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fungi4schools – the new BMS education website

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Keywords:

A-level teaching
Online education
Primary school
Secondary school
Teaching mycology

ABSTRACT

The one place it's almost impossible to find fungi is in the UK National Curriculum for schools. The state of the National Curriculum (NC) is a real concern because the current specifications all contain material on animal and plant comparisons with little or no consideration for the largest group of higher organisms on Earth: Kingdom Fungi. This means that children are missing out on being taught about the importance of an entire Kingdom of higher organisms. To try to compensate for this educational deficiency, the British Mycological Society has taken up the challenge by devising resources teachers can use within the current NC because they address NC topics and also give proper representation to fungi. These resources include specially-produced and ready-to-use lessons and classroom activities, teacher's guides and pupil class sheets, all classroom tested and well received by pupils. But the resources also feature articles published over many years in the Society's journals that need to be brought out of the library archives and made immediately accessible to schools. These resources are available now for free download from the British Mycological Society's new education website at www.fungi4schools.org, which is described in this article.

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1. Introduction: Who else can give you an entire Kingdom? [and part of two others ...!]

For many years the under-representation of Kingdom Fungi in our national curricula for schools has been a source of concern to mycologists. After all, fungi form what is arguably the largest kingdom of higher organisms on the planet and we're surrounded by them, and dependent on them, every hour of every day of our lives, so it's alarming that the one place it's difficult to find fungi is in the statutory National Curriculum. We detailed the problem in our article in the November 2005 issue of *Mycologist* (Moore *et al.* 2005), and our concerns were more widely publicised in the January 6th edition of the *Times Educational Supplement* (Moore *et al.* 2006a).

The essential problem is that the Qualifications and Curriculum Authority (QCA) doesn't seem to know that fungi exist. The word 'fungus' does not appear in the 87-page NC

Programme of Study for Science (published 1999), which is the statutory instrument that defines the curriculum for Key Stages 1–4 (ages 5 to 16), and the same applies to the revised 2006 curriculum. Yet with a little bit of thought, fungi can be used for teaching many areas of the current curriculum specifications and in cross-curricular activities. The question is: who is going to apply the thought and develop the resource? If the statutory body responsible for NC programmes cannot do it, then the task falls to dedicated mycologists, like the British Mycological Society (BMS), to attempt to compensate for this educational deficiency by producing appropriate teaching resources.

Over the past year we have developed work-sheets and classroom materials ranging in suitability from primary level to post-16 and now they can be downloaded (free!) from a new educational website published by the BMS at <http://www.fungi4schools.org/> (Fig. 1).

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Figs 1-5 – Screenshots of fungi4schools web pages. Fig. 1 – the home page (some menu items were added after this article was written). Fig. 2 – Beginners Start Here page. Fig. 3 – Mycology Answers or most frequently asked questions page. Fig. 4 – Page offering resources for Key Stages 2 and 3. Fig. 5 – The Key Stage 4 resources page.

The contents of this site are described below, but we recommend you visit the site; look around – there’s a painting course, answers to frequently asked questions, advice about fieldwork, advice about photography, interactive books, photographs, presentations, posters, and lots more. And most of the resources are copyright-free for educational use. If you can promote the site to your local schools, then please do so. If you can think of something else that should be on the site, or even better provide something, then tell me.

2. The Home Page <http://www.fungi4schools.org/>

The home page (Fig. 1) welcomes the visitor and offers hyperlinks to all the main levels of the site. There are at least two links to each level – a central ‘menu’ of one-line descriptors being flanked by two marginal panels containing alternative descriptions. I will describe the contents of the main levels using the descriptors in the central menu.

3. Beginners start here

This is where we begin to explain the jargon and advise about all sorts of things by providing published articles about introductory topics (Fig. 2). Most of these articles were originally published in *Mycologist* or *Field Mycology*. They are provided on the website as PDF-files, so that the user needs only to click the hyperlink on the web page to download the article. Immediate accessibility is a key principle of the design of the website. Of course, it does mean that I’ve had to scan all the articles to generate the PDFs – all 200 of them!

- **Explaining the jargon:** a series of *Mycologist* articles by Jack Marriott explains the terms that are used to describe fungal fruit bodies.
- **First steps in the classroom:** articles in which Sheila Francis, with early school years in mind, advises about collecting in the field and suggests a few activities that can be done in the classroom.
- **Venturing into field study:** to encourage people to start looking at fungi out there in the great outdoors, this section illustrates how diverse fungi are in nature. In this series of articles Sheila Francis, Bruce Ing, Margaret Holden, Dave Minter, Tom Preece, Hedda Weitz and Chris Yeates introduce their favourite places and favourite fungi, with simple straightforward introductions to mushrooms, toadstools, truffles, fairy rings, jelly fungi, birds nest fungi, puffballs, stinkhorns, brackets, mildew, rusts and much more besides.
- **Mushroom or toadstool?** One of the most common questions asked by the general public is about the difference between ‘mushrooms’ and ‘toadstools’. The usual answer, that both words are unscientific ‘folk’ terms that in most cases mean what you want them to mean, is made a little more helpful here with two *Mycologist* papers by Tony Baker in which he explores the origins of the two words.
- **More serious field work:** we hope that people will be inspired to get seriously interested in collecting fungi, so in this section we provide immediate access (that means click the hyperlinks to download them) to the British Mycological

Society’s advice on striking the balance between picking and conserving fungi: *British Mycological Society Conservation Policy* and *The Wild Mushroom Picker’s Code of Conduct*. As they get more serious about collecting, users are given access to Liz Holden’s *List of Recommended English Names For Fungi in the UK*, the guide produced by Richard Iliffe *Collecting and Recording Fungi*, and they’re introduced to Teachers Guide 5 from our *Key Stages for Fungi* teaching resource (available elsewhere on the site), TG05: *Discover More*, which has a collection of information and advice about Local Fungus Groups, books (especially field guides), and Internet resources. This section also offers hyperlinks to the British Mycological Society’s Fungal Records Database (*BMSFRD*) and *BMS Distribution Maps*.

- **Organized help with field study:** There are almost 40 Local Fungus Recording Groups around the country, and the British Mycological Society organizes a Network to which most belong. They’re made up of enthusiasts who run them on a voluntary basis. We recommend schools make contact with their local group(s) because they are very often keen to share their knowledge of wild fungi. The groups offer a friendly and welcoming environment that helps new members thoroughly enjoy the world of fungi and improve identification skills, and members of these groups are sometimes willing to give talks or organize workshops in schools. This web page provides a hyperlink to a list of contact addresses, and a list of hyperlinks to the URLs of those Local Fungus Recording Groups that have their own web pages.

4. Frequently-asked questions

In her series ‘*Mycology answers*’ in *Mycologist* between 1993 and 1999, Susan Isaac dealt with a wide range of common questions about fungi (Fig. 3). Users can browse through the questions on this web page and download the explanation. There are 27 of these articles, covering topics like: Why does jam go mouldy, even in the fridge? How are soya beans fermented? Why does “athlete’s foot” itch? What are mycotoxins? How are beer and lager produced? Peanuts, fungal toxins and the health of wild birds. Is pigmentation an advantage to fungi? And 20 more.

5. Teaching resources for key stages 2–3

Here we offer access to stories, games, and activities for 7 to 12-year olds (Fig. 4). The index page offers a reprint (PDF file) of an article by Liz Holden in *Field Mycology* (Holden 2003) describing a whole day of games and activities for 10–12 year-olds. A full kit of downloadable resources for these activities, which has been produced by Liz Holden, was added to the site in the summer of 2006.

The storybook by Maggie Hadley, *Fungus Fred goes Foraying*, which was published by the Society in 2002, tells an engaging story about how Fungus Fred investigates the different types of fungi in nature. It is suitable for children in the age range 7–11 y. The book is full of fungi facts and encourages children to have fun learning. The website offers the chance to see the entire book, page by page. Users can also order the printed

version by mail using an order form downloaded from the site. Of course, there's nothing to stop you printing the pages from the website – just hit the F11 key to remove screen 'clutter' and remember to set your printer's paper orientation to landscape. There are no copyright issues for educational use.

Another page by page offering is the "explainers' guide to fungi" *How the Mushroom Got its Spots*, written by Sue Assinder and Gordon Rutter. This booklet is aimed at anyone who wants to tell children, or non-experts of any age, more about the fascinating world of mushrooms, toadstools, moulds and other fungi. There are 18 worksheets that can be downloaded as PDF files, and the complete text of the booklet can also be downloaded from the website. The printed version can be ordered, too (it's free, but we charge for postage), using the order form you can download from the site. The same form allows users to order *The Fungi Name Trail: A key to commoner fungi* the fold-out chart by Liz Holden and Kath Hamper; as well as the *Pocket Guide to Common Fungi* (illustrated with startlingly realistic water colour paintings by Peter Thwaites).

6. Teaching resources for key stage 4

This web page (Fig. 5) links users to the extensive range of specially-written classroom-ready resources (teacher's guides, class sheets, quizzes, games) all linked to the National Curriculum. They are all free to download and free to copy, and they're provided in two formats: PDF file (for easy printing) and Word.doc so the user can edit and modify the documents to their own requirements.

The materials provided here have been designed for pupils in years 8 to 11 of secondary school). In classroom trials pupil feedback was positive and the pupils were interested and enthusiastic to be learning about a topic many had hardly touched upon before.

All of the resources are available as free downloads from the website but they've also been printed as a package that is available for distribution (free) from the author. These resources include:

- class sheets dealing with cells and cell biology, which ensure proper representation of both yeast and filamentous fungus.
- a series of five ready-made KS4 lessons (that include class sheets for pupil and teacher) comprising an introductory Welcome to the World of Fungi, Reproduction and Conservation, Favourite or Nastiest Fungus, Fungi and Industry and Fungi and Disease.
- a series of class sheets describing 15 different 'What's your favourite fungus?' stories from which the pupils extract important points, a pack of playing cards that mirror the class sheets and can be used to play a variety of games (and all the time the players are holding cards that each carry a different 'fun fact'), and a 'name-game' starter exercise.

7. Post-16 resources

Post-16 pupils can explore a range of biological features at 'close-to-research' level with materials accessible here

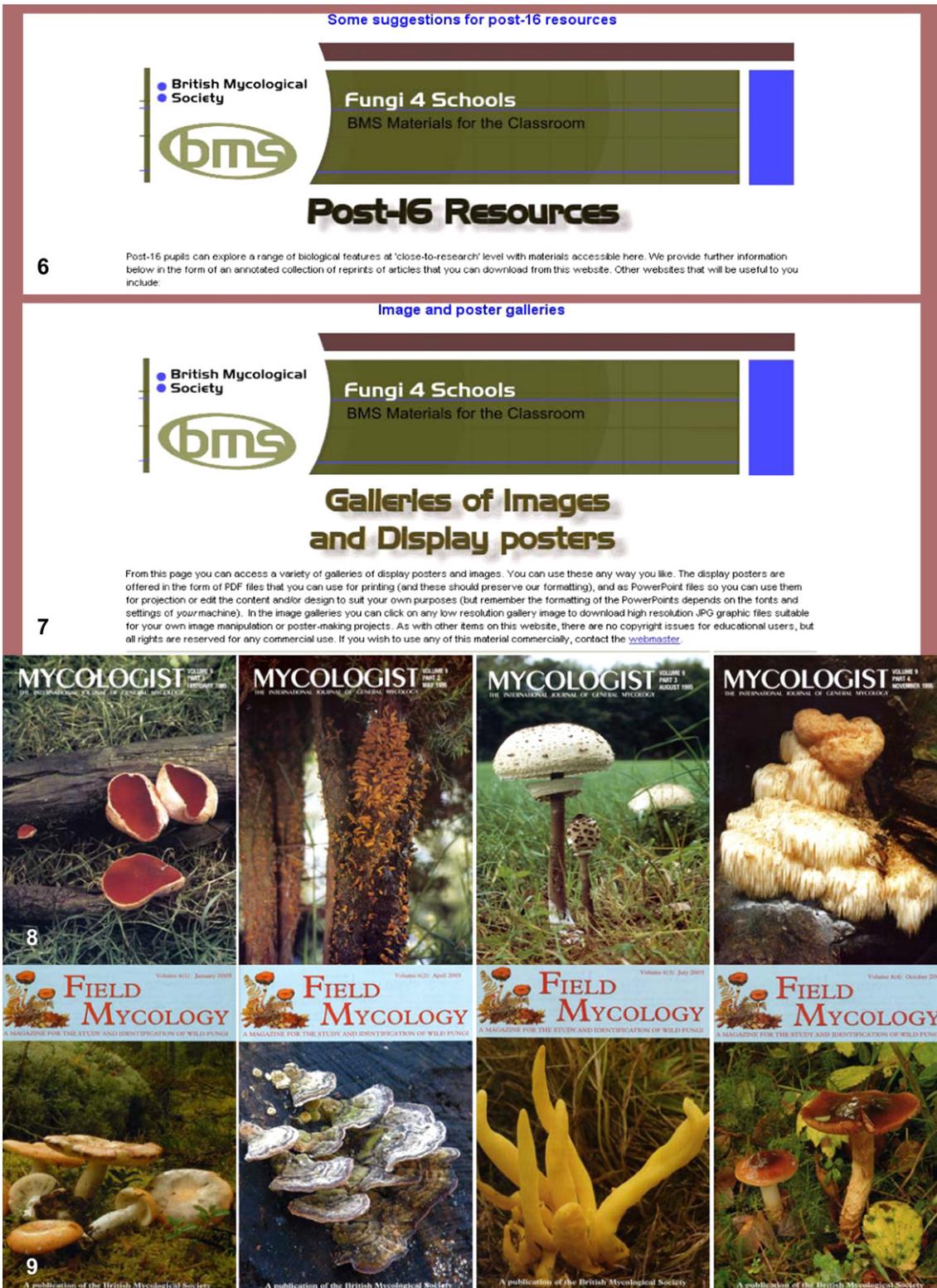
(Fig. 6). This page links to websites and an annotated collection of reprints of articles (free to download from this website) suggesting projects on exploring genomes and genomics, medical and health topics, toxins; fungi as food; fungal growth, kinetics and mechanics; biotechnology; fungi in the environment; soil, minerals, mycorrhizas, alien fungi, and geomycology. The websites hyperlinked are:

- www.world-of-fungi.org/ which provides the opportunity to study fungal growth kinetics using a realistic mathematical model and user-friendly computer visualization.
- the Fungal Cell Biology Group website at <http://129.215.156.68/cdrom.html> from which the Biology of Living Fungi CD by Patrick Hickey and Nick Read can be obtained.
- The MISAC website at www.microbiologyonline.org.uk/misac.
- The Society for General Microbiology at <http://www.microbiologyonline.org.uk/>.
- <http://www.doctorfungus.org/> which gives information about fungal infections and mycology in general.
- The Aspergillus Website (<http://www.aspergillus.man.ac.uk>), which offers comprehensive information about one of the most common causes of deep-seated mycosis in the western world.
- <http://www.rogersmushrooms.com/> which is based on Roger Phillips' field guide, Mushrooms.
- BMS Fungal Records Database at <http://194.203.77.76/fieldmycology/BMSFRD/bmsfrd.asp>.
- BMS Distribution Maps at <http://194.203.77.76/fieldmycology/BMSFRD/Maps.asp>.
- The BMS website at www.britmycolsoc.org.uk.

In other sections on this web page we offer collections of reprints covering a range of topics. The intention is to provide teachers and pupils with ideas and starter references (as 'get it now' reprints) for investigations that could become AS or A2 level projects. We plan to expand this section steadily. At the moment it includes: *Exploring genomes*, *Medicine*, *Fungi as food*, *Fungal growth and biotechnology*, *Fungi in the environment*. Each of these sections features a short introduction and then a collection of reprints from *Mycologist* or *Field Mycology*. The sections also offer chapters taken from the book *Slayers, Saviors, Servants, and Sex: An Exposé of Kingdom Fungi* by David Moore (published by Springer-Verlag, New York: 2001). These are in the form of non-printable PDF files as the book is still commercially available.

8. Courses on drawing and painting, and photographing fungi

There are a couple of special treats on this page. In the late 1980s and early 1990s botanical artist Lorna Minton published a complete eight-part course on sketching and painting fungi in *Mycologist*, which followed an eight-part master class in fungal photography by wildlife photographer Gordon Dickson. This page makes reprints of the articles accessible. It also offers a few other articles. For example, Shelley Evans and Pauline Greenhalgh about how to use a flat bed scanner to take photographic images, and Alan Braddock about photography



Figs 6–7 – Screenshots of fungi4schools web pages. Fig. 6 – the Post-16 page. Fig. 7 – Page offering galleries of posters, graphics and photographs. Fig. 8 – Mycologist covers from 1995. The fungi4schools website features 35 cover illustrations like this. Fig. 9 – Field Mycology covers from 2005. There are 24 Field Mycology cover illustrations on the fungi4schools website.

through the microscope for absolute beginners. This latter theme (microscopy) is picked up in the next page.

9. Advice on microscopy, from buying a microscope to making your own photomicrographs

A web page that features articles from *Field Mycology* by Shelley Evans, Maurice Moss, Archie McAdam, Alan Hawkswell, and Ern Emmett, which together provide the beginner with advice about choosing a microscope, setting up the microscope, preparing specimens, and stains and mountants. We take the opportunity to repeat links to articles about photomicrography by Gordon Dickson and Alan Braddock, and to the compilation of movies that illustrate key aspects of the cell biology of living filamentous fungi on the CD by Patrick Hickey and Nick Read, *Biology of Living Fungi*.

10. Galleries of free-to-download Display Posters and Graphics files

From this page users can access a variety of galleries of display posters and images. The display posters are offered in the form of PDF files that can be used for printing (these should preserve our formatting), and as PowerPoint files so the user can use them for projection or edit the content and/or design to suit his/her own purposes. In the image galleries users can click on any low resolution gallery image to download high resolution JPG graphic files suitable for image manipulation or poster-making projects. As with other items on this website, there are no copyright issues for educational users, but all rights are reserved for any commercial use.

- **Display posters:** are text-based posters describing the main features of fungi in the form of displayed bullet points, together with a set of six pictorial stories written by Roland Weber about interesting fungus facts (Fig. 7).
- **Mycologist cover pages:** From 1987 to November 2000 the magazine *Mycologist* was published with a striking full-page cover-picture on every issue. This is a gallery of those *Mycologist* cover-pictures (Fig. 8).
- **Field Mycology cover pages:** This gallery shows how *Field Mycology* continues the tradition of using striking full-page cover-pictures on every issue (Fig. 9).
- **Photographs of fungi:** several teachers have asked about images they can use in their own projects, so this collection (mostly of my own digital images) is likely to be the first of many. Contact the author if you have any photographs to contribute.

11. Promoting and using the resource

The first edition of www.fungi4schools.org was uploaded to the server on 30th December 2005 to make it available for the Association for Science Education annual conference held in Reading (5-7 January 2006). As usual, the BMS Roadshow attended the ASE meeting and we handed out more than 800 copies of a CD version of the website, together with

supporting leaflets (this works out to one every 100 seconds the ASE exhibition was open!). Improvements and additions to fungi4schools have been made throughout 2006 and the website presently comprises over 500 Mb of data.

To promote the site we've arranged for hyperlinks on the websites and mentions in Newsletters of the Biosciences Federation, the British Ecological Society, CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services), Institute of Biology, National Science Learning Centre, SETNET (Science, Engineering, Technology and Mathematics Network), the DfES website TeacherNet, and the site has been accredited by the British Educational Communications and Technology Agency (Becta) so we expect inclusion in the replacement for the National Grid for Learning later in the year. The site is included in the *Times Educational Supplement's* Resource Bank and has been the subject of publications in the *Times Educational Supplement* and *School Science Review*, which is the ASE's journal for science teachers in 11-19 education.

12. What's it for?

The BMS can't teach the pupils, but can provide the tools, and the motivation, for the teachers to do the job. The fungi4schools site offers ideas and resources that teachers can use to bring fungi into their treatment of a wide range of National Curriculum topics. So the site is aimed more at school teachers than at school pupils. Having said that, the interactive presentation of *Fungus Fred goes Foraging* is eminently suitable for KS2/3 pupils and there are many opportunities for KS4 and post-16 pupils to research their own project topics on the site.

During the development of this website, we have also been contributing to development of a microbiology section in a web site aimed at Key Stage 2 pupils produced by the Careers & Employability Division at The University of Manchester. This, *The Children's University of Manchester* was first published on the Internet in July 2006. *The Children's University of Manchester* is aimed at the pupils (fungi4schools is aimed at teachers) so the structure and tone of the website is very different. I suggest you visit the site at <http://www.childrensuniversity.manchester.ac.uk/>, to see how well fungi are represented (visit the *Micro-organisms* section), and then recommend the site to your primary school contacts.

13. How can BMS members use the resource?

I hope that all BMS members will be as appalled as I am that the National Curriculum so wilfully ignores Kingdom Fungi, and will be stirred into doing something about it. Here's what you can do.

- Spread the word to your local schools – primary, secondary, and post-16 colleges. Send them a copy of the November 2005 *Mycologist* article (Moore et al. 2005); tell them about the fungi4schools website. You could also give them printed copies of *How the Mushroom Got its Spots* and *Key Stages for Fungi* (the KS4 teaching package collection), which you can

obtain (free) from me (or you can give me the school's address and I'll send them).

- Offer a lecture, seminar or activity session to your local school. Anything that's of interest to you would be useful to the school. Lecture about strobilurins? Guide a foray around the school grounds? Workshop on digital photography? Seminar on confocal microscopy? Show-and-tell session of fungi found in the local woods? Discussion session on tropical plant pathology? Doesn't matter about the topic; while you're doing it you can show how dependent we are on fungi in our daily lives, you can convince the teachers how awful it is that the National Curriculum keeps all this interesting science a secret; and you can tell them about the resources the BMS is making available to them.
- If you want to be more adventurous you, and your Local Fungus Group perhaps, could arrange a science workshop at your local school, inviting parties from other schools in the vicinity. The theme is up to you. Biotechnology? Environment? Molecular biology? Food technology? Health topics? The fungi4schools website offers access to a wide range of support materials appropriate to all of these, and I can provide supplies of leaflets and booklets you can give away. Try it. Do it! If we don't, nobody else will.

14. And what about BMS members outside the UK?

I don't think that the UK is the only country where statutory school biology is limited to animals, plants and bacteria (Moore *et al.* 2006b). What I'd like to know is whether the UK is the only country where the majority of 16 year-olds think that fungi are bacteria. Indeed, is the UK the only country where an otherwise interesting article in a national newspaper can conclude with the information "... Penicillium roqueforti (sic), the bacteria that gives the cheese its distinct flavour." (See p. 67, *Telegraph Magazine* for 11 March 2006). So perhaps BMS members outside the UK would like to take a serious look at the school curricula in their own countries and report back to me? Do the school curricula call for comparisons only between animals and plants? Do they offer

details about animal and plant cells only? Do they only ever mention fungi (and always linked with bacteria) as 'degraders'? These are the symptoms of the disease afflicting the UK National Curriculum. Recognise them? Then tell us about it.

Acknowledgements

The Society has been the main sponsor of the development of the resources used on fungi4schools, but it is a pleasure to acknowledge grants from BBSRC, Research Councils UK and the University of Manchester which have made encouraging contributions over the past few years. I would also like to acknowledge the contribution made by the authors and editors whose work is included on the website, and my undergraduate project students in 2005 and 2006 (Nicole Benjamin, Kelly Fryer, Jennifer A. Heath, Charlotte Quinn, Stephanie Roberts, Rohanne Thompson, and Ruth Townley) who developed most of the specially-prepared materials as undergraduate projects. Sincere thanks are also due to Liz Moore, Liz Holden, Margaret Whalley, Louise Sutherland, Vicky Caldwell, Barbara Grundy and Karen Bolshaw for their help in devising, delivering and describing the teaching resources.

REFERENCES

- Holden E, 2003. The good the bad and the fungi: introducing fungi to children. *Field Mycology* 4: 19–24.
- Moore D, Fryer K, Quinn C, Roberts S, Townley R, 2005. How much are your children taught about fungi in school? *Mycologist* 19: 152–158.
- Moore D, Roberts S, Quinn C, Townley R, Fryer K, 2006a. Mushroom surprise. More than a mushroom: the low-down on fungi for all key stages. *Times Educational Supplement* (ASE Science Special) published 6 January 2006 [published on the TES website at http://www.tes.co.uk/search/story/?story_id=2177722].
- Moore D, Pöder R, Molitoris H-P, Money NP, Figlas D, Lebel T, 2006b. Crisis in teaching future generations about fungi. *Mycological Research* 110: 626–627.