FEATURE ARTICLE

Using Open Resources to Teach Mycology

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Abstract

This article discusses a variety of open resources that can be used to teach mycology. Many schools may not routinely teach a mycology class – and if they do, students might not want to invest in a textbook. Options for resale are probably much smaller than with a class in which more students routinely enroll. This article is important in showing both students and faculty how much information about fungi is available online. Some websites are transient, so the reader must carefully check them before use. The sites selected cover most topics that are typically covered in a mycology class. However, depending on faculty emphasis, not all of the information presented in the article may be relevant. These resources should enable faculty to achieve the major teaching objectives in a mycology class, enabling students to gain an appreciation of the diversity of fungi and a basic understanding of their biology, ecology, genetics, morphology, and taxonomy.

Key Words: *diseases; fungi; genomics; mycology; open resources.*

○ Preface

This article is organized into the following sections:

- Introductory Information
- Fungal Taxonomy & Genomics
- Fungal Diversity & Ecology
- Fungal Drugs & Diseases
- Fungi in the Environment (Mycoremediation)
- Fungi in the Food Industry
- Yeasts
- Molds
- Lichens
- Images of Fungi
- Other Resources

> *"These resources should enable faculty to achieve the major teaching objectives in a mycology class."*

At the end of each section is a table describing the different open-access resources, with a reason for using them and their advantages or disadvantages (since journal articles and OpenStax resources are mentioned a few times, their advantages and disadvantages are not listed in each table). Journal articles are the most stable resources, but they typically don't age well. OpenStax resources (https://openstax.org/) are freely available online textbooks that are moderately stable; older editions are periodically replaced with newer ones (though not as frequently as traditional textbooks). These texts give basic information, but some teachers may want to supplement them with more details.

○ Introductory Information

A good way to begin a mycology class is to discuss how fungi are often overlooked as disease vectors. Fungal diseases or conditions, such as athlete's foot, are typically thought of more as an annoyance than as potentially fatal. This view is misguided – fungi can cause serious infections, and treatment can be difficult. Most fungal infections occur in immunocompromised people, but fungi can also affect individuals with an intact immune system. Some fungi are resistant to certain drugs that should help treat fungal infections. Since fungi are eukaryotes, there are far fewer treatment options than exist for bacterial infections. Fungi can also adversely affect our foods and various ecosystems, but there are limited funds for research in those areas (Editorial, 2017).

In the past, fungi were classified as plants, but this categorization is no longer accurate (American Society for Microbiology, 2021). Various OpenStax books contain a wealth of background information on fungi, including characteristics, cell structure and function, classification, ecology, fungal parasites and pathogens, and importance in human life. These include *Principles of Biology* (https://cnx.org/contents/24nI-KJ8@27.4: qolmBHBA@7/Fungi), *Biology 2e* (https://openstax.org/details/books/biology-2e), and *Microbiology*

The American Biology Teacher, Vol. 83, No. 8, pp. 504–512, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: https://doi.org/10.1525/abt.2021.83.8.504.

(https://openstax.org/details/books/microbiology). There is some overlapping material, but a combination of these resources can be used to give students a good background knowledge of fungi. These resources also discuss infections and toxins caused by fungi. These topics are broken down and discussed more specifically below. Two sources of introductory material are listed in Table 1.

○ Fungal Taxonomy & Genomics

The OpenStax biology textbooks can be used for a good introduction to the diversity of phyla (e.g., OpenStax, 2016a, 2018a, 2018b). Table 2 lists several resources on fungal taxonomy and genomics.

An article by Stajich (2017; available on the American Society for Microbiology website, https://asm.org/) explains how fungi can be placed into different taxonomic groups on the basis of morphology but also by using a DNA sequencing approach.

Much material can be obtained from the NCBI website (National Center for Biotechnology Information, https://www.ncbi.nlm.nih.gov/), which can be used to teach students that one step in identifying unknown fungi would be to determine their DNA sequence and then to use these sites, particularly the BLAST function, to see whether this sequence has previously been reported in fungi. It should also be taught that these sites can be used to study other aspects of fungi, including taxonomy, the genome, various aspects of DNA and protein structure, the design of primers, and more. Other sites that are specific to fungi can also be used; such resources include the Aspergillus Genome Database (http://aspgd.org/), FungiDB (Fungal & Oomycete Informatics Resources, https://fungidb.org/fungidb/), MycoBank (https://www.mycobank.org), EnsemblFungi (https://fungi.ensembl.org), *and the U.S. National Fungus Collections* (https://nt.ars-grin.gov/fungaldatabases/). It would be worthwhile to BLAST some sequences in the NCBI site and compare them to the fungal databases.

Table 1. Open resources for teaching introductory material about fungi.

Web Link	Advantages/ Disadvantages
https://rdcu.be/bMSxK	• This link from the journal *Nature Microbiology* explains why fungi should be studied and not neglected. • This resource is an editorial that should be easily understood by students.
https://asm.org/Articles/2021/January/Three-Reasons-Fungi-Are-Not-Plants?utm_source=RealMagnet&utm_medium=email&utm_content=ASM%5FNews%5F20210118&utm_campaign=Other%20Topics%20ASM%20News%20General	• This link from the American Society for Microbiology explains the uniqueness of fungi. • The link is moderately stable, but at various times the organization may update their website.

Table 2. Open resources for teaching about fungal taxonomy and genomics.

Web Link	Advantages/ Disadvantages
https://courses.lumenlearning.com/suny-osbiology2e/chapter/classifications-of-fungi/ https://courses.lumenlearning.com/suny-osbiology2e/chapter/characteristics-of-fungi/ https://openstax.org/books/microbiology/pages/5-3-fungi	• These links from the freely available textbooks OpenStax *Biology 2e* and OpenStax *Microbiology* introduce the phyla and characteristics of fungi.
https://www.asmscience.org/content/journal/microbiolspec/10.1128/microbiolspec.FUNK-0055-2016 This source can also be directly accessed by going to the journal at doi:10.1128/microbiolspec.FUNK-0055-2016	• This link discusses both morphological and genomic mechanisms of classification. • It is noted that mechanisms of classification have changed over time. • The source is the journal *Microbiology Spectrum*, which is published by the American Society for Microbiology. • This is a review article that should be understandable to students.
https://www.ncbi.nlm.nih.gov/ http://aspgd.org/ https://fungidb.org/fungidb/ Mycobank.org https://fungi.ensembl.org https://nt.ars-grin.gov/fungaldatabases/	• These sites can also be used to study fungal taxonomy, the genome, and various aspects of DNA and protein structure, designing primers, meetings, lab resources and protocols, career resources, and publications. • These sites are a major resource for scientists. • The sites themselves are stable but they are frequently updated with new information.

○ Fungal Diversity & Ecology

This section presents the use of some example journal articles (Table 3). Faculty may wish to look for current research articles when teaching this section.

Fungal diversity varies depending on environmental factors that include temperature, precipitation, and seasonal factors. It is

Table 3. Open resources for teaching about fungal diversity.

Web Link	Advantages/ Disadvantages
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6426159/	• This link discusses how fungal diversity is influenced by global change. • The link is to the journal *Applied Plant Science*. • This is a research article with a few figures. Some teachers may want to have their students learn how to interpret results, while others may want to just discuss the findings in this paper.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7558612/	• This link discusses how fungi can survive under extreme conditions. • The link is to the *International Journal of Environmental Research and Public Health*. • This is a review article that should be understandable to students. • This link can be used to discuss the diversity of fungi in different environments.
https://mbio.asm.org/content/10/2/e01189-18	• This link discusses fungal diversity in marine life. • The link is to the journal *mBio*, which is a publication of the American Society for Microbiology. • This is a review article that has some pictures showing the diversity and morphology of fungi. It should be understandable to students.

also sensitive to global change (Andrew et al., 2019). A study that discusses Antarctica as an environment with extreme conditions states that fungi surviving in these conditions produce enzymes and other metabolites that can be beneficial (Zucconi et al., 2020). Another study examines fungal diversity in marine life (Amend et al., 2019).

○ Fungal Drugs & Diseases

The Centers for Disease Control and Prevention (CDC) and partners designate one week each year as Fungal Disease Awareness Week (September 20–24 in 2021). The CDC's webpage "Think Fungus: Fungal Disease Awareness Week" (https://www.cdc.gov/fungal/awareness-week.html) contains a selection of links to information about fungal diseases and conditions (e.g., coccidioidomycosis, histoplasmosis, and blastomycosis), as well as background information about fungal diseases, different types of fungal diseases, who gets fungal diseases, how to investigate fungal outbreaks, the work of the CDC's Mycotic Diseases Branch, and the problem of antifungal resistance (CDC, 2017, 2019, 2020a, 2020b, 2021a, 2021b, 2021c). Also included are links to information on how to diagnose fungal diseases (https://www.cdc.gov/fungal/diseases/index.html) and on whole-genome sequencing and fungal disease outbreaks (https://www.cdc.gov/fungal/outbreaks/wgs.html#anchor_1569512528). This section can also be presented in the context of molecular biology techniques. See Table 4 for further resources.

An article by Hyde et al. (2019) discusses the use of fungi in the fight against human diseases. Fungi produce natural products that can help with symptoms and/or side effects experienced by patients who have cancer, diabetes, or cardiovascular disease. Other fungal products are helpful in improving nerve function or acting as immunosuppressive agents.

Table 4. Open resources for teaching about fungal diseases.

Web Link	Advantages/ Disadvantages
https://www.cdc.gov/fungal/awareness-week.html	• This link contains information about Fungal Disease Awareness Week, including example social media posts and other information, to educate the public about fungi. • There are also a variety of links to different examples of fungal diseases, outbreaks, and other relevant information on fungal diseases. • There are also additional resources to consult. • The CDC is a very reliable sourceof information on diseases. • The information on this site may be updated as new outbreaks of fungal diseases are reported. For example, there is a link for "Fungal diseases and COVID-19."

Table 4. *continued*

Web Link	Advantages/ Disadvantages
https://doi.org/10.1007/s13225-019-00430-9	• This is a long article that discusses the use of fungi in strategies against human disease. Other functions of fungi are also discussed. • Instructors will need to decide which sections of this article to use. • This article is from the journal *Fungal Diversity*. • This is a review article that should be understandable to students.
https://openstax.org/books/microbiology/pages/22-4-respiratory-mycoses https://openstax.org/books/microbiology/pages/21-4-mycoses-of-the-skin https://openstax.org/books/microbiology/pages/26-4-fungal-and-parasitic-diseases-of-the-nervous-system	• These links discuss mycoses of the skin, respiratory, and nervous systems. • These links are from OpenStax *Microbiology*, a freely available textbook.

For specifics on fungal diseases, the OpenStax *Microbiology* textbook can be consulted (see https://openstax.org/details/books/microbiology), in particular chapter 21.4 on mycoses of the skin, chapter 22.4 on respiratory mycoses, and chapter 26.4 on fungal diseases of the nervous system.

○ Fungi in the Environment (Mycoremediation)

Mycoremediation can be used to discuss positive features of fungi. Table 5 presents two review articles on mycoremediation (Akhtar & Mannan, 2020; Park & Choi, 2020).

○ Fungi in the Food Industry

Fungi make a number of contributions to the food industry, including edible mushrooms. Fungi have been used to enhance flavors, especially in cheese. *Saccharomyces cerevisiae*, for example, is involved through fermentation in the making of beer, wine, and bread (Hyde, 2019). For pictures and explanations of different types of mushrooms, see MushroomExpert.com. Table 6 lists several other resources on the food industry.

Table 5. Open resources for teaching about mycoremediation.

Web Link	Advantages/ Disadvantages
https://doi.org/10.1016/j.btre.2020.e00452	• This review article from the journal *Biotechnology Reports* discusses how fungi break down environmental pollutants. • It has a few figures on different pollutants, the sources of the pollutants,and the fungi that are involved in mycoremediation. • The article does not have a lot of data that could be confusing to students, but faculty may want to discuss only certain parts of the article to help the students learn about mycoremediation.
https://doi.org/10.1007/s00253-020-10746-1	• This review article from the journal *Applied Microbiology and Biotechnology* takes a genomic approach to explain the different classes of fungi and their enzymes that are involved in mycoremediation. It also discusses the discovery of different fungal genes. • It can be used to explain how genetics can be used to study different topics in mycology. • This article does not have a lot of data that could be confusing to students, but faculty may want to discuss only certain parts of the article to help the students learn about mycoremediation.

○ Yeasts

Bioinformatics was discussed in the section on taxonomy and genomics, but teachers may want to start a discussion of yeasts by referring to resources listed in Table 7, including the *Candida* Genome Database (http://www.candidagenome.org; Skrzypek et al.,

Table 6. Open resources for teaching about fungi in the food industry.

Web Link	Advantages/ Disadvantages
https://doi.org/10.1007s13225-019-00430-9	• This is a long article that discusses many uses of fungi in the food industry. Other functions of fungi are also discussed. • Instructors will need to decide which sections of this article to use. • This article is from the journal *Fungal Diversity*.
http://www.mushroomexpert.com/ or https://namyco.org/online_teaching_resources.php http://www.mushroomexpert.com/studying.html#identifying	• This site gives pictures and explanations about different mushrooms. It also describes how to identify different mushrooms. • This link was obtained from the website of the North American Mycological Association. • This site may change over time.

2017) and the *Saccharomyces* Genome Database (http://www.yeastgenome.org/; Cherry et al., 2012). Similar to the other databases, these websites can be used to learn about taxonomy, the genome, and various aspects of DNA and protein structure, design of primers, meetings, lab resources and protocols, career resources, and publications. These websites are also helpful for connecting with other scientists in the yeast community.

Table 7. Open resources for teaching about yeasts.

Web Link	Advantages/ Disadvantages
http://www.candidagenome.org http://www.yeastgenome.org/	• These sites can be used to study yeast taxonomy, the genome, and various aspects of DNA and protein structure, designing primers, meetings, lab resources and protocols, career resources, and publications. • These sites are a major resource for scientists. • The sites themselves are stable but they are frequently updated with new information.

Table 7. *continued*

Web Link	Advantages/ Disadvantages
https://www.cdc.gov/fungal/diseases/candidiasis/index.html	• This link can be used to teach basic information about candidiasis, with other links to vaginal and invasive candidiasis as well as to *Candida* infections of the mouth, throat, and esophagus. • This website is associated with a government agency. • The link is very stable but is also updated if outbreaks occur. • For more details, teachers may need to consult current literature.
https://www.cdc.gov/fungal/candida-auris/index.html	• This link can be used to teach basic information about *Candida auris*. • This website is associated with a government agency. • The link is very stable stable but is also updated if outbreaks occur. • For more details, teachers may need to consult current literature.

Many students will be familiar with yeasts, if only because of common vaginal yeast infections. The CDC has links to information about *Candida albicans* and candidiasis, and about the drug-resistant *C. auris* (CDC, 2020d, 2021d).

Additional information can be obtained from journal articles like those in Table 8, including a review article about candidalysin by Naglik et al. (2019). This topic will also teach the students about the MAPK signaling pathway and inflammation. See also Richardson et al. (2018), which gives more information on candidalysin and signaling and can also be used to teach students research techniques.

Some instructors may teach students about various lab-based techniques by going over the primary journal articles presented in this paper, while others may want to give a background on some techniques before discussing the research articles.

A review of some protein-based techniques can be found in the OpenStax *Microbiology* textbook (chapter 20). Different reagents, enzymes, cell culture, and molecular techniques used when working with yeast can be found on a variety of company websites, including Zymo Research (https://www.zymoresearch.com/pages/yeast-reagents-and-enzymes), Lucigen (https://www.lucigen.com/masterpure-yeast-dna-purification-kit/), and InvivoGen (https://

Table 8. Research articles on yeasts.

Web Link	Advantages/ Disadvantages
https://www.sciencedirect.com/science/article/pii/S1369527418300948	• This is a review article about candidalysin, which is the toxin released by the invasive, hyphal form of *Candida albicans*. Students could be taught about the discovery of candidalysin and how epithelial signaling pathways are activated. • This paper has a good figure showing the different molecules activating in the signaling pathway. • This article should be understandable to students.
https://pubmed.ncbi.nlm.nih.gov/29109176/	• This primary research article can be used to teach about ECE, candidalysin, inflammation, and signaling. • This article can also be used to teach about different research techniques such as cell culture, cytokine expression, immunopathology, and the western blot. • This article also shows different cytokines, molecules used in signaling. • The paper could be used as an introduction to research, but some students may have difficulty reading a primary research paper.

www.invivogen.com/fungin). Before using them in class, teachers should consult and confirm these and similar webpages and websites, as they may be transient and change without notice.

Students can learn about different strains of yeast, their culture conditions, and in some cases the sequence of the rRNA or DNA at the ATCC website (American Type Culture Collection, https://www.atcc.org/). Since the ATCC is a widely used company, it is not likely that this website will be unavailable in the near future, though particular information may be moved or removed.

Table 9. Open resources for teaching about molds.

Agency	Web Link
Centers for Disease Control and Prevention	https://www.cdc.gov/mold/faqs.htm
National Institute of Environmental Health Sciences	https://www.niehs.nih.gov/health/topics/agents/mold/index.cfm
U.S. Environmental Protection Agency	https://www.epa.gov/mold
U.S. Department of Agriculture Food Safety and Inspection Service	https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/molds-on-food-are-they-dangerous_/ct_index
Occupational Safety and Health Administration	https://www.osha.gov/SLTC/molds/

○ Molds

This topic may be of particular interest to students, especially in the many parts of the country where mold-related allergies are often a problem. Table 9 provides open resources for mold-related topics, such as where they are found and how to control them. These links are all to reputable U.S. government websites. The sites themselves are stable, but some of the information may change with time. These sites give basic information, so some teachers may want to use other resources for more details. The sites contain links to additional resources.

○ Lichens

A good start to the study of lichens (Table 10) would be at the website of the American Bryological and Lichenological Society (http://www.abls.org/; this website is currently being moved, which points to the transient nature of many websites, but much information is currently available). The website contains links to the journals *The Bryologist* and *Evansia*. It also has a link for taxonomic resources, grants, and events.

Table 10. Open resources for teaching about lichens.

Web Link	Advantages/ Disadvantages
http://www.abls.org/	• This link is to the American Bryological and Lichenological Society. There is information on the society's two journals: *The Bryologist* and *Evansia*. It also has a link for taxonomical resources, grants, and events.

Table 10. *continued*

Web Link	Advantages/ Disadvantages
	• This website is currently being moved and some of the links do not work. • The new site is https://ablsociety.wixsite.com/abls but it is not complete. • This organization is reputable, but the movement of the website points to the unstable nature of websites.
https://namyco.org/lichen_basics.php	• This is a webpage of the North American Mycological Association. • The website has a good review of the basics about lichens. • There are photographs of lichens, but their use is copyright protected. • This site may change over time.

The North American Mycological Association provides a good review of the basics of lichens, as well as photographs that show the symbiotic relationship between fungi and plants. The website contains eco-connections, human uses, and additional references, though these resources have not been updated recently. It should be noted that NAMA places copyright regulations on the use of its text and photos (see https://namyco.org/lichen_basics.php).

○ Images of Fungi

Teachers may want to begin a mycology class by discussing and showing photographs depicting the diversity of fungi, which could lead to a discussion of the different shapes, sizes, colors, and habitats of fungi (Table 11). MykoWeb.com contains hundreds of pictures of fungi, most of them showing species found in California (though obtaining permission to use images from the site requires several steps; see http://mykoweb.com/photography/PhotoUse.html).

The Georgia Mushroom Club provides photographic resources on classification of mushrooms (http://gamushroomclub.org/resources/GA_Common_Mushroom_Genera.pdf) and on habitats for fungi (http://gamushroomclub.org/resources/GA_Mushroom_Habitats.pdf).

The Microbiology Society provides images of fungal growth in Petri dishes obtained from exposure to bread mold and from the air inside and outside, as well as drawings of fungal morphology (https://microbiologysociety.org/why-microbiology-matters/what-is-microbiology/fungi/observing-fungi-in-a-petri-dish.html).

Table 11. Open-resource images of fungi.

Web Link	Advantages/ Disadvantages
https://www.mykoweb.com/	• This site has a vast array of pictures of various fungi, but the teacher must be careful to get permission to use the images. • Included are images of many different fungi from California, but also many different types of mushrooms. This diversity can serve as a good introduction to a course on mycology. • This website may not be stable. It was made by Michael Wood, who is a past president and past webmaster of the Mycology Society of San Francisco. He was also the former webmaster of the North American Mycological Association. Although these organizations are very credible, since the site is maintained by an individual, it might not always be available.
http://gamushroomclub.org/resources/GA_Common_Mushroom_Genera.pdf http://gamushroomclub.org/resources/GA_Mushroom_Habitats.pdf	• These links are to PDF drawings that show features and habitats of mushrooms in Georgia. These sites can be used to teach students that mushrooms are very diverse. These figures can be used to discuss the texture, color, spores, caps, gills, and other features of mushrooms as well as the different habitats. • This link is from a regional mushroom club. It is relatively credible, but the site may not always be available. • This site does not contain real pictures of mushrooms, and the site does not list any copyright regulations.

Table 11. *continued*

Web Link	Advantages/ Disadvantages
https://microbiologysociety.org/why-microbiology-matters/what-is-microbiology/fungi/observing-fungi-in-a-petri-dish.html	• This site has images of fungal growth in Petri dishes obtained from exposure to bread mold and from the air inside and outside. There are other drawings of fungal morphology. • These images do not have copyright protections, but there is one picture on the site that does. • This is a reputable society. However, the site may be updated from time to time.
https://www.bio-rad.com/webroot/web/pdf/lse/literature/Bulletin_6696.pdf	• This is a website from a biotechnology company. • This is a widely used company, so the website is moderately stable but could change with time. • This images are part of a lab that could change in the future. • There is no mention of copyright regulations on the website.
https://www.smithsonianmag.com/science-nature/watch-amazing-time-lapse-growing-mushrooms-180976118/	• This website has a video of growing mushrooms. It shows many different types of mushrooms that have different shapes, colors, and morphologies. • This video is from *Smithsonian Magazine*. • This website is relatively stable.

The company Bio-Rad offers a kit on biofuels to study the enzyme cellobiase produced by mushrooms. Some of the instructor materials that go along with this kit include flashcards of different mushrooms and also indicate the habitat of the different mushrooms. These experiments could also teach the students how fungi affect the environment and can play a role as a biofuel (see https://www.bio-rad.com/webroot/web/pdf/lse/literature/Bulletin_6696.pdf).

Smithsonian Magazine has a video showing various mushrooms growing (https://www.smithsonianmag.com/science-nature/watch-amazing-time-lapse-growing-mushrooms-180976118/).

The reader can also refer back to the paper on the diversity of fungi in marine life (Amend et al., 2019). Some faculty may also be able to find fungi and take pictures in the areas in which they live.

○ Other Resources

Experiments with Fungi

Biointeractive.org has some videos that show students how a scientist would use the scientific method to perform an experiment on fungi. This site is relatively stable. In one video (https://www.biointeractive.org/classroom-resources/can-fungus-save-plants-global-warming), a scientist explains that he wants to study the symbiotic relationship between plants and fungi under the stress condition of high temperature. They examine the organisms both together and separate. They learn that when the plants and fungi are in a symbiotic relationship, they can withstand high temperatures, in a few different environments, much better than when the organisms are separate. These data then can be expanded to study ways to make crops more resistant to heat and ultimately to alleviate the impacts of climate change.

In another video (https://www.biointeractive.org/classroom-resources/effects-fungicides-bumble-bee-colonies), scientists discuss their interest in the mechanisms by which a fungicide harms bumble bees. They discuss the root of the problem in the fact that pollen contains a large amount of yeast. They design an experiment examining the size of the bumble bee colony in the presence and absence of fungicide. Students can learn about the steps in the experiment and how scientists culture the micororganisms, including yeast, found in pollen.

Publications

This section lists some major open-access journals on fungi. There are also other types of journals, for instance on genetics, that include articles on fungi.

Fungal Biology (https://www.journals.elsevier.com/fungal-biology) publishes in all fields of basic and applied research involving fungi and fungus-like organisms (including oomycetes and slime molds). Areas of investigation include biodeterioration, biotechnology, cell and developmental biology, ecology, evolution, genetics, geomycology, medical mycology, mutualistic interactions (including lichens and mycorrhizas), physiology, plant pathology, secondary metabolites, and taxonomy and systematics.

Fungal Ecology (https://www.journals.elsevier.com/fungal-ecology) publishes investigations into all aspects of fungal ecology, including population dynamics; adaptation; evolution; roles in ecosystem functioning, nutrient cycling, decomposition, and carbon allocation; ecophysiology; intraspecific and interspecific mycelial interactions; fungus–plant (pathogens, mycorrhizas, lichens, endophytes), fungus–invertebrate, and fungus–microbe interactions; genomics and (evolutionary) genetics; conservation and biodiversity; remote sensing; bioremediation and biodegradation; and quantitative and computational aspects – modeling, indicators, complexity, and informatics.

Fungal Genetics and Biology (https://www.journals.elsevier.com/fungal-genetics-and-biology) publishes basic research conducted by mycologists, cell biologists, biochemists, geneticists, and molecular biologists. Research areas include biochemistry, cytology, developmental biology, evolutionary biology, genetics, molecular biology, phylogeny, and physiology.

PLOS Pathogens (https://journals.plos.org/plospathogens/) publishes articles on pathogens and how they interact with their host organisms, including articles related to bacteria, fungi, parasites, prions, and viruses.

Studies in Mycology (https://www.journals.elsevier.com/studies-in-mycology) publishes systematic monographs on the biodiversity of filamentous fungi and yeasts, with an emphasis on fungal taxonomy and biodiversity.

Journal of Fungi (https://www.mdpi.com/journal/jof) provides an advanced forum for studies related to pathogenic fungi, fungal biology, and all other aspects of fungal research.

Some instructors may also be interested in consulting popular literature. Two examples are the offerings of *Fungimag.com* (http://www.fungimag.com) and publications of the North American Mycological Association (https://namyco.org).

○ Conclusion

This article presents examples of open-access fungal resources that can be found online. There are obviously more topics and different approaches that can be used. The reader should note some of the advantages and disadvantages of the resources selected. It is important to check that websites are still available, as they may change with time. A few journal articles were selected, but these should be periodically exchanged for newer studies. Depending on the level of the class, different types of articles may or may not be useful. The OpenStax resources give good background information.

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