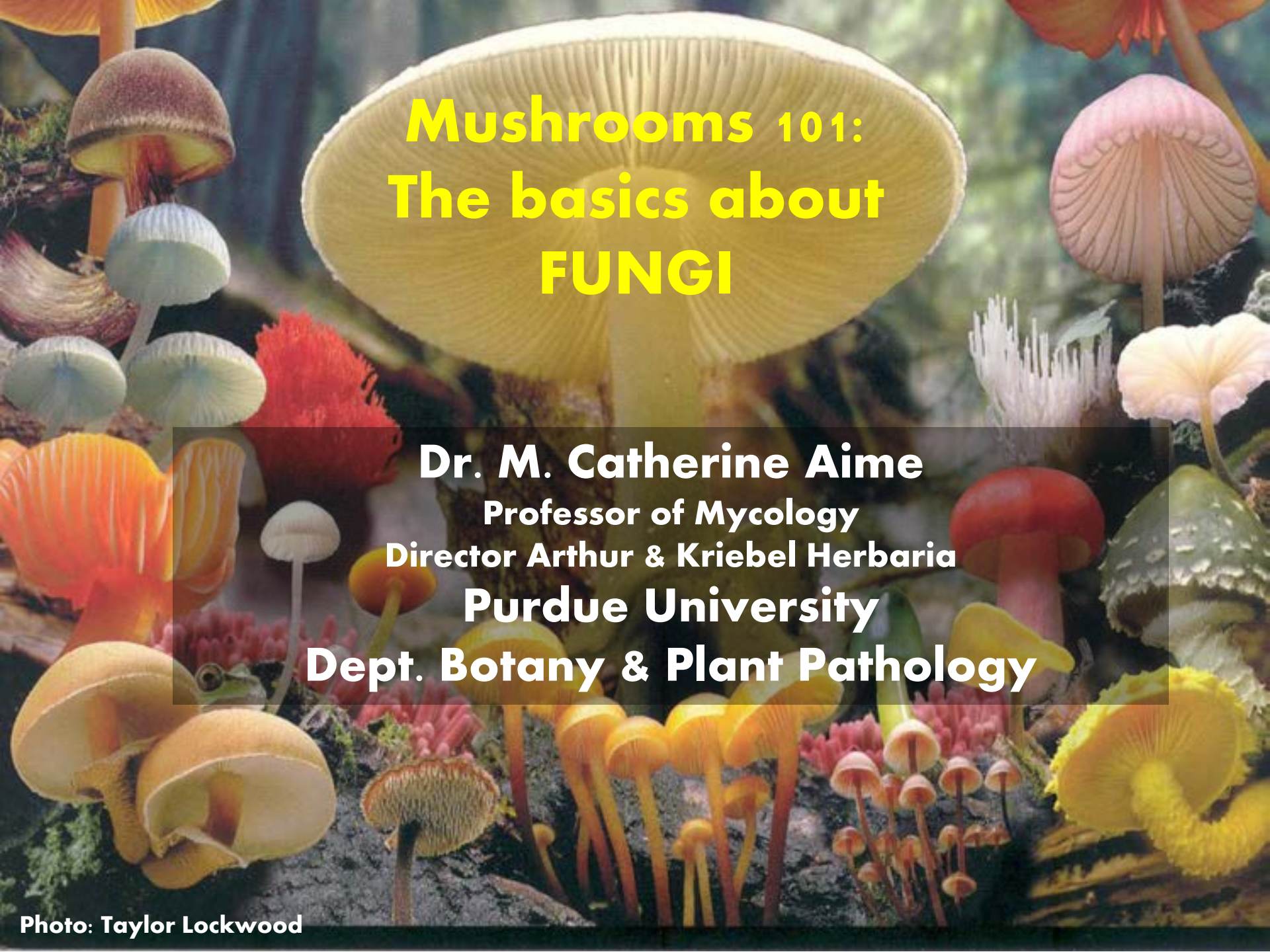


Mushrooms 101: The basics about FUNGI

Dr. M. Catherine Aime
Professor of Mycology
Director Arthur & Kriebel Herbaria
Purdue University
Dept. Botany & Plant Pathology

Photo: Taylor Lockwood

What are they?

Example — Fairy ring

What is the world's oldest known organism?
What is the largest?

The humongous fungus... (*Armillaria*)

"All the News That's Fit to Print"

The New York Times

National Edition

VOL. CXLI .... No. 48,924 THURSDAY, APRIL 2, 1992

World's Biggest, Oldest Organism Twin Crowns for 30-Acre Fungus:

By NATALIE ANGIER

Scientists have discovered what could be the largest and oldest living organism on earth, an individual mightier than the blue whale, the giant sequoia tree or such past pretenders to size supremacy as the dinosaur.

The organism is a giant fungus, an interwoven filagree of mushrooms and rootlike tentacles spawned by a single fertilized spore 1,500 to 10,000 years ago and now extending for more than 30 acres in the soil of a forest near Crystal Falls, Mich., along the Wisconsin border.

The fungus, called Armillaria bulbosa, has many tiny breaks in it but is genetically uniform from one end of its expanse to the other, which is why scientists say it rightfully deserves to be called a single individual. They suggest it has been growing possibly since the end of the last Ice Age, making it older than any other known organism on earth. If all its mushrooms and tendrils are considered together, the fungus weighs about 100 tons, about as much as a blue whale.

Dr. Myron L. Smith and Dr. James B. Anderson of the University of Toronto in Mississauga, Ontario, and Dr. Johann N. Bruhn of Michigan Technological University in Houghton report their discovery of the mammoth Armillaria in today's issue of the journal Nature.

"This is a fascinating report," said Dr. Thomas D. Bruns, an assistant professor of plant pathology and a fungal researcher at the University of California at Berkeley. "The catchy part of it is, when you really begin to appreciate how large this thing is, it's mind-boggling. People usually think of a mushroom as a little creature, but most of the action of a fungus is underground."

The organism survives by feeding on dead wood and other detritus, spreading outward right beneath the surface as it senses the presence of nutrients nearby. But scientists believe that the fungus has probably reached its maximum dimensions; at one, and possibly several, of its borders, the Armillaria is bumping up against competing fungi, which are blocking the older giant's further colonization of the forest.

Researchers said the finding will force biologists to rethink their assumptions about what constitutes an individual, a fundamental problem in the study of the natural world and its ecosystems. Scientists normally view a single organism as something bound by a type of skin, whether of animal flesh or plant cellulose. But fungi, along with other organisms like coral and some types of grasses, grow as a network of cells and threadlike elements whose boundaries are not always clear.

What is more, some elements of the newly discovered Armillaria grow independently, thus straining the idea that the entire fungal patch can truly be considered an individual. Nevertheless, biologists said that given its uniform genetic makeup the mold merited its ranking as a one giant creature.

"The individual is the basic unit of biology," said Dr. Rytas Vilgalys, an assistant professor of botany at Duke University. "Fungi like Armillaria offer us an opportunity for re-examining what the basic unit might be."

Scientists said the new work was particularly significant because it used so-called genetic analysis, similar to the techniques of DNA fingerprinting, to prove that the 30-acre fungus was a discrete being, which had grown over the years by sending out clonal shoots of itself. Other extremely large fungal growths have been identified in the past, but researchers could never be sure that the growths represented individual fungi, rather than populations of smaller molds whose edges had become smeared together.

"We used genetic markers to distinguish between these two possibilities," Dr. Anderson said. "It shocked us to have found such a large fungal entity that is so ancient."

"A lot of people have asked us if this is an April Fool's joke," he continued. "I've assured them it is not."

Larger Growths Are Possible

As startled as they were to discover the colossal patch of fuzz, the researchers said their Armillaria may not even be the largest fungal clone around.

"It's the most successful one we're aware of, but this is in a mixed forest with many kinds of trees," Dr. Bruhn said. "We would think where there was a stand of pure trees like birch or aspen, a single fungus might be more successful still." In that case a fungus with a taste for a particular type of tree might be able to proliferate especially quickly and over the entire area before encountering any competitors.

The new discovery also underscores the ubiquity and power of the planet's fungi, a kingdom of organisms quite distinct from the plant and animal kingdoms.

"Fungi are the base of all terrestrial ecosystems," Dr. Bruns said. "No ecosystem on the planet would continue to operate without fungi to decompose and recycle wood and plants."

But fungi are not always innocuous; they sometimes attack healthy tissue. A few virulent fungal species, like the Dutch elm pathogen, have ... devastate entire populations of ...

Mapping a Discovery

The scientists came upon the ... described mega-fungus in 1988 ... studying tree pathogens for the ... Walking over a couple of acres of ... on the Michigan-Wisconsin ... they collected samples of Ar... mushrooms, familiarly known ... ton or honey mushrooms, together ... the underlying, shoestring-like ... tures called rhizomorphs, which ... nourishment for the fungus. Th... amined 12 genes from the fungi ... and realized that all their ... were the clonal offshoots of a ... being.

Going back over the next ... years and collecting ever more ... laria samples, they continued ... back the borders of that fungus ... at last realizing that they had ... thing enormous on their hands.

Giant fungus was found in forest near Crystal Falls, Mich.

Mushrooms growing through a tree stump are only tips of an organ... iceberg. A 100-ton giant fungus, extending through 30 acres ... Michigan forest, is believed to be the largest organism in the world.

Through experiments measuring the growth rate of the fungus on wooden stakes, they were able to estimate how long it would have taken the clone to reach its current dimensions.

Feeding Off Rivals

The scientists now believe that at some point in the distant past a fertil... ized spore, blown from a parent ... laria mushroom, settled onto the ... germinated and extended ... brown rootlike rhizomorphs ... ward, seeking wood debris to ... Eventually, the fungal webbing ... began sprouting mushrooms to ... above ground and disperse new ... spores to the wind.

HUMUNGUS FUNGUS

Crystal Falls is "House of the Humungous Fungus", perhaps the world's largest and oldest living organism. It covers 38 acres beneath an Iron County forest near the Wisconsin border. It is believed to be 1,400 to 10,000 years old and weigh about 100 tons - about the same as an adult blue whale. It is the species called Armillaria Bulbosa and the mushrooms it produces are commonly called "honey mushroom." The mushroom is the only edible part of the fungus. Armillaria bulbosa is very common, occurring in hardwood forests in North America, Europe and Japan.

The fungus was discovered by Myron L. Smith and James B. Anderson, both of the university of Toronto. They came across the fungus while doing research for the U.S. Navy in 1988. When Johann N. Bruhn, a research scientist with Michigan Technological University in Houghton, wrote an article on it in the Journal of Nature in April of 1992, scientists were deluged with inquiries from the United States, Canada, and Britain.

Although everyone wants to see the "Humungus Fungus" for themselves, it is mostly underground except for tiny offshoots that poke through the surface in the fall, edibles commonly known as button or honey mushrooms. People are generally disappointed if they actually go to the site looking for the big mushroom.

"The fungus is an integral part of the ecosystem, feeding on decayed wood and producing carbon dioxide essential for the process through which plants generate life-giving oxygen" said Johann N. Bruns during a guided tour of the area. "Without organisms such as this, it wouldn't take long before life on earth would cease."

Although the "Humungus Fungus" is actually located in Mastedon Township, the Crystal Falls Business Association, compiled of business owners in both the City and Township of Crystal Falls, saw an opportunity to draw tourism to the area and established the "Humungus Fungus Festival".

The fungus made the national news and even the "Late Night with David Letterman" show picked up on the fun with the top ten "facts" about the fungus as:

- Came out of hiding to appear as character witness in Gotti Trial.
- Bill Clinton once tried to smoke some of it.
- Has vanity plate: "Fungus-1"
- Some polls show it running neck and neck with Jerry Brown.
- Elvis once had staff try to bulldoze it onto a 40-acre pizza.
- Section of it used to make William Shatner's hairpiece.
- Might be an old YMCA they forgot to disinfect.
- Believed to be smarter than Quayle.
- Nicknamed "Debbie".
- Tastes a little like chicken.

The fungus has also been featured on the side of a U-Haul van.

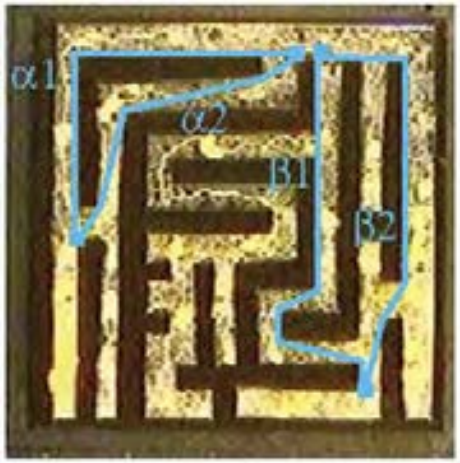
The local merchants have "cashed in" on the fungus by selling Fungus Fudge, Fungus Burgers, and Fungus Tee Shirts.

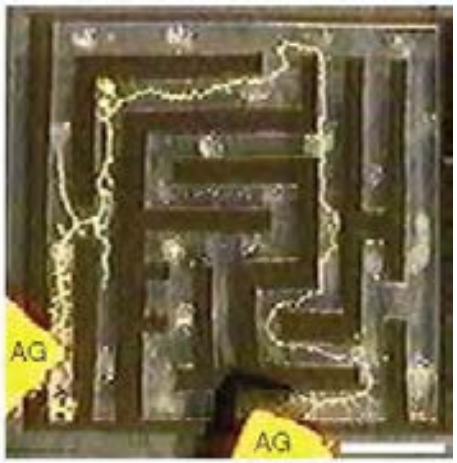
Soon to be a part of a documentary on the Crystal Falls area, the Humungus Fungus is alive and well in the earth south of the City.

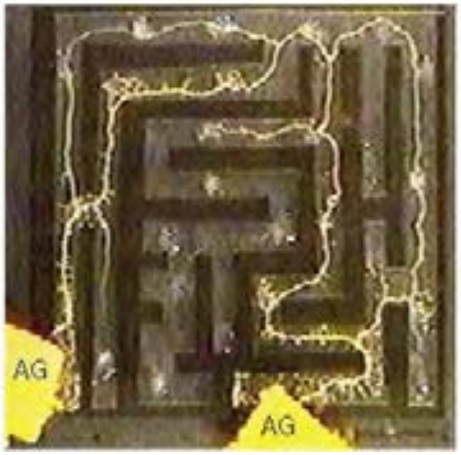
http://www.crystalfalls.org/humongou.htm

Can a fungus be smart?

Toshiyuki Nakagaki, Hiroyasu Yamada and Ágota Tóth. 2000.
Intelligence: Maze-solving by an amoeboid organism. *Nature* 407: 470.







d

	None	β1	β2	β1, β2
None	2	0	0	0
α1	0	0	0	0
α2	0	5	6	3
α1, α2	0	0	0	3

A. Structure of the organism before finding the shortest path. Blue lines indicate the shortest paths between two agar blocks containing nutrients. **B.** Four hours after the setting of the agar blocks (AG), the dead ends of the plasmodium shrink and the pseudopodia explore all possible connections. **C.** Four hours later, the shortest path has been selected. **D.** Path selection. Numbers indicate the frequency with which each pathway was selected. 'None', no pseudopodia (tubes) were put out.

What are they doing?

1. Saprobes: Essential decomposers

- Fungi are extremely important primary and secondary decomposers of organic materials.
- A handful of Fungi are the only organisms that can effectively and completely degrade lignin. Lignin is a complex, three-dimensional non-stereopolymer that protects plant cellulose from attack. Probably the most recalcitrant of all natural products.

2. Symbionts: Essential partners for plants and animals

- **Mycorrhizae**: 90% of the world's plants have a beneficial fungal mycorrhizal partner colonizing the roots. The fungus helps the plant absorb water, nutrients and minerals, especially phosphorus.
- **Lichens**: Mutualism between a fungus and an alga; allows colonization of harsh environments. Also animal gut mutualists.

3.

Pathogens: Essential for maintaining equilibrium in natural ecosystems

Causal agents of emerging global epidemics
e.g., chytridiomycosis, "the worst infectious disease ever recorded among vertebrates" in terms of the number of species impacted, and it's propensity to drive them to extinction (Gascon et al, 2007).

4.

Uses for fungi: Food

60 MINUTES

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VIDEO
60 Minutes Presents: Killing Bin Laden

60 MINUTES
Will Israel's "Iron Dome" help bring peace?

60 MINUTES
Africa Mercy: Hospital of hope

January 8, 2012 8:25 PM

Truffles: The Most Expensive Food in the World

...sell for as much as $3,600 ... which has dampened the ... fungi. Lesley Stahl reports.

Web Extras
Truffles: The Most Expensive Food in the World
Reporter's find: Truffles on polenta
Truffles: Sacred? Sacrilegious? Sexy?
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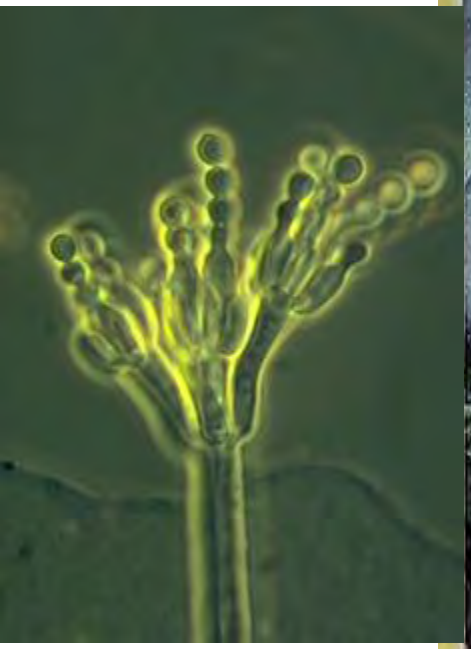
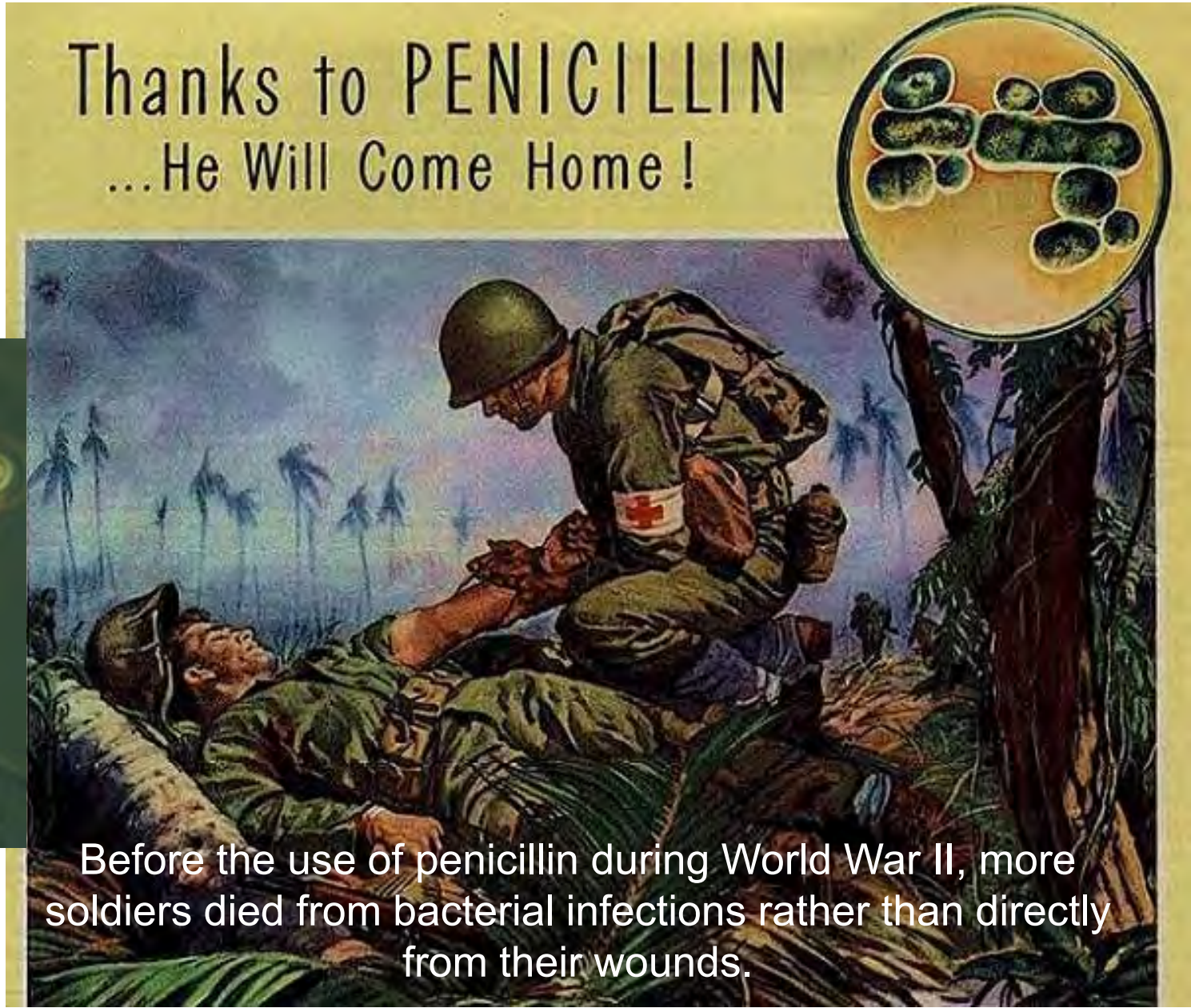
4.

Uses for fungi: Medicines...





Before the use of penicillin during World War II, more soldiers died from bacterial infections rather than directly from their wounds.

4.

Uses for fungi: Medicines...

Piptoporus betulina

antibiotic and styptic properties

Sunday, December 13, 1998 THE DENVER POST

SCIENCE TODAY

'Iceman' provides rare glimpse of prehistoric use of medicine

By John Noble Wilford
The New York Times

A traveler out of the past, the Iceman, whose mummified body was discovered in the Tyrolean Alps in Northern Italy in 1991, has given archaeologists and other scientists a lifelike picture of what people wore and ate and carried with them on treks into the Alps 5,300 years ago, at the end of the Stone Age and beginning of the Copper Age in Europe.

An anthropologist reported this month that the Iceman also was providing a rare glimpse of prehistoric medicine, including his apparent use of a natural laxative and antibiotic.

Among the Iceman's possessions were two walnut-size lumps with a consistency somewhere between cork and leather. Each lump was pierced and tied to a leather thong, perhaps so it could be fastened to some part of his clothing or belt. At first, the material was mistakenly described as tinder for starting fires.

But Austrian microbiologists have identified the lumps as the fruit of the birch fungus, Piptoporus betulinus, which is common in alpine and other cold environments. If the fungus is ingested, it can bring on short bouts of diarrhea. It also contains oils that are toxic to certain parasitic bacteria, thus acting as a form of nature's own antibiotics.

Scientists have not yet been able to determine the cause of the Iceman's death, but studies of his body have yielded a picture of a man stiff with arthritis who had not eaten in his last eight hours and may have died of exhaustion in a sudden snowstorm.

An autopsy of the well-preserved body has at least revealed the apparent reason the fungus was among the Iceman's remedies of the road. British scientists found in the man's colon the eggs of a parasitic whipworm, Trichuris trichiura. This infestation causes diarrhea and acute stomach pains. It also can bring on anemia, which might explain the evidence of low iron content in some of the mummy's muscles.

In the current issue of the British medical journal Lancet, Dr. Luigi Capasso, an anthropologist at the National Archeological Museum in Chieti, Italy, reviewed the evidence and concluded, "The discovery of the fungus suggests that the Iceman was aware of his intestinal parasites and fought them with measured doses of Piptoporus betulinus."

As Capasso pointed out, the birch fungus contains toxic resins that attack parasites like whipworm and another compound, agaric acid, which is a powerful laxative. The combined properties of the fungus could have brought at least temporary relief by purging the Iceman's intestines of nearly all of the worms and their eggs.

The birch fungus, Capasso wrote, was probably the only such remedy available in Europe before introduction of the far more toxic chenopod oil from the Americas.

In "The Man in the Ice," published in 1994 (Harmony Books, $25), Dr. Konrad Spindler, an archaeologist at the University of Innsbruck in Austria who led the early investigation of the mummy, noted the first evidence suggesting that the Iceman might have been carrying some natural medicines.

"All folk medicine has its origins in prehistory," Spindler wrote. "Over hundreds and thousands of years remedies were passed on from generation to generation. The modern pharmaceutical industry has frequently analyzed the active constituents of traditional medicines and makes use of them to this day, where synthetic forms cannot be produced.

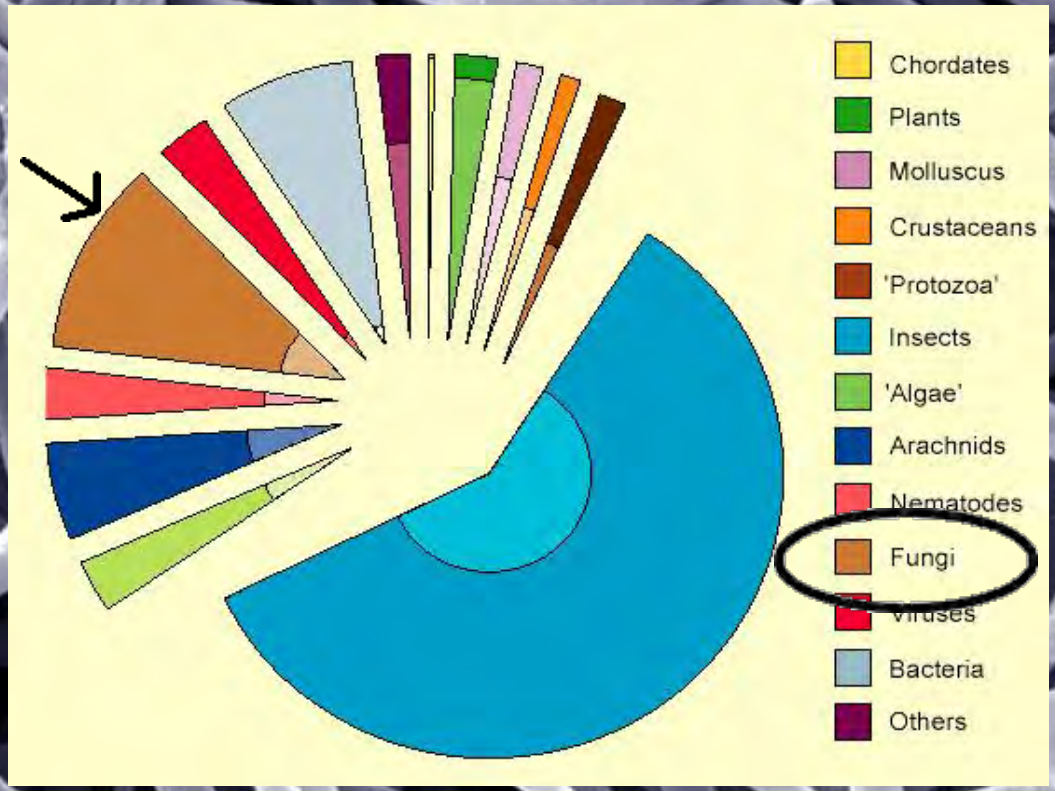
Seen in this light, the Iceman with his modest but no doubt effective traveling medicine kit, is not all that remote from ourselves."

Dr. John F. Leslie, a fungal geneticist at Kansas State University, called the reported link between the fungus and the Iceman's intestinal parasites "an interesting and exciting finding."

Dr. Michael G. Rinaldi, a clinical mycologist at the University of Texas Health Science Center in San Antonio, said he would like to see more evidence supporting the inference that the Iceman was consciously treating the parasites with the fungus.

If that proves to be the case, he said, "it just shows that from earliest time, people when they were sick would try whatever they could to make it go away, even if they never had a clue as to why it made them feel better."

One of the most diverse, least catalogued of all kingdoms



How many fungi?

Hawksworth 1995, 2001

- **6 species of fungi for every species of plant**
- **~250,000 species of flowering plants**
- **~1.5 million species of fungi**

- Based on temperate region
- Primarily macrofungi

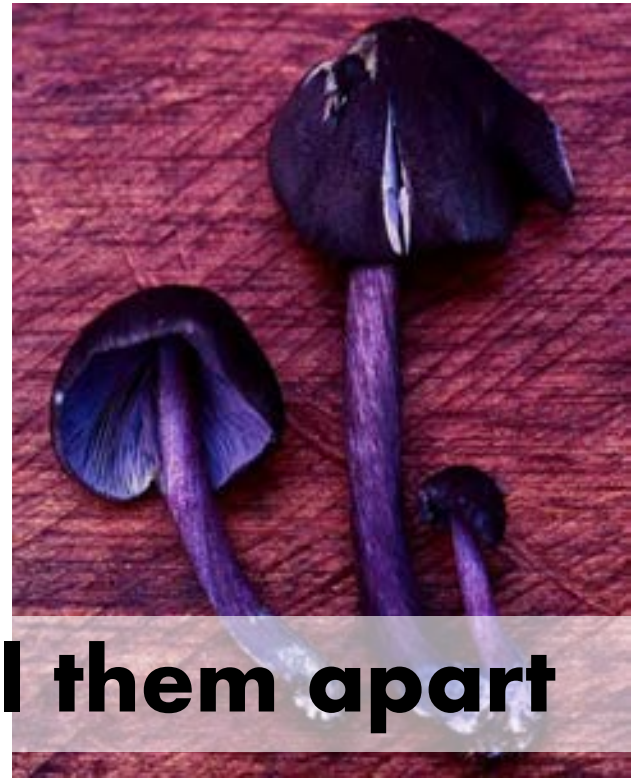
As little as 5% of estimated species have been described (in the last 200 years)!

Microfungi

- Plant endophytes
- Plant epiphytes
- Soil communities
- Insect associates
- ETC.

- Ca. 5.1 million species

Tropical Fungi



Mushrooms: How to tell them apart


There are
No
Easy
Rules!!!!!

HOW TO IDENTIFY MUSHROOMS TO GENUS I: Macroscopic Features

BY DAVID L. LARGENT

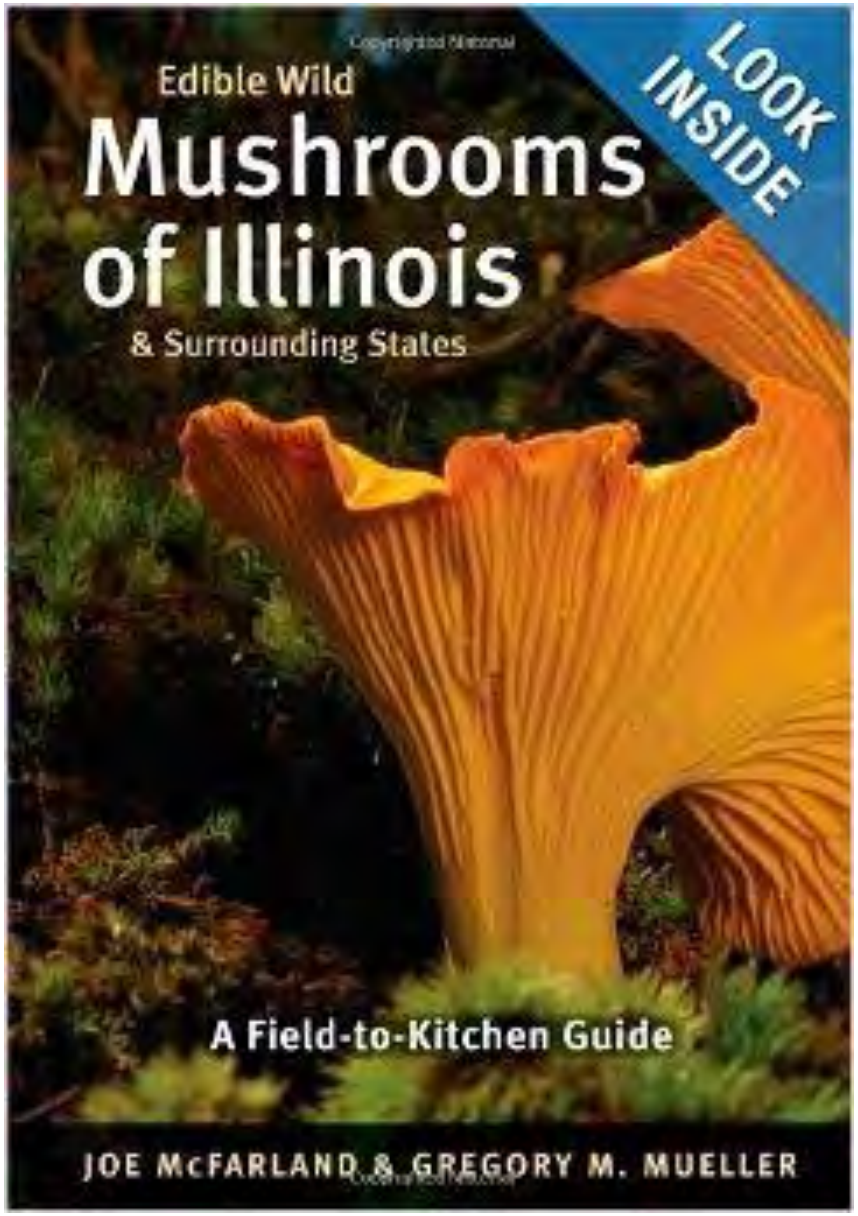
Illustrations by Sharon Hadley
Key by Daniel E. Stuntz

AIME

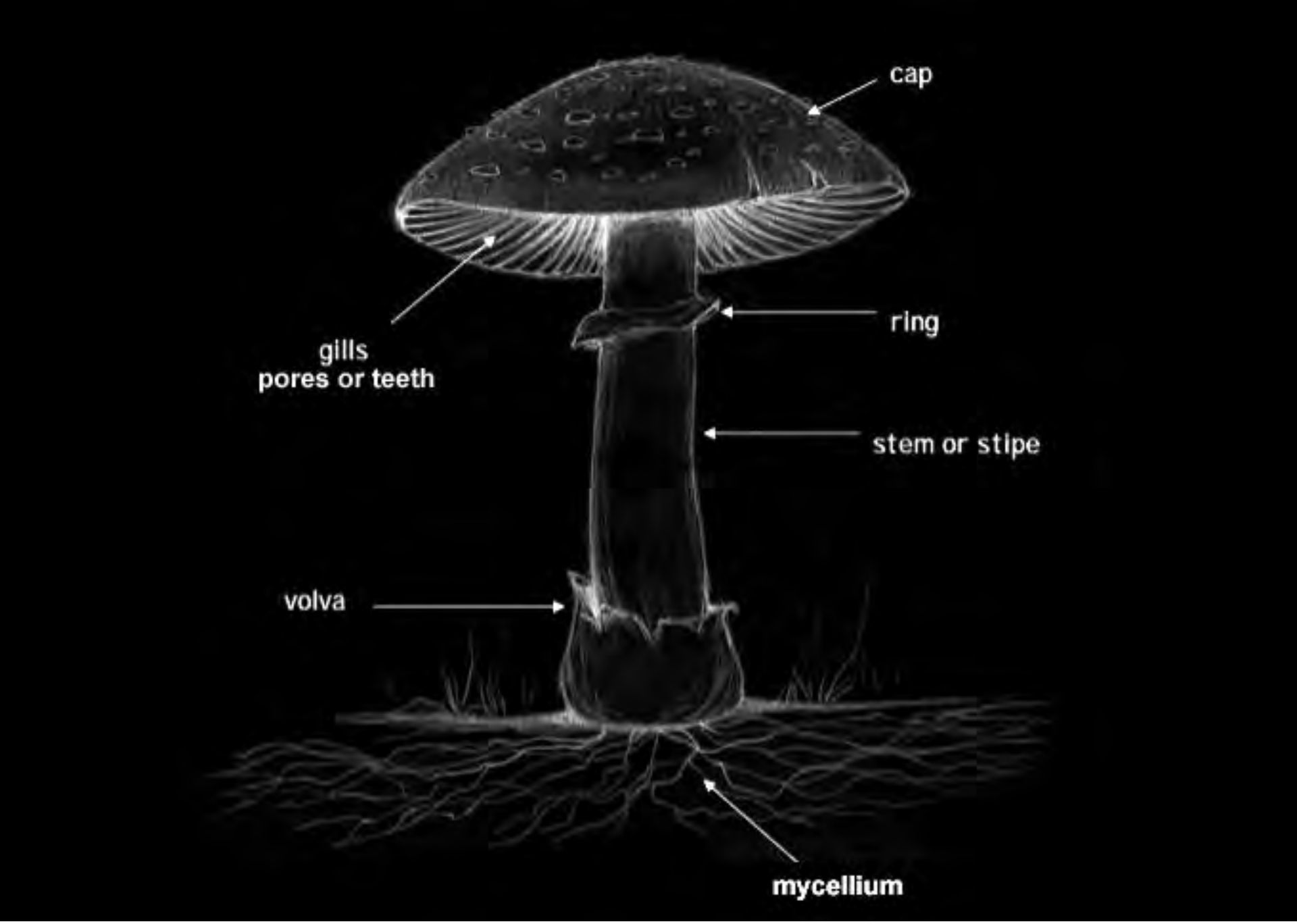
HOW TO IDENTIFY MUSHROOMS TO GENUS VI: Modern Genera

BY DAVID L. LARGENT
TIMOTHY J. BARONI

Mad River Press, Eureka, California


LOOK INSIDE
Edible Wild
Mushrooms of Illinois
& Surrounding States
A Field-to-Kitchen Guide
JOE McFARLAND & GREGORY M. MUELLER


Substrate


cap
gills
pores or teeth
ring
stem or stipe
volva
mycellium

Marasmius

Mycena

Armillaria mellea

Conocybe lactea

Coprinus comatus

Agaricus campestris

Lepiota


Chlorophyllum molibdites


Leucocoprinus birnbaumii

Amanita

Amanita caesarea

Amanita phalloides

Russula

Lactarius

Lactarius indigo


boleto

polypores

polypores

Laetiporus sulphureus

jelly fungi


SNOW FUNGUS
漳州
雪耳

Hericium erinaceus


Clavulina

stinkhorns

stinkhorns

birds nest fungi


Cantharellus

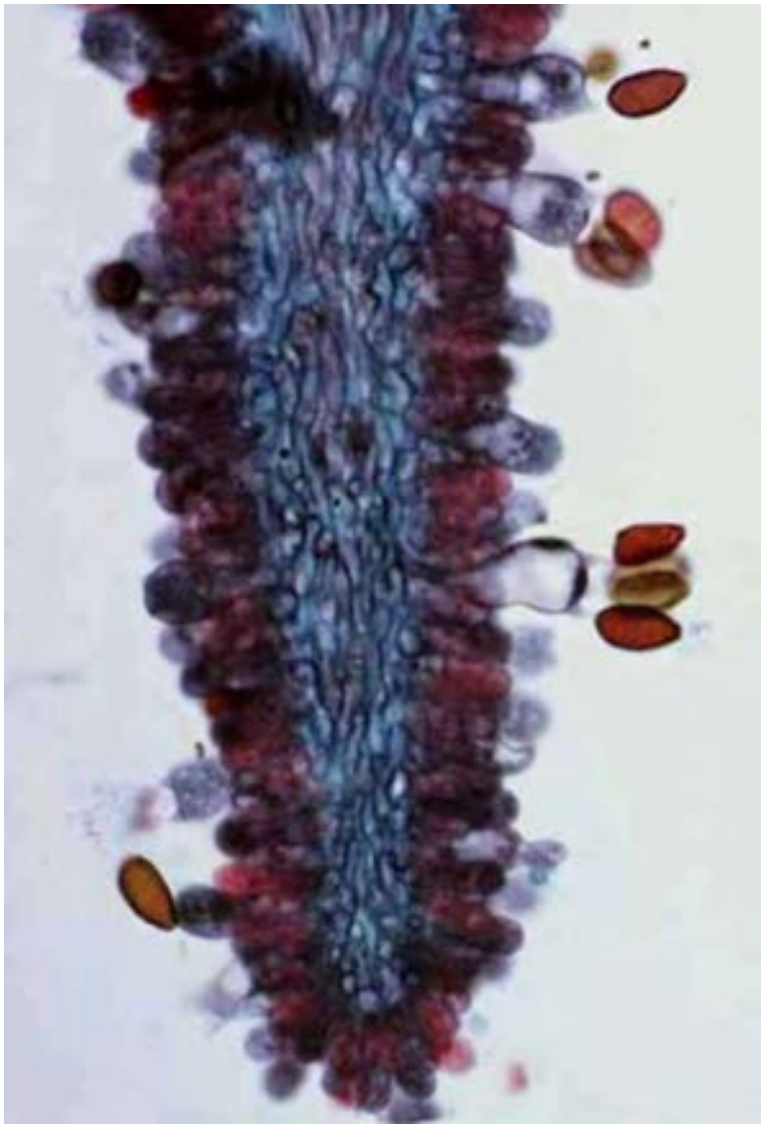

Cantharellus cinnabarinus


Calvatia gigantea

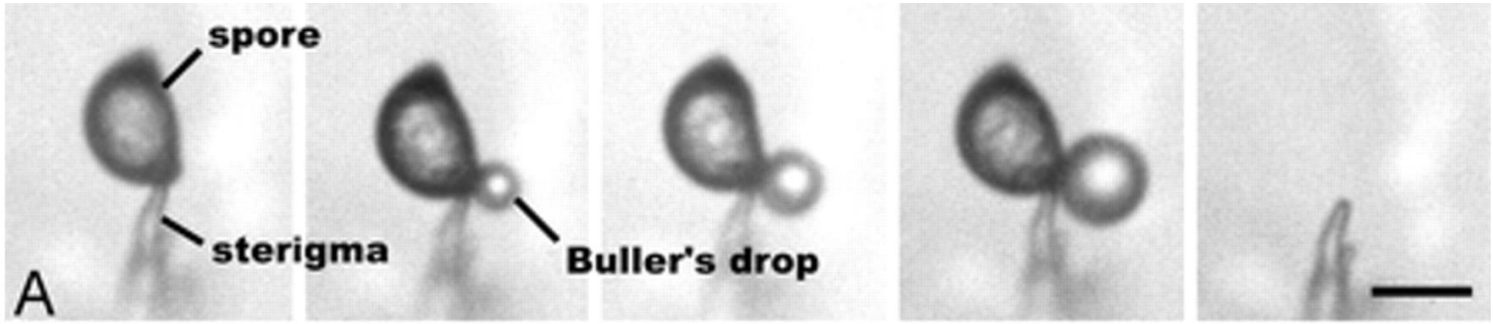
Huitlacoche

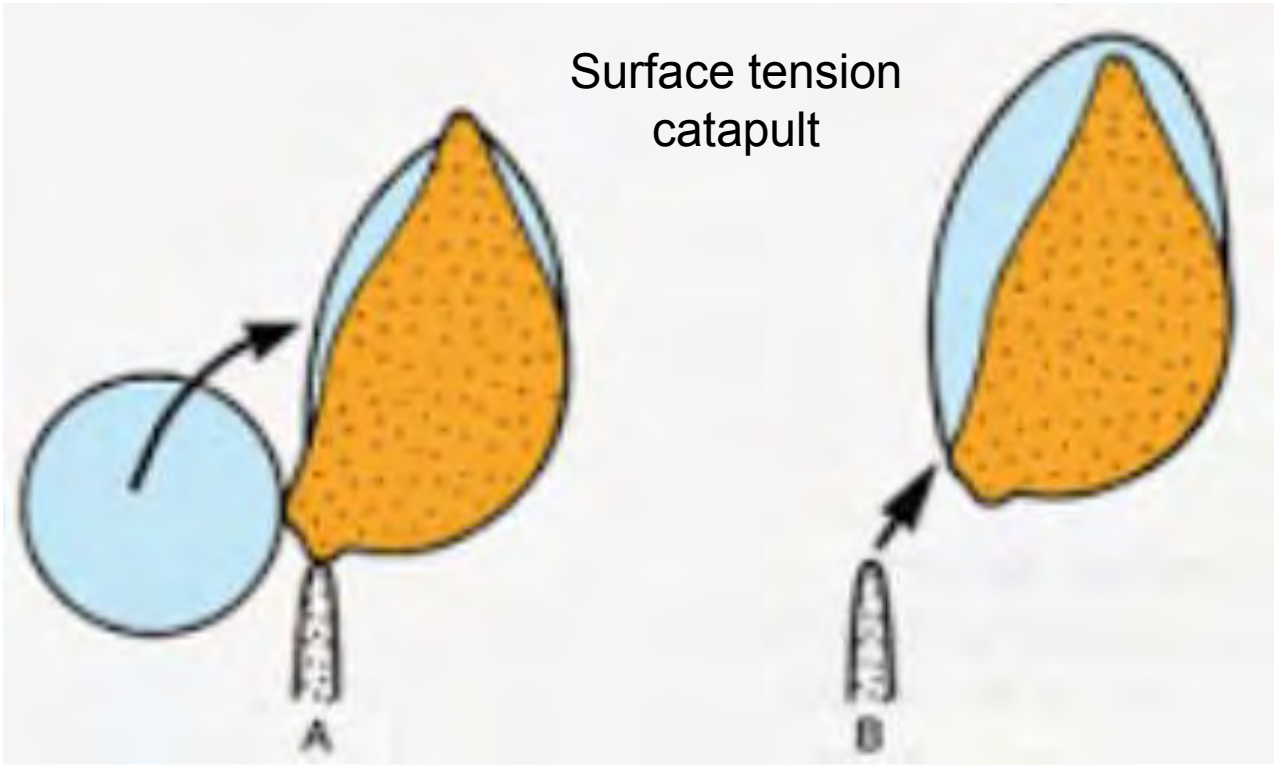
Gills—the surface on which basidia are produced

Relative to spore production over a flat surface, gills achieve a maximum 20-fold increase in surface area—think about what that means for the total number of basidiospores produced!



Ballistospory = Forcible Spore Discharge





Acceleration of a basidiospore is ca. 25,000g (10,000 x acceleration of space shuttle at launch)

Cup fungi


Scutellinia scutellata

Morels


Eric Smith