Book Review

Fungipedia. A Brief Compendium of Mushroom Lore by Lawrence Millman. 2019. Illustrations by Amy Jean Porter. Princeton University Press. Princeton, New Jersey, USA and Oxford, England, UK. 184 pp. ISBN 978-0-691-19472-1 (Hard cover)

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Like billions around the world, last spring 2020, we were all involved in teaching (JASB) and learning. Our course, which emphasized fungi, bacteria, and insects associated with the fruits and seeds of a native eastern North American tree, was switched to the online environment due to COVID-19 concerns. Thereafter, we actively and productively engaged in activities suitable for the suddenly changed environment that were related to the original course topic and kept the usual joyful learning atmosphere. After the spring 2020 semester came to an end, and no longer having the fun every Saturday for 5-6 hours, mostly engaged in laboratory activities, one of us stumbled across *Fungipedia* (Figure 1) Although we were no longer officially in a course, we enthusiastically decided to use some of our summer time to read this delightful book to learn more about fungi. Then, we decided to write this book review to remember that we continued learning in spite of the pandemic and all the transformations our world is going through (Figure 2).

Figures 1-2. 1. Cover of *Fungipedia*. 2. A sign of the times in which we live and wrote this book review. Fried chicken for sale as "coronao", a take on the word coronavirus.

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There are only a few books whose reading we remember dearly for years. For one of us (JASB), reading Voltaire's *Candide* and *Letters from England* as well as the anonymous, *La Vida de Lazarillo de Tormes y de Sus Fortunas y Adversidades* (*The Life of Lazarillo de Tormes and its Fortunes and Adversities*), was so enjoyable that he wanted to keep reading to find out what mischief was going to happen next. Never in our wildest dreams did we imagine that *Fungipedia* would have a place among our favorite books. Each of the approximately 190 one- or two-page long sections, consists of an enjoyable vignette on the biology of fungi, or mycology, or some riveting piece of interdisciplinary mycological folklore, or a biographical wiki on a student of the fungi, or mycologist.

Fungi generally are multicellular absorbers whose cell walls contain large, sugar-based compounds, or polysaccharides. One type of polysaccharide, known as chitin, contains nitrogen. The others lack nitrogen and are collectively called glucans. Instead of garnering energy by "eating" it from the Sun, as most plants and other photosynthetic organisms do[2], or getting energy by ingesting other organisms, like animals do, fungi secrete chemicals, or enzymes, that breakdown the item of digestive interest and then absorb some of its contents into their cells.

Basic morphology and common names. Most fungi are multicellular organisms. Although ultimately all organisms begin with one cell, some fungi remain unicellular for life. Some of those unicellular fungi are known as yeasts. Yeasts have great importance in economic mycology. Think about all of the food items we enjoy eating whose existence is owed, in part, to yeasts and their fermenting activities (e.g., some breads, beers, and wines, as well as other products fermented by both bacteria and fungi (e.g., sourdough, kimchi, and vinegar). However, the basic morphological unit of most fungi is the filament or hypha (plural, hyphae), which are the products of cells that have divided along one dimension. When these multicellular structures form visible relatively two-dimensional structures, they are often called molds. Many hyphae growing tightly together form a mycelium (plural, mycelia). However, many of the most familiar mycelia are tridimensional. They form the familiar mushrooms and get a variety of common names, including morels, chanterelles, and many others (Figure 4). For some of us, enjoying the study of fungi, like love, entered through the kitchen but – beware! - some fungi can kill us (Figure 5). Fungi have existed for millions of years, well before humans were around. Some, like the extinct *Prototaxites* (Figure 6), are so distinctly tall and massive that some scientists are not sure whether it is a fungus.

2 *Monotropa* (Figure 3, above) is an example of a non-photosynthetic plant genus that gets its nutrients with the help of fungi. Some groups of bacteria, such as green sulfur bacteria and purple sulfur bacteria, and many so-called "protists", such as algae, are also photosynthetic.

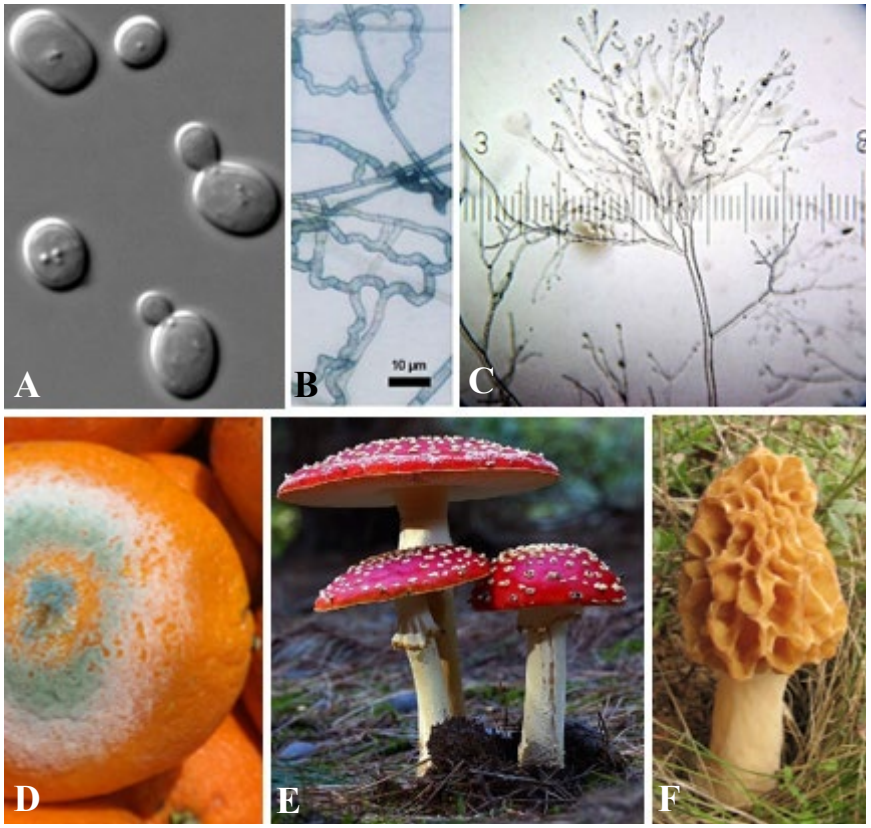

Figure 4. Morphology of fungi. A. Yeasts remain unicellular during their life history. Image from https://en.wikipedia.org/wiki/Yeast#/media/File:S_cerevisiae_under_DIC_microscopy.jpg . By Masur. B. Filaments, or hyphae (singular, hypha), the basic morphological unit of most fungi. Image from "File:Appressoria and Hyphae of Colletotrichum sublineolum.jpg" by Photchana Trakunsukharat, Department of Agriculture, Thailand is licensed under CC BY 3.0 . C. Mycelium, or group of hyphae. https://upload.wikimedia.org/wikipedia/commons/thumb/d/d1/20100916_011605_Mycelium.jpg/1024px-20100916_011605_Mycelium.jpg . D. Mold growing on an orange. Image from https://www.goodfreephotos.com/albums/plants/mold-on-an-orange.jpg . E. *Amanita muscaria*, an hallucinogenic and readily recognizable mushroom. Image from https://commons.wikimedia.org/wiki/File:Fly_agaric_(41660548781).jpg . This work has been released into the public domain by its author, Bernard Spragg. NZ. The fly agaric, as *A. muscaria* is commonly known, is depicted in the cover of *Fungipedia*. F. Morel. Image from https://ccsearch.creativecommons.org/photos/6f9e24d9-0f44-4ef4-aa12-17a13c57ba55 by Henk Monster is licensed under CC BY 3.0.

Figure 5. Some poisonous fungi. Image from https://ccsearch.creativecommons.org/photos/d8905c27-0214-42c0-8834-eca7303eac1d Poisonous fungi - 24 species, including Agaricus, Hypophyllu Wellcome V0043131.jpg

Figure 6. One of several renditions of *Prototaxites*. Courtesy of the Smithsonian Institution. Painting by Mary Parrish.

Life History. Fungi can have complicated life cycles including asexual and sexual portions. In the sexual ones, the genetic material is scrambled yielding greater diversity.

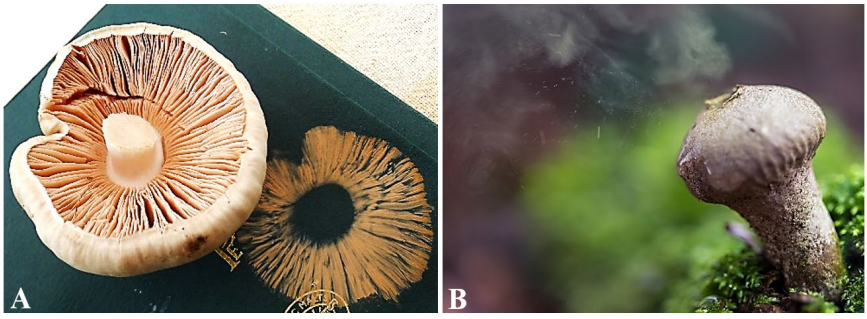

Figure 7. Fungi reproduction. A. For long-distance dispersal in space and/or time, fungi (and many other organisms) have spores, minuscule containers where the their progeny "travel" until they reach an appropriate circumstance to "germinate". "File:Possibly Pluteus semibulbosus...pink spore print - Flickr - gailhampshire.jpg" by gailhampshire from Cradley, Malvern, U.K is licensed under CC BY 2.0 . B. Spores can be ejected in numerous, fascinating ways: through air, as in the image, water, using other organisms, such as insects, etc. Image from "File:Eruption (245756555).jpeg" by Paul Garais is licensed under CC BY 3.0 .

Below, we describe why we enjoyed *Fungipedia* so much. This book is not intended as a group by group introduction to the fungi or as a systematic mycology treatise, with tips on how to distinguish closely related species. Instead, *Fungipedia* emphasizes three topics: 1) interesting features of mycology, 2) how fungi and other living things, especially humans, interact, and 3) some of the scholars who have contributed to our understanding of this extraordinarily diverse and interesting group of organisms.

Biodiversity and some interesting features of the biology of fungi

Fungipedia is organized alphabetically, with short (1 - 2 pages long), easy to read entries that are often peppered with humorous commentaries. These vignettes are good introductory descriptions about how the entries relate to mycology and give readers the opportunity to consider pursuing further research on the topic (Figure 8).

Figure 8. Some interesting features of fungi. A. Bioluminescence. Image from: https://commons.wikimedia.org/wiki/File:PanellusStipticusJuly5_2010_cropped.jpg . PanellusStipticusJuly5_2010.jpg: Ylem, derivative work: Ak ccm (talk). B. Morphology evocative of human affairs, as in this so-called dead man fingers. Image from: https://commons.wikimedia.org/wiki/File:Deadmansfingers_Jul-3-2009.jpg. Freekee / Public domain. C. Production of exudates, as in this species of *Lactarius*. Image from : https://en.wikipedia.org/wiki/File:2007-07-09_Lactarius_quietus_2.jpg by Andreas Kunze. D. Ability to eject packages of spores, called peridioles, far away through the action of raindrops as in this bird's nest fungus. Image from: https://search.creativecommons.org/photos/8444bb90-e507-4603-b8f9-c2c67b6d4fbd , "Bird's nest fungi .(Nidulariaceae)" by Bernard Spragg is marked with CC PDM 1.0 .

Interactions between fungi and other living things, including humans

Of great interest to all of us were the many cases of interactions between fungi and non-human organisms. The wealth of fascinating potential research topics to be found therein was endless (Figure 9).

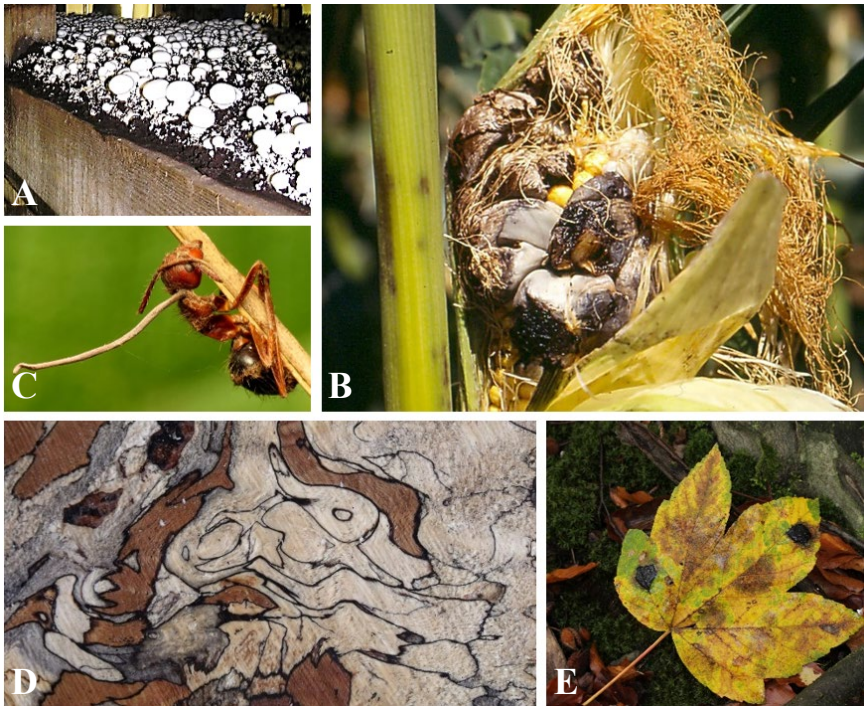

Figure 9. Examples of interactions between fungi and other organisms. A. Mushrooms being grown by humans for consumption. Image from https://search.creativecommons.org/photos/b2e07400-c511-440a-bf22-38e0487a0c4e . "Agaricus bisporus mushroom cultivation" by Plant pests and diseases is marked with CC PDM 1.0 . B. Corn smut, a fungal parasite of corn. Interestingly, in México, it is edible and eaten as filing in traditional dishes. https://ccsearch.creativecommons.org/photos/342896e9-592d-4918-820e-8a2feb79da3f . C. Fungus parasitizing an ant, changing its behavior, and making it move upward on a plant and hold to it until death parts the living fungus and the dead ant apart. Image from: https://ccsearch.creativecommons.org/photos/cef4cae9-88ac-4b78-82b6-c21bf2a6e109 . "Ant killed by Ophiocordyceps fungus" by treegrow is licensed under CC BY 2.0. D. Different species of fungi interacting with other fungi in wood, a phenomenon known as spalting. The different colors represent the boundaries of different species of fungi. Image from: https://ccsearch.creativecommons.org/photos/383597ec-2844-4c74-95ad-b051d36f2e1d . "Fungal Spalting" by puffin11uk is licensed under CC BY-SA 2.0 . E. Fungi as decomposers, along with bacteria and other microorganisms. Image from: https://ccsearch.creativecommons.org/photos/8f377a0f-31dd-4c91-a702-8085481506c8. "File:Rotbachtal-0006.jpg" by Björn Sothmann is licensed under CC BY-SA 4.0 . There are countless additional interactions, including the strong implication of fungi in the decline of amphibians and snakes as well as many other plant diseases caused by fungi.

A favorite aspect of *Fungipedia* are the many examples of folklore and uses of fungi throughout various cultures and epochs. While sometimes amusing, these stories often show different roles fungi play in people's lives and how fungi can be perceived. For instance, in ancient times, some mushrooms had symbolic or ritualistic meanings. Some cultures consider that mushrooms may be related to their ancestors; others related them to the origin of humanity.

A number of fungi have been used to achieve altered states of consciousness. Scientists have been using what they have learned from those "toadstool", as some fungi have sometimes been called, to synthesize drugs of medical importance (e.g., to treat cancer), analgesics, stabilizers, etc. One of us (SB), ended up rereading many excerpts that she found funny or interesting aloud to her roommate and then her family. In sum, we got the impression that there appears to be a tendency for fungi to be named after human bodily functions, especially reproduction, to be associated with compounds that make humans achieve altered states of consciousness, and with music. The motto, "sex, drugs, and rock and roll" seems popular among common names of fungi.

Some of the scholars who have contributed to the understanding of fungi

Also, we enjoyed the entries dedicated to specific people (Figure 10). For instance, after reading Mary Banning's and Beatrix Potter's entries, one of us (SB) was led to look up Banning's art, which was beautiful, and then further read about her life. The stories of these two women with interest in mycology inspired author SB. With brief introductions of scientists who have worked on fungi and their work, one of us (XZ) feels he knows better how fungi relate to his life. Also, we enjoyed the author's sense of humor which contributed to making *Fungipedia* more readable and enjoyable than traditional textbooks.

Lastly, hours before this review went to press, JASB's longest-lasting friend sent him an image of an attentive and curious girl (Figure 11). That is how we all felt as we read *Fungipedia*. Although the image suggests the girl may become an entomologist, with only 1-2% of the estimated five million extant species, perhaps she will become a mycologist.

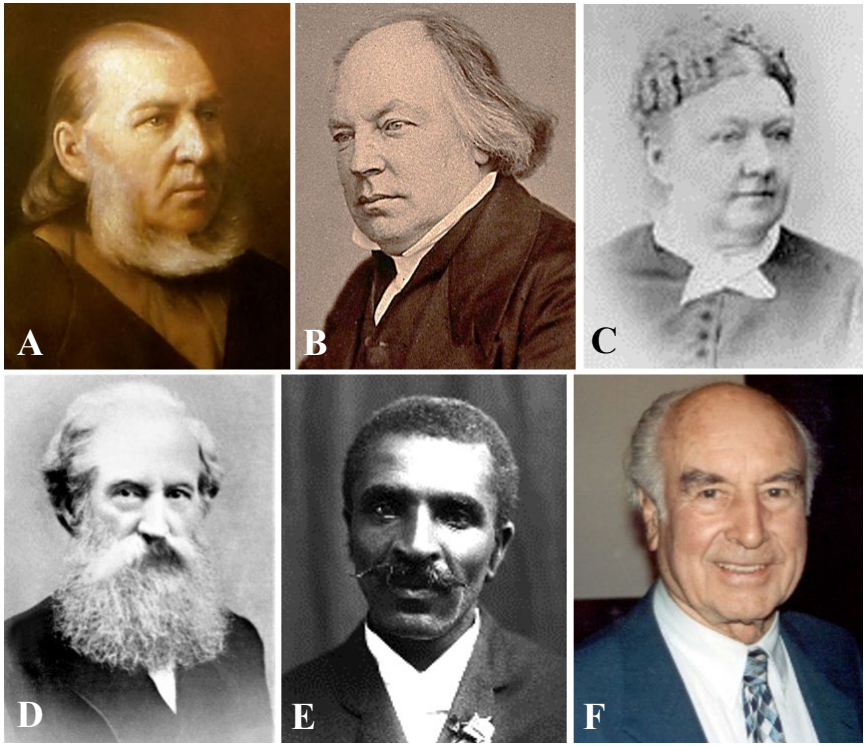

Figure 10. Basic morphology of fungi. A. Sergey Timofeyevich Aksakov (1791-1859, Russia) noted that "certain trees only produce their own kinds of mushrooms" suggesting that he suspected there are close interactions between fungi and plants. Image from https://en.wikipedia.org/wiki/Sergey_Aksakov . B. Reverend Miles Berkeley (1803-1889, UK). Attributed for the creation of the word, "mycology". Image from https://ccsearch.creativecommons.org/photos/c5507f64-00ab-4c2c-bf3a-330733eff178 . C. Mary Banning (1822-1903, USA), studied fungi of Maryland, USA. Image from https://commons.wikimedia.org/wiki/File:Mary_Elizabeth_Banning.jpg . Banning is not to be confused with Mary Anning (1799-1847), the British paleontologist. D. Mordecai Cubitt Cooke (1825-1914, UK), a "Victorian hippie" who was interested in hallucinogenic compounds. E. George Washington Carver (1864?-1943, USA) was first to identify the fungal pathogen of soybeans and document the *Aspergillus* that attacks peanuts. In 1935, the United States Department of Agriculture named him head of the Division of Mycology and Disease Survey. Image from https://search.creativecommons.org/photos/372aabbf-6ff3-4f5b-bd17-4483a309fdfb . E. Albert Hofmann (1906-2008, Switzerland). A chemist interested in hallucinogenic compounds, such as those in ergot and lysergic acid diethylamide or LSD. Ergotism killed circa 40,000 people in southern France circa 944 CE and some 10,000 others in Russia un 1926. This plate does not represent the large and deserving additional scholars not depicted herein.

If a new edition of this fascinating book is produced, we recommend including key references and images pertaining to each subject next to the item itself, just as in *Wikipedia*, as those will greatly enhance the learning experience of willing readers. Overall, however, we enjoyed this book immensely and recommend it wholeheartedly to those eager to have a delightful entrée into the world of fungi. We have garnered an increased awareness of their existence, particularly when we are suddenly reminded of their quiet, often underground, presence shortly after downpours, not only when we see them above ground or on supermarkets.

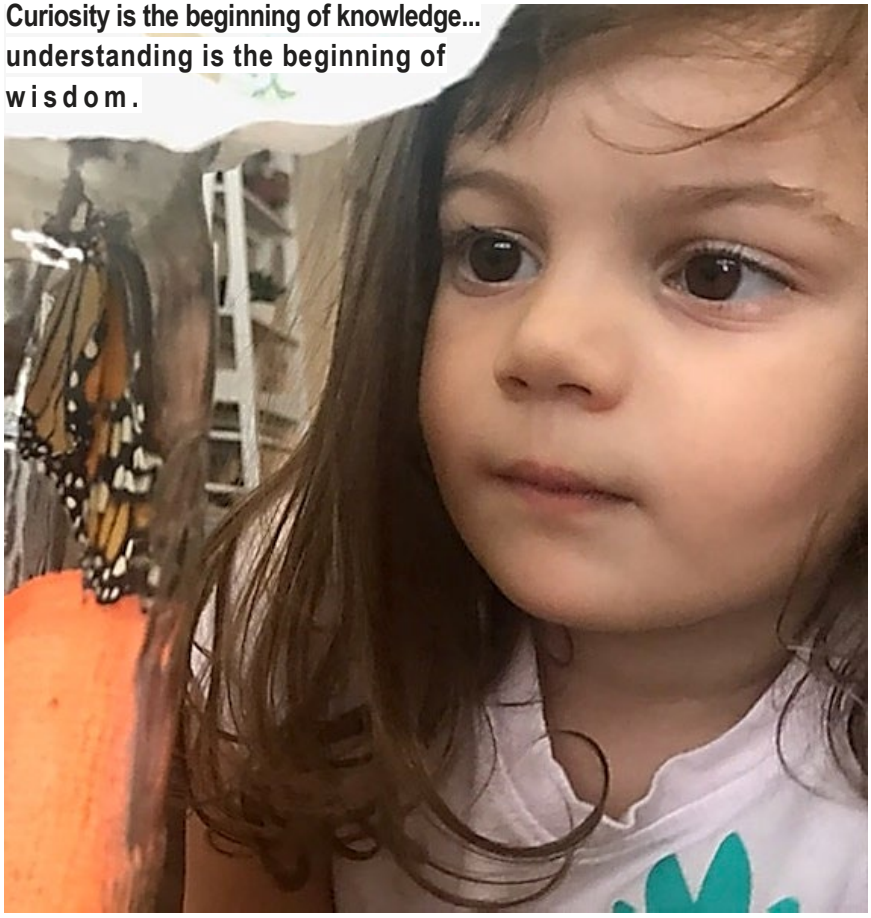

Figure 11. A girl attentively admiring the wonders of nature. Reproduced with permission of the parents who prefer to remain anonymous.