important idea of a key for identifying biological specimens. **Worksheet 14** gives an example of a simple key that could be used to discriminate between several major kinds of fungi that are commonly found on forays. If you wish to extend this exercise, Appendix V gives details of a simple illustrated key that enables the identification of 30 commonly found fungi. Alternatively, detailed keys that allow identification to species level can be found in the excellent field guides listed in Appendix V.

When identifying a fungus, it is usually best to use the common name (where one exists) alongside the scientific name. Explain that the scientific name is there to help (not to confuse!) so that everyone knows exactly what species is being talked about. For example, if you travel abroad, the common names will be in the local language but the scientific names will be constant. You can use **Worksheet 15** to illustrate the relationship that often exists between scientific and common names, whereas **Worksheet 16** is a light-hearted activity that celebrates some of the weird and wonderful names in common use. Both activities have proven popular with adults and children as part of a "mycelial maze" quiz after a foray (see page 14).

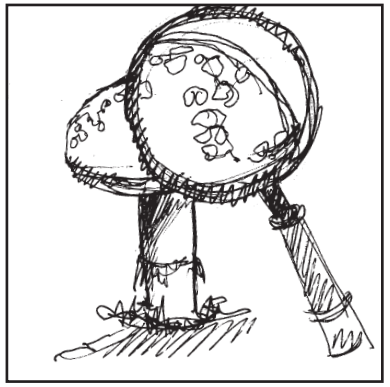


A list of "Recommended English Names for Fungi in the UK" has been compiled by E.M. Holden. A printed version can be obtained from the Plantlife Bookstore (www.plantlife.org.uk), but the list can be downloaded (free) from the BMS website at www.fungi4schools.org/.

Links to the National Curriculum
Sc2 Life processes and living things 5. Variation and classification
KS2 (a) Making and using keys
KS3 (b) Classification into taxonomic groups

# Fungal History and Folklore

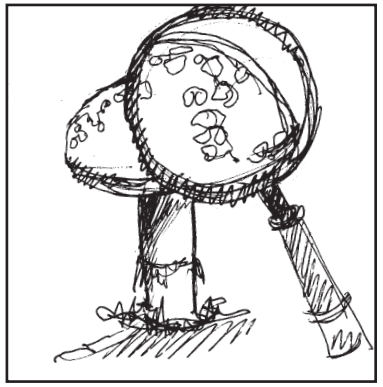
*Calocera viscosa* (Jelly antler fungus)
(Gordon Dickson)



Being able to tell an interesting story or anecdote about the fungi you collect is a good way of capturing people's interest. The following are just a few examples:

- It is said that the ancient highlanders used to pack their circular shields (targes) with dried material from the Birch bolete (*Piptoporus betulinus*). The fungus is light and tough and is a good shock absorber. It was also used for honing blades - the Victorians called it the 'razor strop' fungus and sharpened their old-fashioned razor blades on it. Good job that this fungus also has some antiseptic qualities!
- It was not always so easy to go on fungal forays. In ancient Egypt, the consumption of mushrooms was a privilege restricted to the pharaoh and his family - a commoner was forbidden even to touch one!
- Mushroom poisoning was a problem even in ancient Rome. Emperor Claudius died at the hand of his third wife Agrippina, who fed him a poison mushroom in order to ensure that her son Nero would become the next emperor.
- People have also been using fungi for purposes other than food for thousands of years. Tinder material prepared from the bracket fungus, *Fomes fomentarius* was found with the frozen remains of a Neolithic man in an alpine glacier in 1991, and has been dated to 3350 - 3100 BC.
- Some stories are more speculative. The convulsive fits that took hold of some residents of Salem, Massachusetts in 1692 were diagnosed as "bewitchment" and set in train a series of events that led to the deaths of 19 people. The symptoms are now believed by many to be due to ergot poisoning from eating bread prepared from rye contaminated with the fungus *Claviceps purpurea*.
- Mushrooms are sometimes seen in playing fields and garden lawns growing in circles known as “fairy rings”. The name comes from the old folk-tale that the rings were the work of fairies making themselves a dance floor complete with tiny stools. A different story is told in Germany, where the rings are allegedly caused by dragons flying in circles and scorching the earth with their tails. The truth is that the rings are due to a single mycelium growing outwards from a central point, and the mushrooms spring up in a circle from just behind the growing edge.
- To discover the fungal story behind Santa and his reindeer, see http://www.uio.no/conferences/imc7/NFotm99/December99.htm

*Flammulina velutipes* (Velvet shank)
(Nick Legon)



# Fascinating Fungal Facts

Fungi provide their fair share of trivia

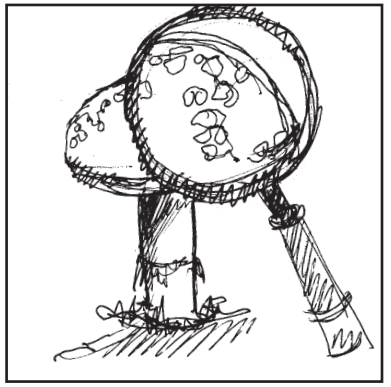
- Poison from a piece of death cap fungus sufficient to cover the tip of a knife (0.5g) can kill 100,000 mice.
- An individual honey fungus is claimed to be the world's largest and oldest living organism. Estimated to be some 1,500 years old and more than 10,000 kg in weight, its underground network of hyphae occupies 15 hectares (*Nature*, 1992, 356: 428 - 431).
- The first discovered antibiotic - penicillin - is from a mould *Penicillium notatum*. The discovery was probably one of the greatest medical advances of the 20th century and it came about entirely by accident.
- When fungi are collected from tropical rainforests approximately one in every eight types collected is a species completely new to science.
- The stinkhorn (*Phallus impudicus*) can reach a length of 20 cm in only 2-3 hours, due to the cells sucking in water.
- One bracket, the Dryad's saddle (*Polyporus squamosus*), is recorded as reaching a weight of 14 kg in only 3 weeks.
- Field mushrooms (*Agaricus campestris*) have been found with a cap circumference of 115 cm.
- Mushrooms are quite capable of forcing their way up through asphalt and lifting paving stones. Two mushrooms growing beneath a 35 kg paving stone that had been cemented into place were able to push the slab up by 4 cm.

## WORKSHEETS

***Worksheet 17:***
*Review questions*

***Worksheet 18:***
*Answers to puzzles and quizzes*

*Geastrum triplex* (Collared earthstar)
(Gordon Rutter)



# HOW MUCH DO YOU KNOW ABOUT FUNGI NOW?

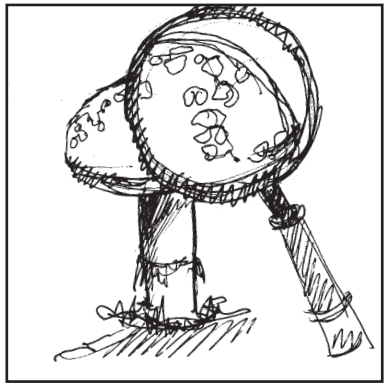
The activities in this section are useful for reinforcement after a foray. The ways they can be used are almost as numerous as the different kinds of fungi. These are just two ideas that we have found to work well.

**Toadstools and trees:** This can be used with both adults and children (be careful though - adults can be quite competitive!). The members of the group stand in a circle. It's surprising how many people find this difficult - asking them to pretend that they have "sticky elbows" is a useful trick. (Don't forget to un-stick elbows once in a circle- people can take things very literally!). Alternate people are designated as either a tree or a toadstool. Make either a true or false statement about fungi - **Worksheet 17** gives some examples, and you can also incorporate some of the facts on the previous page. If the statement is TRUE, trees run outside of the circle in a clockwise direction. If the statement is FALSE, toadstools run around the outside of the circle in an anticlockwise direction. Start off with the easy statements and work up to the ones that require more thought. The more difficult the statement, the greater the potential for confusion! The participants stop when they return to their original positions, and there is opportunity for discussion on why people reacted the way they did.

**Mycelial maze:** You will need one umbrella (to represent the fungal fruiting body) and some long lengths of string (hyphae). Place the umbrella in the middle of the room. Attach the strings to the umbrella handle at one end and then trail off under tables and chairs, ending up with a puzzle or quiz. (Tape down the string where necessary to avoid tripping). **Worksheets 5, 15, 16, 17** and **18** can all be adapted for this purpose. If it is possible to do the activity outdoors, the strings can be hidden under vegetation and dead leaves and can end up at a real fungus to be identified.

## WORKSHEETS

Heddon-on-the-Wall, 2000
(Sue Assinder)



## WORKSHEETS

1. Top fungal facts
2. Kinds of fungi
3. Parts of a mushroom
4. Why study fungi?
5. Supermarket challenge
6. Recording sheet
7. A close look at mushrooms
8. Dyeing wool with fungi
9. Making paper with fungi
10. How to make a spore print
11. How the mushroom got its spots
12. Build a tree
13. Mushroom murder mystery
14. A simple key to fungi
15. What's in a name?
16. Odd one out
17. Fungal brainteasers
18. Answers to puzzles and quizzes

The activities on these worksheets have been collated from several sources. Where appropriate, every effort has been made to identify and acknowledge the original source of the activity. All of the worksheets can be reproduced for educational purposes but not for profit. They can be used in a variety of ways. Most of them are designed to be photocopied and used as handouts, and space has been included on which extra notes can be made if required. Some (e.g. Worksheets 2, 3 and 7) could also easily be adapted as OHP transparencies. A few (e.g. Worksheets 11-13) are targeted specifically at the instructor and explain how to run particular activities. Worksheet 18 provides additional notes and solutions to the various puzzles and quizzes.

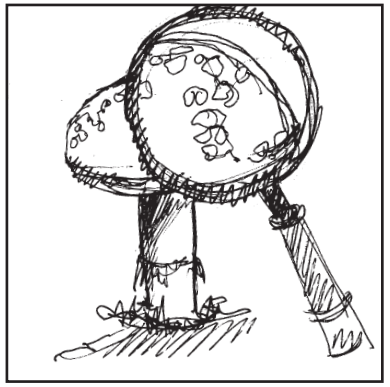
*Tricholomopsis rutilans*
(A W Brand)

**WORKSHEET 1**

**NOTES**

## TOP FUNGAL FACTS

- A fungus isn't a plant or an animal. Fungi have their own KINGDOM
- The part of the fungus you can see is called the FRUIT BODY
- Fungi spread by producing millions of microscopic SPORES
- Fungi are made of minute threads called HYPHAE (plural of HYPHA)
- The main part of the fungus is a dense network of hyphae called the MYCELIUM that is often hidden from sight.



- Different kinds of fungi live in different places. The place where we find a fungus is called its HABITAT
- Some fungi are edible but some are very POISONOUS!
- People who study fungi are called MYCOLOGISTS

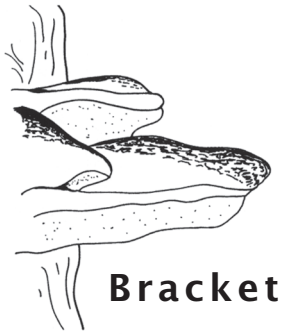
## Worksheet 2

### Notes

Not to scale

## Kinds of Fungi

Stinkhorn



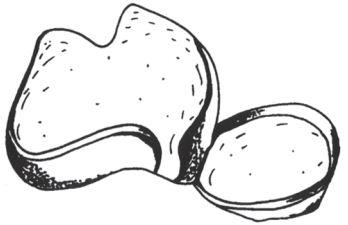
Bracket

Trumpet fungus

Puffball

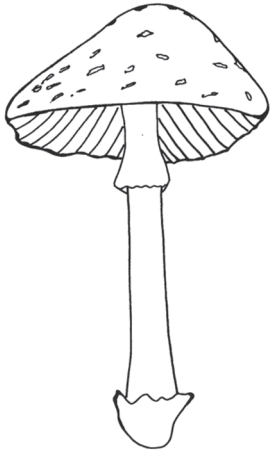
Hard “crust” on wood

Club fungus



Cup fungus

Bolete



Gill fungus

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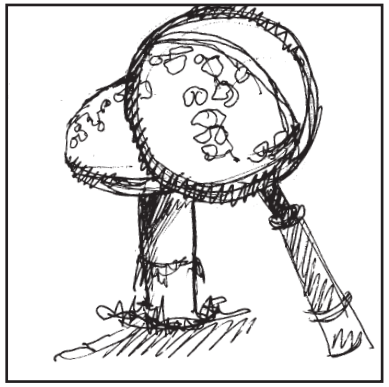

## WORKSHEET 3

### NOTES

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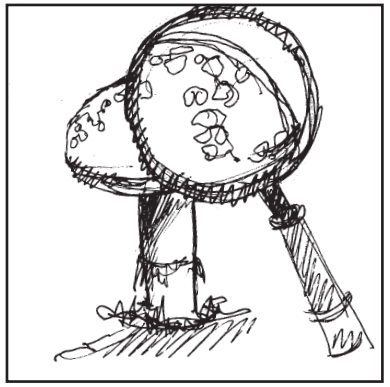
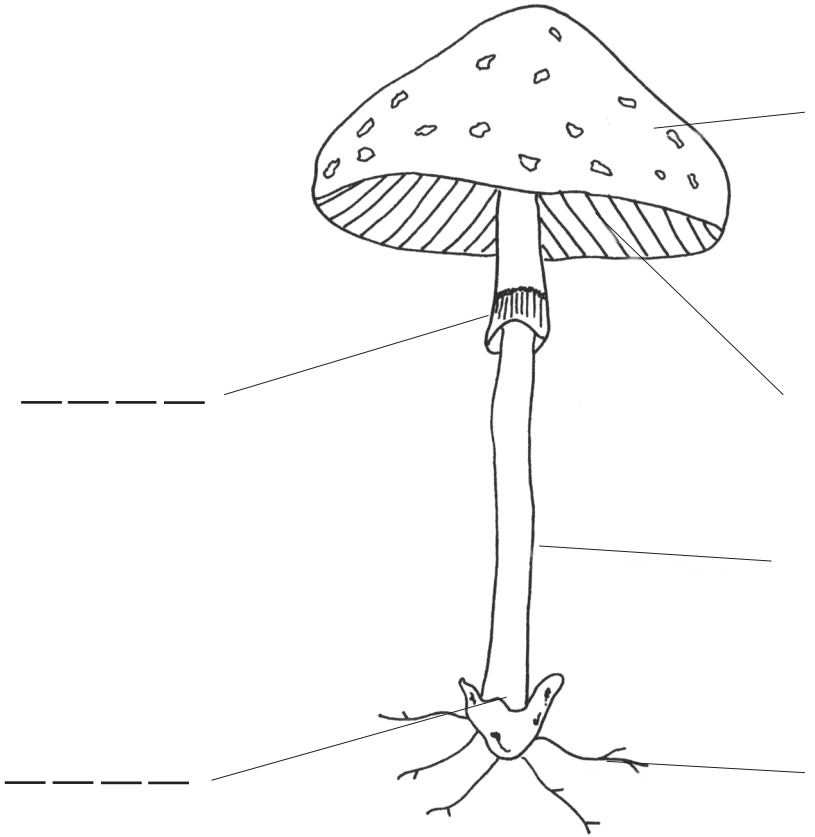


## PARTS OF A MUSHROOM



_ _ _ _ or _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _

_ _ _ _ _ or _ _ _ _ _

_ _ _ _ _

_ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _

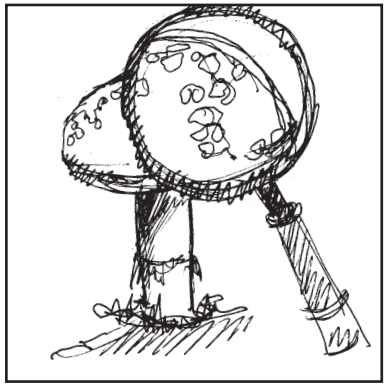
**Choose the correct word(s) for each part of this mushroom**

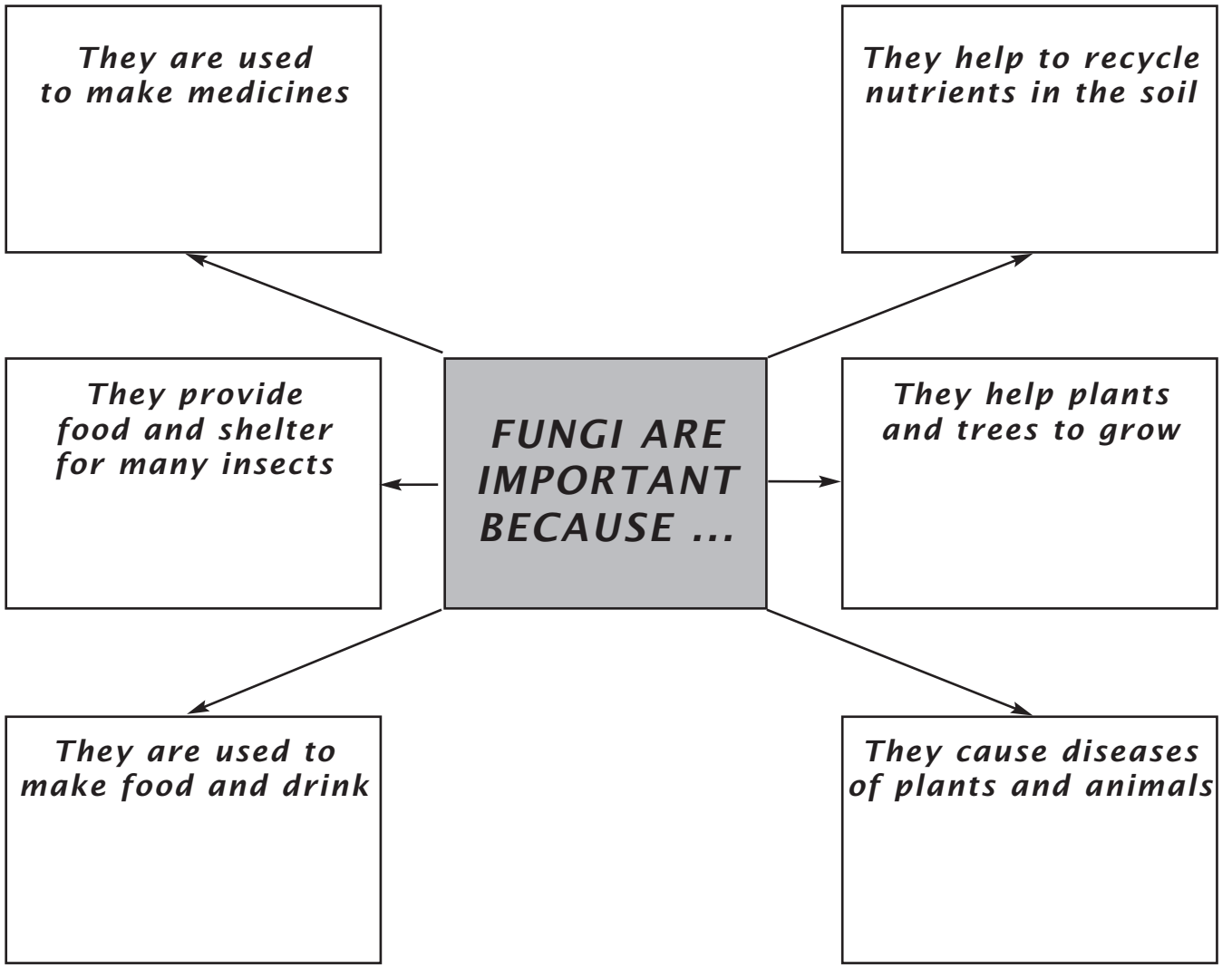
| | | |
|---|---|---|
| STEM or STIPE | MYCELIUM | GILLS |
| CAP or FRUIT BODY | VOLVA | RING |

## WORKSHEET 4

### NOTES

# WHY STUDY FUNGI?





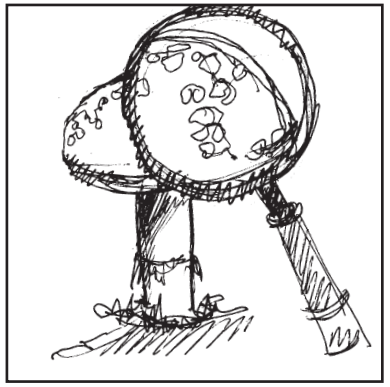
## WORKSHEET 5

### NOTES

# SUPERMARKET CHALLENGE

Many items from the supermarket contain fungi, or fungi have been used to make them. Decide whether the items on display have something to do with fungi and list them in the correct box

| Fungal | Not fungal |
| --- | --- |
| | |



Name two other fungal products that you could find in the supermarket

## WORKSHEET 6

# RECORDING SHEET

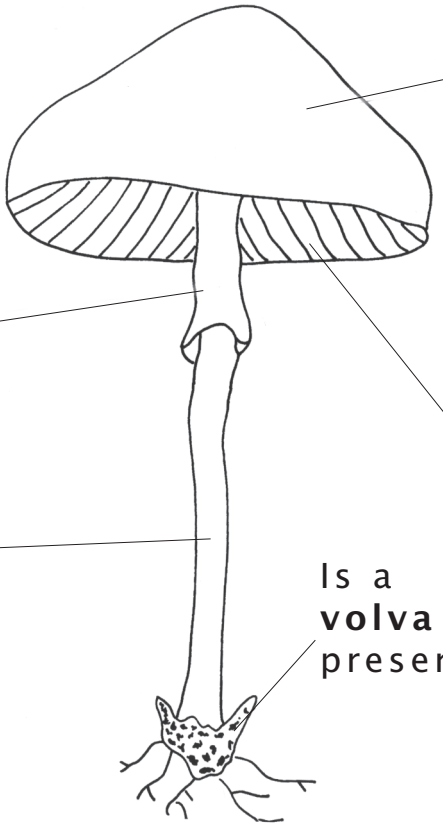
Stand still. Look around. Look again. It is easy to miss fungi so you need to look closely, not just glance at an area. When your eyes and brain are accustomed to searching for fungi you will see them everywhere - including places you have already looked in!

| Kind of fungus (e.g. mushroom, bracket) | Name of fungus (if known) | Number of fruit bodies seen | Describe where the fungus was found | Draw a picture of the fungus |
|---|---|---|---|---|
| | | | | |

## WORKSHEET 7

### NOTES

# A CLOSE LOOK AT MUSHROOMS



**The cap**
Size?
Shape?
Colour?
Flesh colour when broken?
Does it peel easily?
Texture - smooth, sticky, fibrous or scaly?

Is a **ring** (or remains of) present?

**The stem**
Height?
Width?
Smell?
Colour?
Texture?
Hollow?

Is a **volva** present?

**Under the cap**
Gills, pores or spines?
Colour?
Crowed or well-spaced?

**Where is it growing?**
In woodland? In grassland?
Near or under a plant? On wood?
In soil? (What sort?) On manure?

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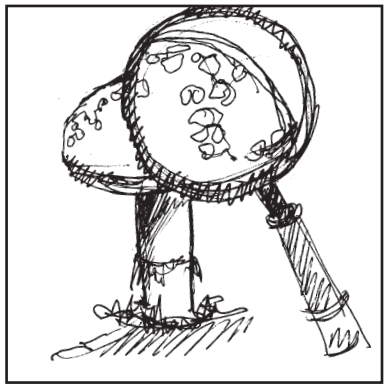
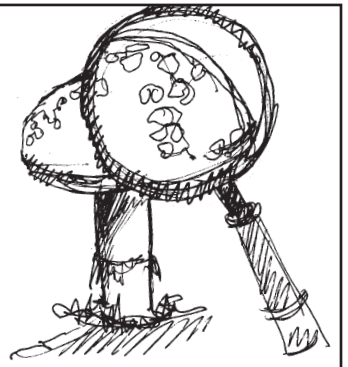


## WORKSHEET 8

## NOTES

**Health and Safety**
**TAKE CARE WITH BOILING WATER!**
**ALWAYS WASH YOUR HANDS AFTER TOUCHING FUNGI**



# DYEING WOOL WITH FUNGI

This experiment shows you how fungi can be used to dye wool a variety of beautiful colours.The dyes come from chemicals that occur naturally in fungi. Different fungi contain different chemicals and so can give different colours.

***You will need:***
Approximately 100g clean mushrooms, coarsely chopped
Approximately 100g of light-coloured natural wool
A large aluminium, tin or copper pot *
Approximately 3 litres water (2 litres if using dried mushrooms)
A mixing spoon
A straining spoon or sieve
A means of heating water

***Tips:***
- Different fungi give different colours, so experiment!
- Try varying the amount of fungus to get different shades of colour.
- You don't have to use mushrooms - brackets, jelly fungi and boletes will also work.
- If there is no colour you have probably just been unlucky - not all fungi produce dyes so try again with a different species.

***What to do:***
1. Boil the water in the pot, add the mushrooms and simmer for 30 minutes.
2. Carefully remove the mushrooms using a straining spoon or sieve.
3. Add the wool to the water and simmer for 30-60 minutes (add more water if the volume is getting low).
4. Allow the wool to cool in the pot, wash in warm water to remove excess dye and dry (e.g. outside on a sunny day or in an airing cupboard).

* Note: Natural dyeing normally requires a colour fixative or "mordant", such as alum (aluminium potassium sulphate). This is not necessary if you use an aluminium, tin or copper pot as the metal in the pot will take part in the dyeing reaction. However, if you use a non-stick saucepan, you should add a few copper coins to the mix.

***How can I find out more?***
For advice on which fungi to use and the colours they produce:
www.rbge.org.uk/research/celtica/fungi/dyes.htm
To see some beautiful results: www.somamushrooms.org/Dye/body_dye.html

**WORKSHEET 9**

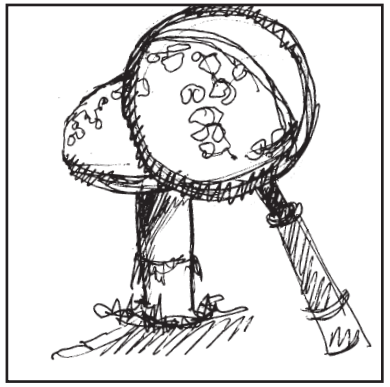
**NOTES**

# MAKING PAPER WITH FUNGI

Paper is basically a flat mat of fibres. Although handmade paper is traditionally made with vegetable fibres, the basic process is no different for fungi, except you are using a chitin rather than a cellulose base.

***You will need:***
Some bracket fungi
A tray (e.g. cat litter tray)
A heavy weight
2-3 sheets of blotting paper
A blender
10-12 pieces of absorbent cloth (slightly larger than intended size of paper)
A mesh frame (specialised paper-making frames can be bought from art shops but home-made alternatives are fine. e.g. mesh netting spread over an embroidery hoop).
Water - lots!

**Health and Safety**
**ALWAYS WASH YOUR HANDS AFTER TOUCHING FUNGI**



***What to do:***
1. Chop up clean bracket fungi and blend them with a small quantity of water in a blender. The amount of fungus required is enough to make a fluffy marshmallow-like consistency when blended with the water. The consistency is important - too watery and the paper will end up too thin, too concentrated and the paper will be lumpy.
2. Pour the mixture into the tray, along with some more water.
3. Place the mesh frame into the tray until all of the mesh is covered by mashed bracket. Gently remove the mesh and hold it above the tray until most of the water has drained away.
4. Quickly invert the mesh onto a piece of cloth and then carefully lift it away from the paper mat. Place another piece of cloth on top of the paper and press gently.
5. Repeat until you have a pile of 10 - 12 sheets of fungal paper.
6. Place the weight on top of the pile to squeeze out the remaining water and then hang the stack of cloth sheets and paper up to dry.
7. Separate the sheets of paper from the cloth and press onto blotting paper if necessary for final drying.

***Tips***
- Experiment with mixing different types of fungi to make mottled paper.
- Look at www.rbge.org.uk/data/celtica/fungi/paper.htm for some beautiful results.

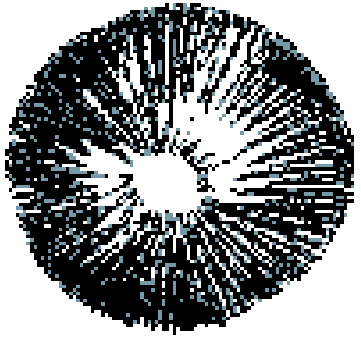
**WORKSHEET 10**

**NOTES**

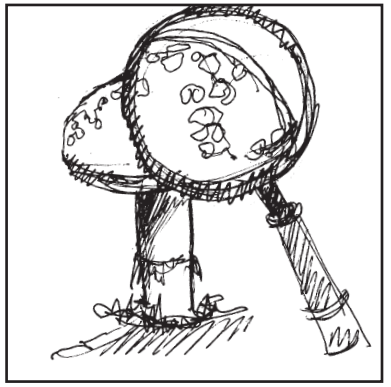
# HOW TO MAKE A SPORE PRINT

Mushrooms produce millions of spores, which are equivalent to the seeds of plants but without the massive food reserves. Spores are made on the plate-like gills underneath the cap of a mushroom (or in the tubes of a bolete). When they are mature they fall off the gill and are blown about by the wind. Spores are so small that you normally need a microscope to see them, but with a spore print thousands of spores are all seen together.

***You will need:***
A mushroom
A sheet of white paper
A sheet of black paper
A jam jar or similar container
Sticky tape
Hair spray (optional)
(Patience)



**Health and Safety**
**ALWAYS WASH YOUR HANDS AFTER TOUCHING FUNGI**



***What to do:***
1. Overlap the two sheets of paper and join them at the back with sticky tape.
2. Gently remove the cap from the mushroom and place it face down on the joined paper so that half is on each colour.
3. Cover the mushroom with the jam jar to stop it drying out.
4. Leave everything where it is for at least 2 hours.
5. Carefully remove the jam jar and fungus. You should see a pattern on one half of the joined paper depending on the colour of the spores.
6. To prevent smudging, "fix" your spore print with hair spray.

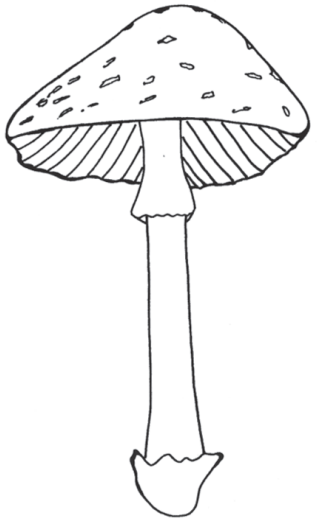
***Problems?***
If there is no pattern the mushroom might be too old or too dry, or you may need to leave it for longer (fungi may take up to a day to release their spores). Shop-bought fungi are not ideal for this activity as the gills can move away from the vertical during transport and storage. Use freshly picked field mushrooms if possible.

## WORKSHEET 11

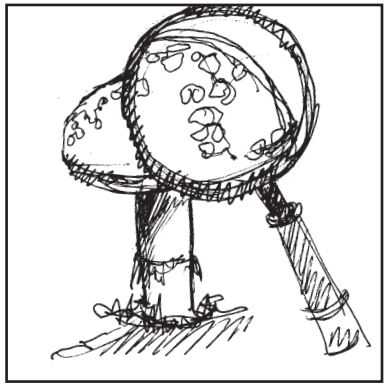
### NOTES

# HOW THE MUSHROOM GOT ITS SPOTS

***You will need:***
A standard size round balloon - preferably red
A roll of white toilet tissue
Water (in a dropper bottle if possible).



***What to do:***
1. Explain that when conditions are suitable, the threads that make up the fungus (underground or hidden in the food substrate) form a tightly packed 'knot' which gradually expands to produce a 'fruit body', represented by the unexpanded balloon.
2. The fungus is protected by being completely enclosed by a membrane called a 'universal veil'. Illustrate this by wrapping the balloon in the tissue paper.
3. Explain that all living things need water to grow and fungi are no exception. Sprinkle several drops onto the top area of tissue and begin to inflate the balloon. "Now watch what happens to the veil when the fungus begins to grow"
4. Keep hold of the bottom of the tissue and let the balloon rupture the tissue - the results should be impressive!

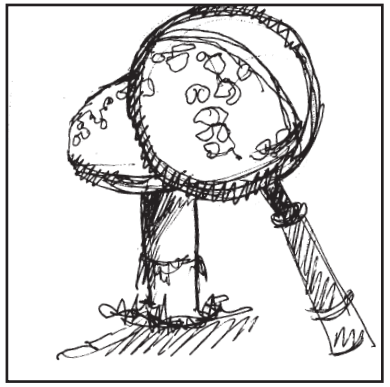


***Tips:***
- Prepare the balloon by blowing it up once before the demonstration - there is nothing worse than trying to blow up a recalcitrant balloon in front of an expectant audience!
- Some brands of toilet tissue work much better than others, so some advance market research is advisable

## WORKSHEET 12

## NOTES

**Acknowledgements**:
©1989 Cornell, Joseph.
This activity was
adapted with permission by
Liz Holden from
'Sharing Nature with Children
II', pp 62-66.
For more information, see the
Sharing Nature
Foundation's website at
**www.sharingnature.com**.



# BUILD A TREE

This game is an extension of Joseph Cornell's 'Build a Tree' in 'Sharing the Joy of Nature II'. It can work for a large group but you must pay attention to how many people are allocated to each role. Introduce it by explaining how trees and mycorrhizal fungi work together for the advantage of both, then set about building the tree:

***Heartwood*** (1 / 2 people) The heartwood player/s stand in the middle of the room. The heartwood holds the trunk and branches upright so that the leaves can capture the sunlight. It has been around a long time and is completely dead, but it is very strong.

***Taproot*** (1 / 2 people) The taproot player/s sit at the base of the heartwood facing outwards. The taproots can go down as much as 10 metres and act as an anchor for the tree and also bring up water from deep in the earth.

***Lateral roots*** (2+ people) The lateral root players lie on the ground with their feet towards the heartwood and spread out their arms. A real tree has hundreds of lateral roots spreading out through the soil. The tap and lateral roots draw water up from the soil. They should practice noisy slurping on instruction from the leader 'Let's slurp'.

***Sapwood*** (3+ people) The sapwood players form a circle around the heartwood, facing inwards and holding hands. The sapwood (xylem) draws the water up from the roots into the highest parts of the tree. On the leader's instruction 'Bring the water up' the sapwood throw their arms up and shout 'Wheeee!'

***Cambium/phloem*** (enough people to form a circle facing inwards around the sapwood). The phloem distributes the food that is made by the leaves to the rest of the tree. On the leader's instruction 'Let's make food', the phloem players flutter their hands in the air. This is followed by 'Bring the food down', when the phloem players go 'Whooo' and drop down towards the ground.

Run through the story so far: 'Let's slurp'; 'Bring the water up'; 'Let's make food'; 'Bring the food down'.

***Bark*** (enough people to form a circle facing outwards around the phloem). The bark protects the tree from fires, insects and fungi.

***Fungus*** (1+ people) The fungus players lie on the ground amongst the roots and exchange of nutrients takes place. The tree receives mineral salts from the fungus that will enable it to grow in poor soil. The fungus receives sugars from the tree and hums contentedly. If the fungi are equipped with umbrellas, they can put them up at this point to represent the fruiting body.

At this point the entire tree can run through its actions, probably without instructions. The leader could remind the bark to watch out for the ghastly, root gobbling, fungal spore and indeed become the spore if so inclined! The whole group should be involved at this point and when finished give itself a round of applause!

## WORKSHEET 13

## NOTES

# MUSHROOM MURDER MYSTERY

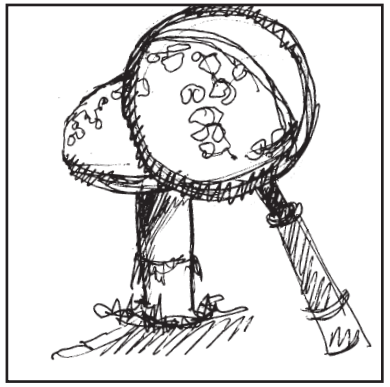
This game illustrates different fungal lifestyles, and the various roles that fungi play in nature. It works well with both large and small groups, and a variety of ages.

***You will need:***

- Pictures of five fungal fruit bodies (including one parasite), stuck onto card. On the back of each card, write the name of the fungus and a few words of description (see suggestions below). Place the cards inside envelopes.
- Duplicate pictures of leaves from each of the affected trees. Stick one copy onto the front of the appropriate envelope, and the other onto card.
- Pictures of leaves from a variety of "bystander" trees, stuck onto card. Shuffle these with the duplicate leaves from the affected trees.

It is best to choose fungi with common names. Include the scientific names in brackets if you wish, but children can find these difficult to read aloud. Suggestions are:
**Woolly Milk Cap** (*Lactarius torminosus*) 'I help birch trees to grow and if my flesh is damaged it produces a milky liquid.'
**Chanterelle** (*Cantharellus cibarius*) 'I am very good to eat and can help several different sorts of trees to grow, including Scots pine.'
**Coral Spot Fungus** (*Nectria cinnabarina*) 'I am those little hard pinkish-orange spots on dead twigs. I may be small but I am very good at breaking down and recycling hazel twigs.
**Wood Woolly Foot** (*Collybia peronata*) 'I have a very woolly base to my stem and I am good at breaking down and recycling oak leaves.'
**Wood Cauliflower** (*Sparrasis crispa*) 'I attack the roots of larch trees and can actually kill the tree completely.'

**Acknowledgements**:
Adapted from original by Liz Holden and reproduced with thanks



***What to do:***
Pick five individuals (or small groups) to be the fungi. Give each of the other participants a picture of a leaf, and tell them to spread out around the room. Explain that many fungi can only live with a particular sort of tree or plant as trees have chemical defences to protect them from the "wrong" fungi. Today all the fungi will find a suitable food source, but one of the trees in the wood will die as a result! (It is helpful if you know who that person will be, as it is more effective if this is the last tree to identify itself).
Give each of the fungi an envelope, and send them off to find the appropriate tree with the matching leaf shape. When everyone is matched, go around the 'wood' and ask each fungus to read out its name and information. Explain what is happening in each relationship (e.g. exchange of mineral salts and sugars in the mycorrhizal fungi, recycling by the saprotroph). The parasitised larch tree can die quietly standing up or noisily on the floor depending on how much overacting you can induce! Make the point that its death is sad for the tree but important for the health of the woodland.

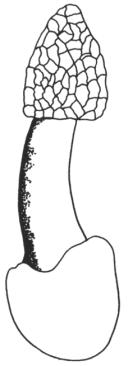
## WORKSHEET 14

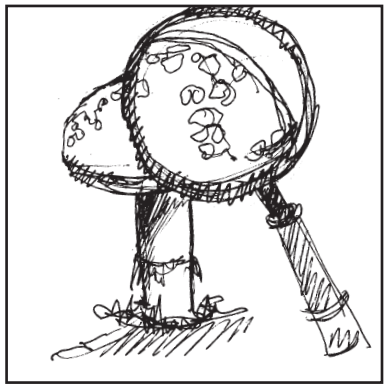
## NOTES

# A SIMPLE KEY TO FUNGI

This is a very simple key designed to discriminate between the major kinds of fungi that you might find on a foray.

| | | |
|---|---|---|
| 1 | Cap with central stalk | Go to 2 |
| 1 | No cap with central stalk | Go to 3 |
| 2 | Plate-like gills under the cap | Gilled mushroom (agaric, russula) |
| 2 | "Pin cushion" under the cap | Bolete |
| 3 | Growing on a tree | Go to 4 |
| 3 | Not growing on a tree | Go to 6 |
| 4 | Like a hard shelf | Bracket |
| 4 | Not like a hard shelf | Go to 5 |
| 5 | Forms a mass over the tree | Crust fungus |
| 5 | Jelly-like | Jelly fungus |
| 6 | Cup-shaped | Go to 7 |
| 6 | Not cup-shaped | Go to 8 |
| 7 | Regular in shape, containing eggs | Bird's nest fungus |
| 7 | Irregular shape, no eggs | Cup fungus |
| 8 | Ball-shaped | Go to 9 |
| 8 | Not ball shaped | Go to 10 |
| 9 | Ball has thin wall | Puff ball |
| 9 | Ball has thick wall | Earth ball |
| 10 | Star-shaped base | Earth star |
| 10 | Not star-shaped base | Go to 11 |
| 11 | Club-shaped or coral-like | Club fungus |
| 11 | Not club-shaped or coral-like | Go to 12 |
| 12 | Spores borne on erect hollow stalk (smelly!) | Stinkhorn |
| 12 | Spores not on erect hollow stalk | Various species |

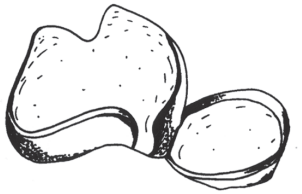


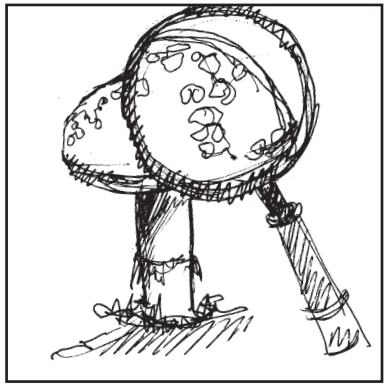


## Worksheet 15

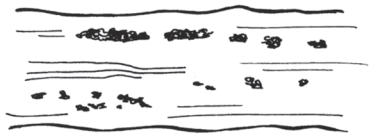
# What's in a Name?

Fungi often have two names, a COMMON name and a SCIENTIFIC name. Use a book (or your knowledge of Latin!) to match up the two names for these fungi.



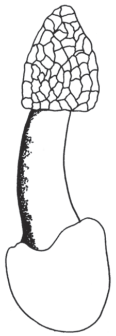


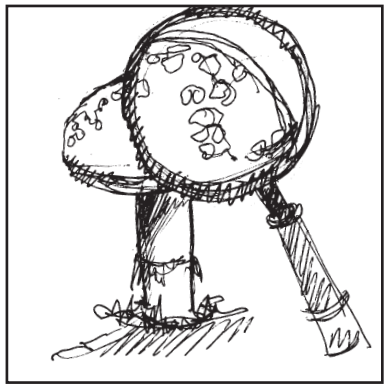
| | |
|---|---|
| **The sickener** | ***Lacrymaria velutina*** |
| **Peppery milk cap** | ***Hygrocybe nigrescens*** |
| **Bleeding brown mushroom** | ***Laccaria amethystea*** |
| **Blackening wax cap** | ***Russula emetica*** |
| **Amethyst deceiver** | ***Lactarius piperatus*** |
| **Weeping widow** | ***Agaricus haemorrhoidarius*** |



**WORKSHEET 16**

# ODD ONE OUT



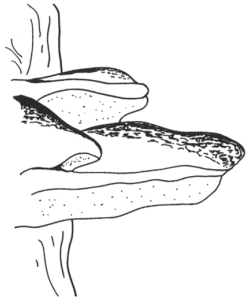


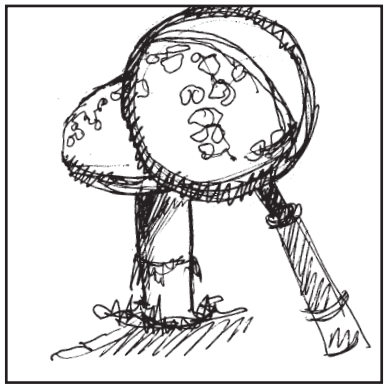
Below are some real names of fungi, and some that we have made up.
Can you spot the four pretenders?

| | | | |
|---|---|---|---|
| **Jelly babies** | **The Panther** | **Parrot toadstool** | **The Deceiver** |
| **The Stainer** | **Shaggy ear fungus** | **Honey fungus** | **Angel's wings** |
| **Golden globe** | **St. George's mushroom** | **Stinking parasol** | **Brown cow-pat toadstool** |
| **Wood woolly foot** | **Greasy tough-shank** | **Slimy spotcap** | **Crusty red cap** |

## WORKSHEET 17

# FUNGAL BRAINTEASERS





**Are the following statements TRUE or FALSE?**

1. Fungi are plants
2. Fungi can only be found during the autumn
3. The Aztecs believed that fungi were Gods and made many statues of them
4. All fungi are bad news for the trees in the wood
5. All fungi are poisonous
6. One small nibble of a Death Cap could kill you
7. Poisonous fungi should be destroyed
8. Some fungi glow in the dark
9. In 1983 the Eiffel tower in Paris was closed for repairs because fungi were destroying it
10. The spores from puffballs can make you go blind

**Re-arrange these phrases to give the names of some common fungi:**

11. Date chap
12. I alarm liar
13. I shake it
14. A flag I cry

**Choose the correct answer(s) for each of the following:**

15. Which is the most deadly fungus?
A *Amanita phalloides*
B *Agaricus bisporus*
C *Cantharellus cibarius*
D *Laetiporus sulphureus*

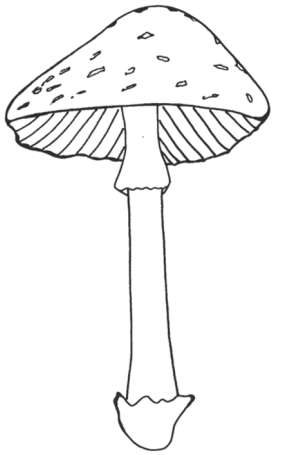
16. Mycorrhizal fungi
A kill trees
B break down dead wood
C help trees to grow
D cause disease in sheep

17. In Italy truffles are collected from underground using
A dogs
B cats
C birds
D cows

18. A person who studies fungi is called a
A taxidermist
B mycologist
C ornothologist
D zoologist

19. The strands that make up a fungus are called
A string
B hyphae
C fronds
D feathers

20. Which TWO of the following fungi are good to eat?
A *Amanita phalloides*
B *Boletus edulis*
C *Boletus satanas*
D *Cantharellus cibarius*



## WORKSHEET 18

# ANSWERS TO PUZZLES AND QUIZZES

**Worksheet 15: What's in a name?**

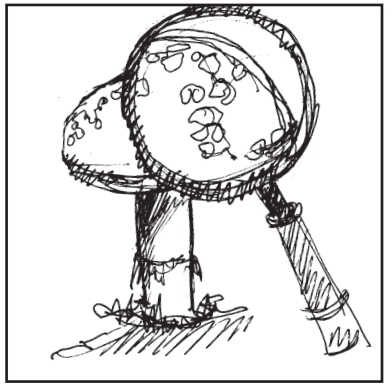
| | |
|---|---|
| The sickener - | *Russula emetica* |
| Peppery milk cap - | *Lactarius piperatus* |
| Bleeding brown mushroom - | *Agaricus haemorrhoidarius* |
| Blackening wax cap - | *Hygrocybe nigrescens* |
| Amethyst deceiver - | *Laccaria amethystea* |
| Weeping widow - | *Lacrymaria velutina* |

**Worksheet 16: Odd one out**

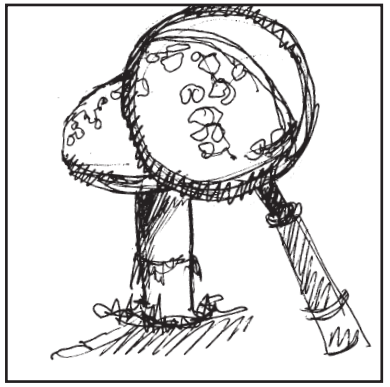
The four pretenders are Golden globe, Slimy spotcap, Shaggy ear fungus and Crusty red cap.

**Worksheet 17: Fungal brainteasers**

1 False (fungi are in a separate kingdom to both animals and plants). 2 False (fungi are generally more abundant in the autumn, but can be found all year round). 3 True. 4 False (many fungi form beneficial mycorrhizal relationships with trees). 5 False (only some fungi are poisonous, but it is important to know which ones!). 6 True. 7 False (although poisonous fungi are harmful to humans, they may still be playing a vital role in the forest ecosystem). 8 True. 9 True. 10 False (this is folklore belief, which fortunately is untrue).
11 death cap. 12 armillaria. 13 shiitake. 14 fly agaric.
15 = A. 16 = C. 17 = A. 18 = B. 19 = B. 20 = B and D.



Heddon-on-the-Wall, 2000
(Sue Assinder)



# APPENDICES



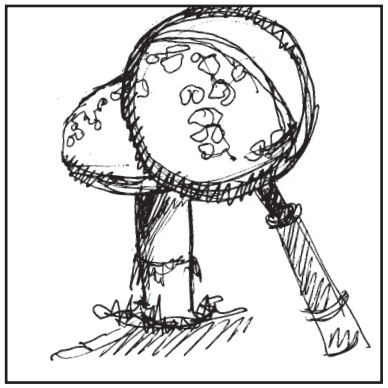
*Tricholomopsis rutilans*
(Purple and yellow agaric) (A W Brand)

## APPENDIX I

**To find out more about the BMS Schools and Community activities, contact:**

E-mail: education@britmycolsoc.org.uk

Website:
www.britmycolsoc.org.uk
www.fungi4schools.org



# ABOUT THE BMS

The **British Mycological Society** (BMS) was founded as a learned society in 1896 and now has some 2000 members from many countries around the world, reflecting its international status. Its objective is to promote mycology in all its aspects. This is achieved by scientific meetings with international programmes, journals and other publications, forays and workshops. The Society is also active in the promotion of conservation and in education through schools, universities and with the general public. Membership is open to anyone with an interest in any aspect of mycology. Anyone with an interest in field mycology could also join one of 30 regional Fungus Recording Groups. Details of the activities of the BMS and how to join can be found on its website at www.britmycolsoc.org.uk.

The **BMS Education Group** was set up in 1999 and views education in its broadest sense. Its roles include the production of educational material for schools and colleges, the provision of training for BMS members and promoting awareness of fungi among the general public.

**The authors:**
Sue Assinder is a senior lecturer in molecular genetics in the School of Biological Sciences, University of Wales, Bangor. Her research interests are in the molecular genetics of fungal growth, for which she uses *Aspergillus nidulans* as a model system. She has a long-term interest in promoting public engagement with science, and has served as Education Officer of the British Mycological Society.

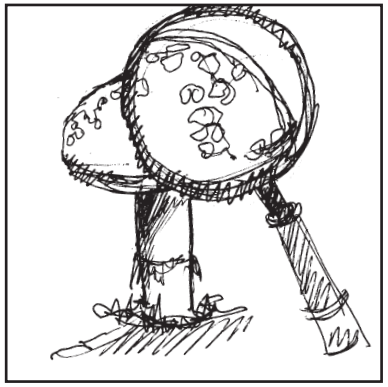
Gordon Rutter is a former member of the BMS Education committee and BMS Council. After completing a Research Fellowship in mycology at the Royal Botanic Garden, Edinburgh, Gordon now works as a freelance science writer and lecturer. A life-long interest in mycology has seen Gordon lead a number of courses and forays as well as travelling around the world in pursuit of fungi - always with a camera in his hand.

bms
British Mycological Society promoting fungal science

## APPENDIX II

**To find out more about BBSRC Schools and Community activities, contact:**

BBSRC Schools Resources
Polaris House
North Star Avenue
Swindon SN2 1UH.
Tel: 01793 413302
E-mail:
schools@bbsrc.ac.uk



# ABOUT THE BBSRC

The **Biotechnology and Biological Sciences Research Council** (BBSRC) is the leading UK funding agency for academic research and training in the biosciences. It supports over 5000 researchers and research students at universities throughout the UK, and at eight BBSRC-sponsored institutes. Research funded by BBSRC furthers understanding of processes at the level of molecules and cells, as well as improving knowledge of how whole organisms work, and how they interact with each other in populations and ecological systems. BBSRC is committed to making information about advances in the biosciences as widely available to people as possible, by disseminating the results of the research that it funds and encouraging public debate about potential applications and implications of the research.

BBSRC produces a range of material for primary, secondary and post-16 students in support of science education. Schools resources are free and may be photocopied for use within educational institutions. Resources can be downloaded from the website at
www.bbsrc.ac.uk/society/schools/welcome.html

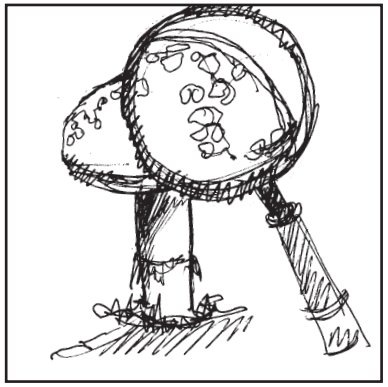
bbsrc
biotechnology and biological sciences
research council

## APPENDIX III

# FUNGI IN THE SCHOOL CURRICULUM

Although fungi do not currently feature strongly in the National Curriculum for Science (England, Wales and Northern Ireland) (www.nc.uk.net), aspects of mycology can easily be integrated into all Key Stages. The central theme of Scientific Enquiry (Sc1) asks pupils to acquire the investigative skills to plan and conduct a scientific study and to evaluate and present the evidence. Several of the suggestions in this booklet will help in the acquisition of these skills, from simple recording of fungal form and habitat at primary level (page 6) through to more open-ended project work with older pupils (page 8). Specific subject areas within Sc2 (Life Processes and Living Things) can also be covered using fungal examples, such as the beneficial and harmful properties of micro-organisms (KS2), the interdependency of organisms in habitats (KS3) and the role of micro-organisms in decomposition and recycling (KS4). Fungi are particularly valuable for illustrating aspects of biotechnology, including the production of antibiotics and other health care products, food and beverages (cheese, beer, bread, mycoprotein) and industrial chemicals (e.g. citric acid). Some of the techniques used in biotechnology can cause public concern (e.g. genetic modification) and there is scope for classroom discussion and debate of controversial issues.

Scottish requirements are broadly similar. The guidelines for the Science component of Environmental Studies (5 - 14) include an attainment outcome on 'Living Things and the Processes of Life'. At the earliest stages of primary (P1-P3), studies of the local environment are encouraged to allow children to appreciate how living things depend upon each other, whilst later stages of primary (P4-P7) should introduce the importance of conservation and recycling. Older pupils (S1/S2) should be able to give the main distinguishing features of micro-organisms and describe their harmful and beneficial effects, and also create and use keys to identify living things.



With a little bit of thought, fungi can be used in many other areas of the curriculum, or in cross-curricular activities, For example, practical work can provide useful quantitative data for analysis in maths lessons. There is scope for creative writing, such as a description of the walk on which the fungus was found. Novel approaches can also be taken in art lessons, such as using fungal paper (Worksheet 9) and ink (from ink cap fungi), or making a collage from spore prints. Appendix VI lists some useful web sites with resources and more ideas for educational activities.

## APPENDIX IV

# SUPPLIERS AND USEFUL CONTACTS

**Fungi Perfecti** (www.fungi.com)
*US-based company specialising in gourmet and medicinal mushrooms, in addition to books and gifts. There is a good on-line catalogue and a mail order service from Fungi Perfecti, PO Box 7634, Olympia, WA 98507, USA*

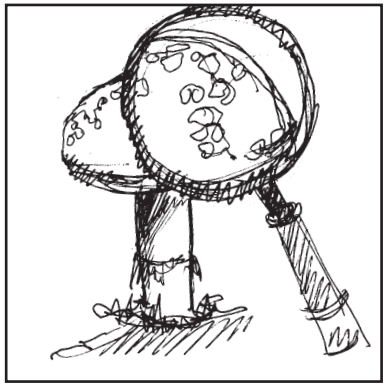
**Mycologue** (www.mycologue.co.uk)
*UK-based internet mushroom mega-store providing a wide range of supplies for mycologists, including field accessories, books, videos and gifts. Contact: 47 Spencer Rise, London NW5 1AR.*

**Dental mirrors**
*Scientific and Chemical Supplies, Carlton House, Livingston Road, Bilston, West Midlands, WV14 0QZ. Tel: 01902 402402*

**'Grow-your-own' kits**
*Future Foods provide kits with full instructions for lawns, grass areas and toilet rolls (!), as well as pre-inoculated mycorrhizal trees. Contact: PO Box 1564, Wedmore, Somerset, BS28 4DP.*
*Ann Miller ( http://www.annforfungi.co.uk) specialises in wood mushrooms fruited on hardwood, from toilet rolls to tree trunks. Contact: Greenbank, Meikel Wartle, Inverurie, Scotland AB51 5AA (ann@annforfungi.co.uk).*

**Local Fungus Recording Groups**
*Over thirty Local Fungus Recording Groups are affiliated to the BMS and form a nation-wide network of field enthusiasts. The Groups welcome field enthusiasts of all ages who are interested in learning more about fungi, and recording for local and national databases. The BMS website lists local contacts and provides links to the sites of individual groups www.britmycolsoc.org.uk.*

**Association of British Fungus Groups (ABFG)** (www.abfg.org)
*An umbrella organisation for Local Fungus Recording Groups that can provide Public Liability Insurance to groups and individuals in the UK. Members receive the quarterly ABFG Journal. Contact: Michael Jordan, Harveys, Alston, nr. Axminster, Devon, EX13 7LG.*



**'The Good, the Bad and the Fungi'**
*A full day of interactive fungal activities has been developed that focuses on why fungi are important in the woodland world and touches on many other interesting ideas - how all parts of the natural world are related, how plants and fungi differ, where fungi fit into food chains, the use of a simple key and how people use fungi in their everyday lives. Identification skills are not necessary to run this day. Contact Liz Holden, Allanaquoich, Mar Lodge Estate, Braemar, Aberdeenshire AB35 5YJ.* E-mail liz@marmycology.co.uk

## APPENDIX V

# FIELD GUIDES AND BOOKS FOR TEACHING

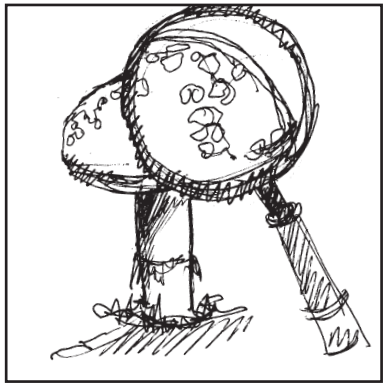
**Mushrooms and Other Fungi of Great Britain and Europe** by Roger Phillips, Pan 1981
*An excellent guide with over 900 species illustrated with large photographs. The book is large format, so big pockets are needed if used in the field.*

**How to Identify Edible Mushrooms** by Patrick Harding, Tony Lyon & Gill Tomblin, Collins 1996
*Covers edible species and their look-alikes, arranged by habitat. A useful field-guide although there are many species it does not cover because of its specific remit.*

**Mushrooms and Toadstools of Britain & Europe** by R. Courtecuisse & B. Duhem, Collins 1995
*Over 3,000 species are described, with many of them illustrated. The descriptions are quite short but the keys are excellent.*

**Mushrooms and Toadstools** by John Ramsbottom, Collins 1953
*A bit dated but still one of the most readable accounts of the fungi, including anecdotes as well as science. Commonly turns up in second-hand bookshops at very reasonable prices.*

**Fungi Name trail** by Liz Holden & Kath Hamper 2002
*Beautifully illustrated simple 'yes/no' key, designed as an introduction to dichotomous keys. Enables the identification of 30 commonly found fungi. Equally suited to working with 10 -14 year olds in a teaching situation or with families looking at fungi just for fun. Available from the Field Studies Council website at www.field-studies-council.org/publications/.*



**Fungus Fred goes Foraying** by Maggie Hadley 2002
*Fred's story and related activity sheets aim to make young people (age 7-11) more aware of fungi in their everyday environment. Available by mail order from the BMS.*

**Pocket Guide to Common Fungi** by Peter and Christine Thwaites 2005
*This leaflet with 50 startlingly realistic water colour paintings by Peter Thwaites was produced jointly by Fungi for Fun (www.fungiforfun.co.uk/) and the British Mycological Society; it is available for mail order purchase through the BMS.*

*For mail order purchases from the BMS you can download an order form from the educational website www.fungi4schools.org/.*

## APPENDIX VI

# MYCOLOGICAL EDUCATION ON THE WEB

**Fungi4schools** (http://www.fungi4schools.org/)
*This is the British Mycological Society's collection of resources for schools. Sample lessons, quizzes, games, interesting articles - they're all here. From key stage 2 to post-16, and it's all free!*

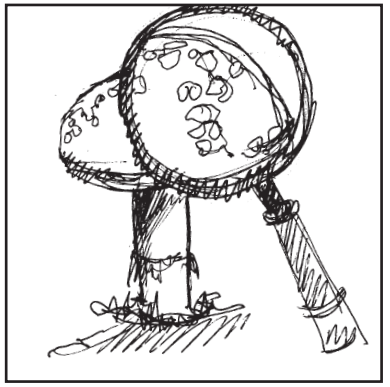
**Microbiology Online** *(http://www.microbiologyonline.org.uk/)*
*Hosted by the SGM (Society for General Microbiology), it has curriculum-targeted resources for all key stages and post-16, which can be downloaded at minimal cost, and also includes the web pages of MISAC (Microbiology in Schools Advisory Committee) (Appendix Vll)*

**The WWW Virtual Library: Mycology** (http://mycology.cornell.edu/)
*The most comprehensive listing of mycological resources on the internet, including an invaluable section on teaching and learning about fungi.*

**Fungi Images on the Net** (www.in2.dk/fungi/)
*A metadirectory from which you can locate and view nearly 1600 beautiful and informative images of fungi.*

**Fun Facts About Fungi** *(*http://herbarium.usu.edu/fungi/funfacts/factindx.htm*)*
*A colourful site from the University of Michigan Fungus Herbarium, with simple experiments and puzzles suitable for KS2/3.*

**Fungal Genetics Stock Center** *(http://*www.fgsc.net/teaching/labfungi.htm*)*
*The teaching section contains ideas for post-16 project work with fungi for which suitable strains can be obtained from the FGSC.*



**North American Mycological Association** *(http://*www.namyco.org/*)*
*Includes an excellent teaching section with downloadable lesson plans and handouts and a comprehensive bibliography.*

**Tom Volk's Fungi** *(*http://tomvolkfungi.net/*)*
*A "one stop shop" for mycology, featuring a "fungus of the month" column, with entertaining text and good photos, plus a plethora of other information, including tips for teachers on ways to use the internet for teaching about fungi.*

**National Centre for Biotechnology Education** *(http://*www.ncbe.reading.ac.uk/*)*
*Includes a downloadable version of "Practical Biotechnology:a guide for schools and colleges", with several fungal examples.*

## APPENDIX VII

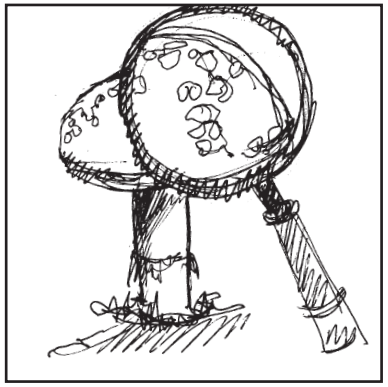
# HEALTH AND SAFETY GUIDANCE

Strict adherence to the two simple rules on Page 3 will eliminate most of the safety issues associated with practical work with fungi. Most importantly, fungi must only be eaten if there is 100% certainty that they have been correctly identified as safe. There are a large number of edible species in the UK but there are also several poisonous ones with a mortality rate in excess of 90%. The majority of fungi actually lie somewhere between these extremes. People differ in their ability to tolerate and digest certain compounds. If someone is trying a species for the first time, only a small amount should be eaten in case of allergies and some should be kept back uneaten so that the fungus can be identified immediately if problems arise. Allergic reactions to fungal spores are also possible and inhalation of spores should be avoided.

### Safety in the laboratory:

Teachers may be nervous of carrying out experimental work with fungi because they perceive it to be unsafe, or they are unsure of the relevant regulations. However, plenty of advice is at hand (see below) and these concerns should not be an obstacle to conducting interesting investigations with fungi in a school laboratory.

Safe disposal of cultures at the end of the experiment is an important issue. Non-cultured waste (e.g. from the activities in Worksheets 8-10) should be double-wrapped and disposed of in an outside bin. Discarded cultures on Petri dishes must be sterilised at 121˚C for 15 minutes in a pressure cooker or autoclave, and can then be disposed of with normal waste. Autoclaving is also the preferred method for disposing of mouldy food material but is unlikely to be feasible in most primary schools (although the local secondary school may be able to help out). The next best alternative is to use a freshly prepared solution of disinfectant. The ASE 'Be Safe!' guide (see below) recommends VirKon, which is available in 50 g sachets from suppliers such as Philip Harris. A less satisfactory alternative is a good quality brand of domestic bleach, which should be diluted by no more than nine times its volume with water. Open the cultures under the surface of the disinfectant (wear gloves) and leave to soak overnight. Pour away the disinfectant, seal the culture in a polythene bag and place in the dustbin.



There are several useful sources of information and reassurance:

- The Microbiology in Schools Advisory Committee (MISAC) represents a wide range of educational institutions and scientific organisations, including the BMS and the SGM. MISAC helps teachers recognise the potential of microorganisms as educational resources and provides authoritative advice on the safe use of microorganisms in schools. It can also provide information on where to find resources, including cultures, and offer many suggestions for suitable and safe investigations. Information about MISAC can be found on the Microbiology On-line web site hosted by the SGM (www.microbiologyonline.org.uk) and individual advice is available from MISAC, c/o SGM, Marlborough House, Basingstoke Road, Spencers Wood, Reading RG7 1AG (education@sgm.ac.uk).

- The Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) offers advice on health and safety, including risk assessment, sources and use of chemicals, living organisms, equipment and laboratory design. Membership is open to education authorities and hence all of their schools in the UK (except Scotland) and associate membership to independent schools and FE colleges. Members can obtain advice by telephone (01895 251496), by fax (01895 814372), by e-mail (science@cleapss.org.uk) or by writing to the CLEAPSS School Science Service, at Brunel University, Uxbridge UP8 3PH. A Helpline query can also be sent from the website (www.cleapss.org.uk).

- In Scotland, the Scottish Schools Equipment Research Centre (SSERC) provides information on health and safety, practical microbiology and training courses. St Mary's Building, 23 Holyrood Road, Edinburgh EH8 8AE.

## Safety in the field:

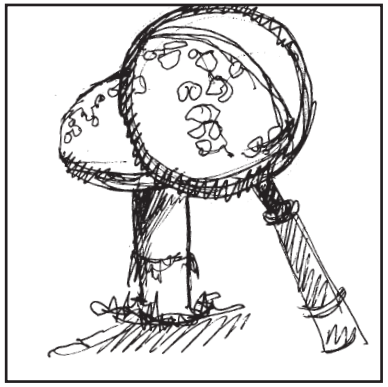
Most of the safety issues are common to any work in the field. It is important to carry out a risk assessment before venturing out, taking into account the topography of the site, local hazards and the nature of participants. Note that school children should have cuts and abrasions covered when collecting samples from the soil. Check that you have insurance, either through the School or the organisation responsible for the foray, and make sure that a first aid kit and mobile phone are available in case of emergencies.

## Publications

- The 'Be Safe' guide (3rd ed.) published by the Association for Science Education (ASE) provides a wealth of information on health and safety in primary school science and technology, including sections devoted to microorganisms (Section 14) and outdoor studies (Section 16). It can be purchased on-line on the ASE web site (www.ase.org.uk).

- The SGM has produced a guide to basic practical microbiology techniques (Basic Practical Microbiology: A Manual) that includes information on safety guidelines, Good Microbiological Laboratory Practice, sterilisation and methods for obtaining, preparing and using cultures. The guide, plus supplementary factsheets, can be downloaded from the Microbiology On-line web site.

- The CLEAPSS guide L190 deals with the use of microorganisms in primary schools and is available to members free of charge. For secondary schools and colleges, information on microbiology and sterilisation is in Chapter 15 of the CLEAPSS Laboratory Handbook.



## APPENDIX VIII

# TIPS FOR RUNNING A FORAY

### Planning

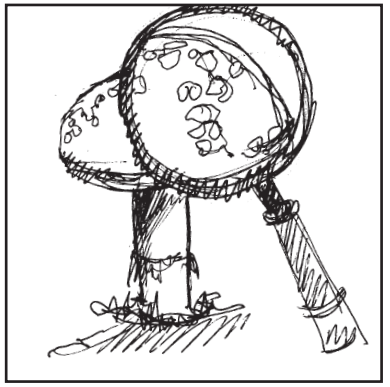
- Get permission from the landowner if applicable
- Advertise clearly the starting time, meeting point, duration, requirements (e.g. stout footwear and clothing appropriate to terrain and weather, small basket - not plastic bags) and optional extras (e.g. knife, field guide, hand lens/magnifying glass).
- Check out the site in advance if possible: access, parking, footpaths, presence of fungi(!). Work out a possible route, identifying any special hazards.

### Briefing

- If you have the use of an indoor venue for the briefing, you may like to use some or all of Worksheets 1-4 as an introduction. If not, keep the preamble short and briefly cover:
  - The purpose of the foray
  - Any local restrictions on picking
  - The timescale
  - Where to look for fungi and how to collect them properly (importance of getting the whole fungus)
  - The importance of noting the location of the fungus, associated organisms, etc.
  - Responsible picking according to the Code of Conduct (see below)
  - The Countryside code (shutting of gates, no trampling of wild flowers).
- Always point out that some fungi are edible, but NEVER eat one unless you are absolutely sure that it has been correctly identified.

### During the foray

- Call the group together at intervals to review finds
- Demonstrate practical skills as means of identification (Page 7)
- Incorporate anecdotes, fascinating fungal facts and folklore (Pages 12-13)
- Use selected specimens to highlight the ecology and biological roles of fungi



### After the foray

- Display and label finds if possible. (Pre-prepared labels of some common species can save time).
- Dispose of fungi back in the woodland, not in a pile in the car park.
- If appropriate, make a list of the finds for distribution to participants

### Wild Mushroom Pickers' Code of Conduct

The Wild Mushroom Pickers' Code of Conduct was produced by a consortium of organisations involved in the conservation and collecting of fungi including English Nature and the British Mycological Society. It is available free of charge from English Nature's Enquiry Service (tel. 01733 455101) and can also be viewed on the English Nature web site (www.english-nature.org.uk) and www.fungi4schools.org/.

# GLOSSARY

**Ascomycete**: A fungus that reproduces by making spores inside a sac-like structure called an **ascus**.

**Basidiomycete**: A fungus that reproduces by producing spores on the outside of a club-shaped cell called a **basidium**.

**Fruit body**: The part of the fungus where the spores are produced. In an ascomycete, the fruit body is known as the **ascocarp** and in a **basidiomycete** it is called the **basidiocarp** (or **basidiome**).

**Gills**: Plate-like structures on the under-surface of the cap of some mushrooms.

**Habitat**: A place with a particular kind of environment suitable for the growth of an organism.

**Hypha** (pl. **hyphae**): Individual thread-like filament that forms the mycelium and fruit body.

**Lichen**: A complex plant made up of an alga and a fungus growing in symbiotic association.

**Mushroom**: A descriptive term for a fungus with a cap and stem. The word **toadstool** can be used synonymously and neither should be taken to imply anything about the edibility of the fungus.

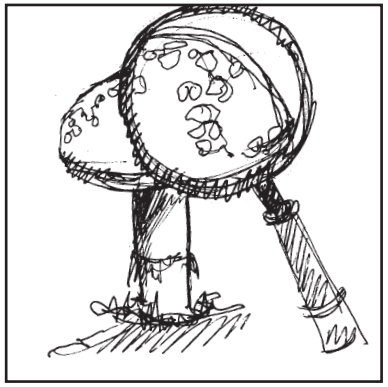
**Mycelium** (pl. **mycelia**): A mass of hyphae (usually underground) that makes up the body of the fungus.

**Mycorrhizal**: Forming a symbiotic relationship with plant roots. The fungus obtains sugars from the plant, whilst the plant gains increased supplies of nutrients captured from the soil by the fungus.

**Parasite**: An organism living in or on another living organism (host) from which it extracts nutrients.

**Saprotroph:** An organism that obtains its nutrients from dead and decaying plant or animal matter.

**Spore**: The reproductive structure of a fungus. It differs from a plant seed in that it does not have its own food reserves.



**Stipe**: The stem or stalk of a mushroom.

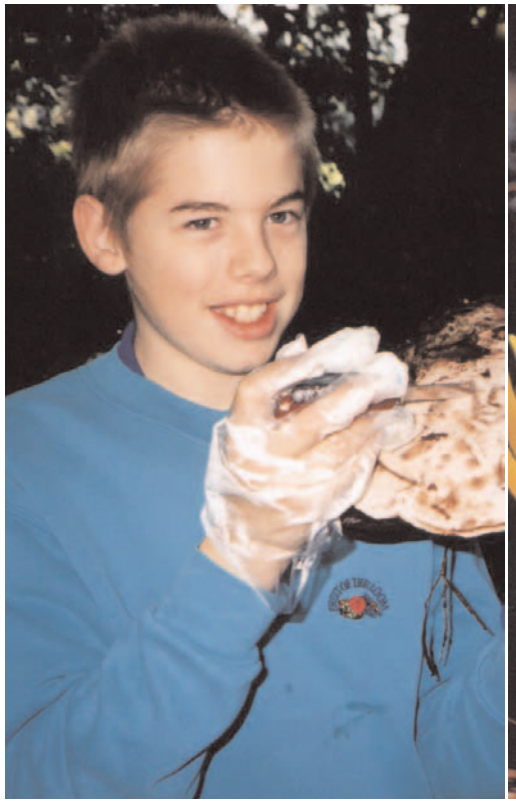
**Substrate**: The material on which a fungus grows.

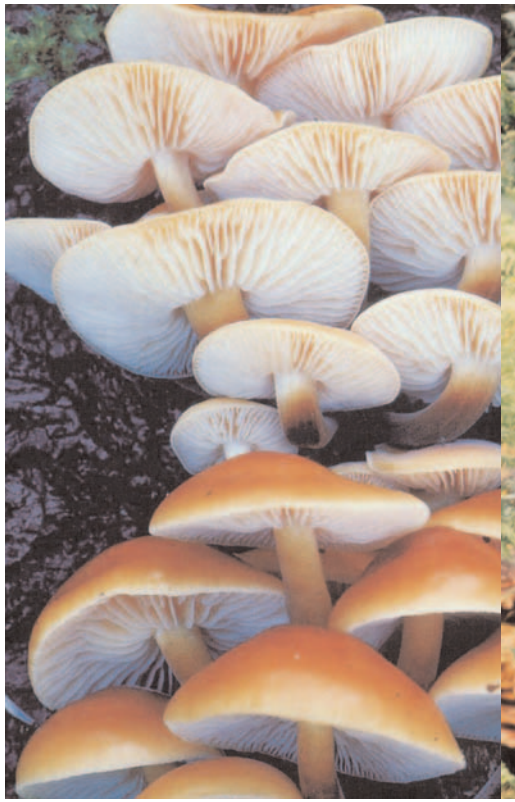
**Symbiosis**: A relationship between two different organisms that is beneficial to both. (e.g. mycorrhizal fungi and plants; a fungus and an alga in a lichen).

**Universal veil**: A protective membrane enclosing the developing fruit body in some fungi.

**Volva**: A cup-like bag derived from the remains of the universal veil that encloses the base of the stem in some mushrooms.

**Yeast**: A single-celled fungus. The commonest is Brewer's Yeast (*Saccharomyces cerevisiae*) used in brewing and baking.



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