

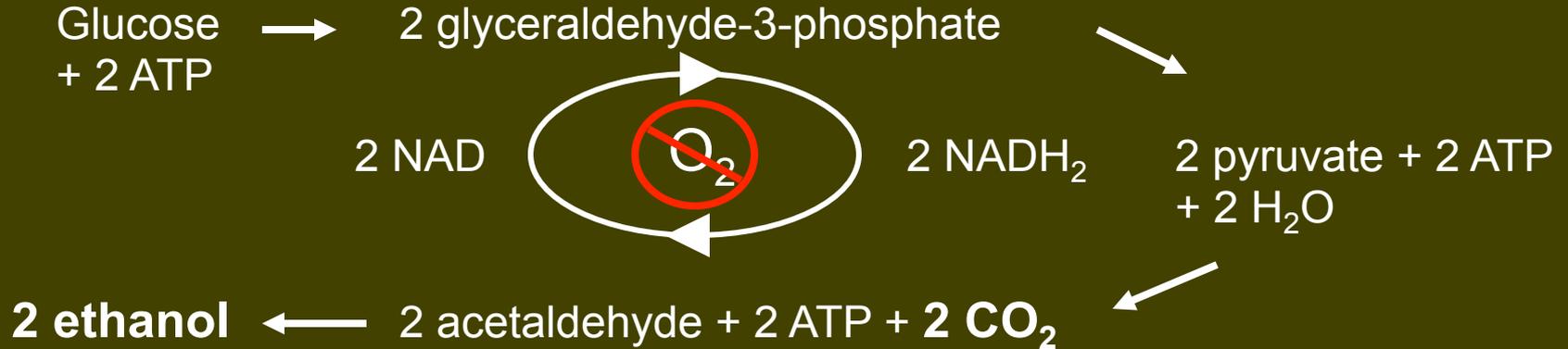
# 1. Economic, ecological and cultural importance of Fungi



# Fungi as food

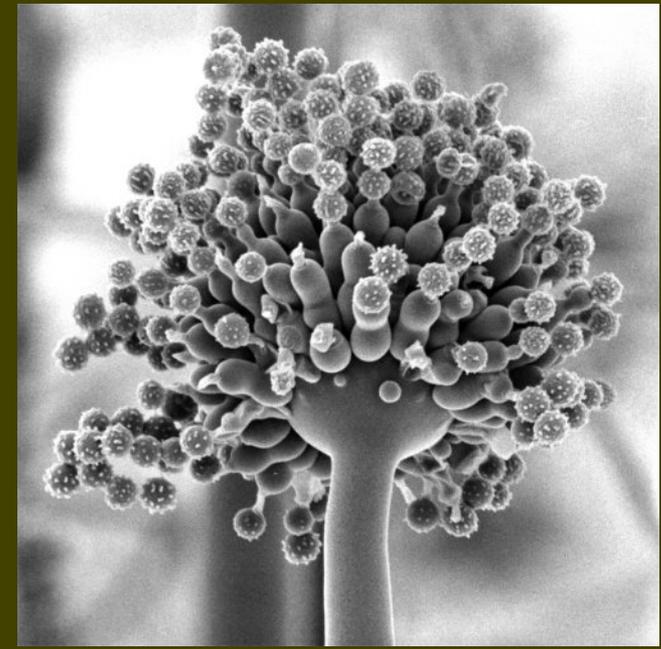
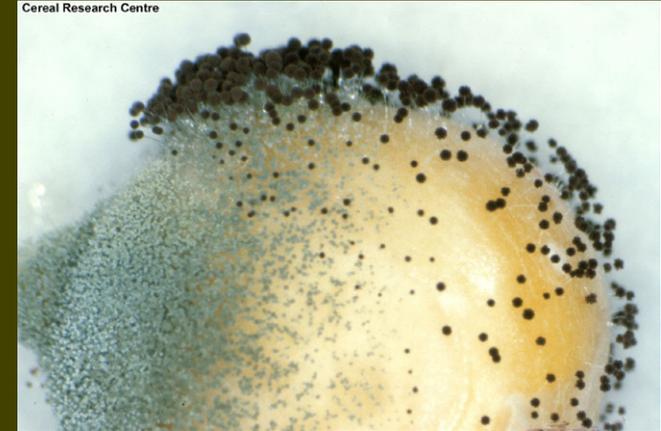
Yeast fermentations, *Saccaromyces cerevesiae* [Ascomycota]

alcoholic beverages, yeast leavened bread



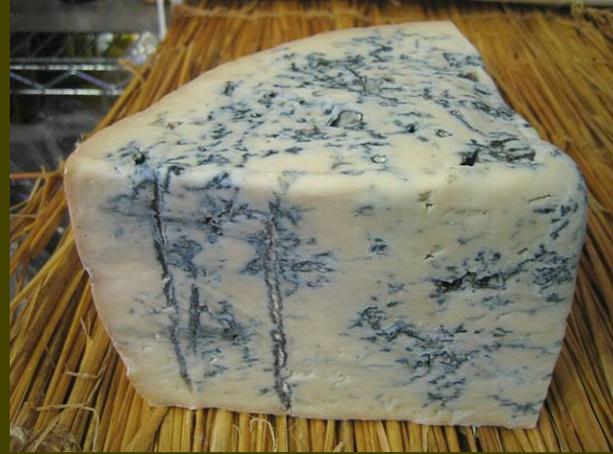
# Fungi as food

Citric acid *Aspergillus niger*



# Fungi as food

Cheese *Penicillium camembertii*, *Penicillium roquefortii*



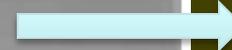
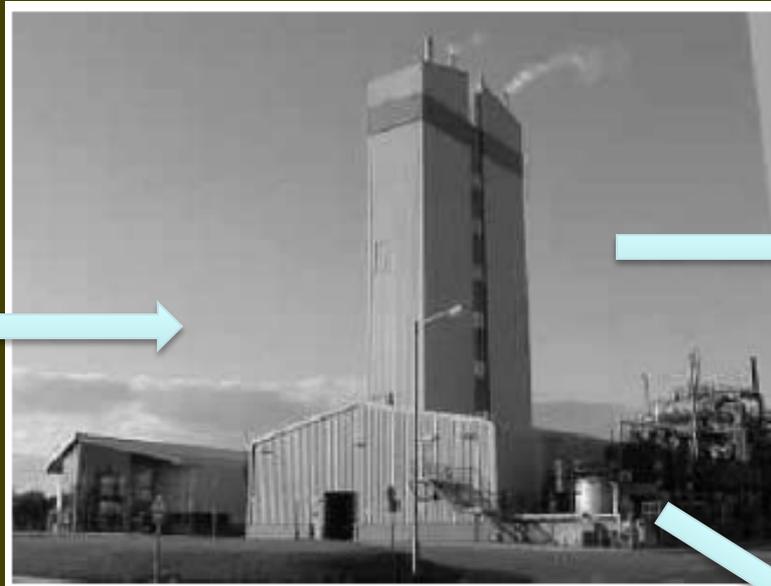
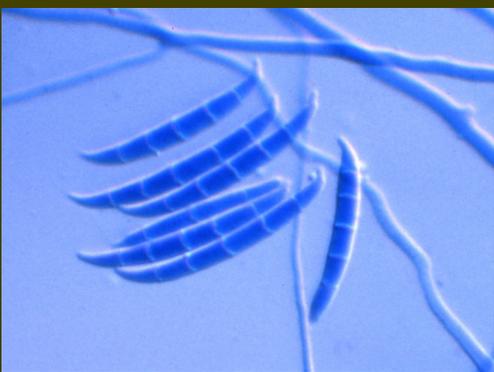
Rennet, chymosin produced by *Rhizomucor miehei* and recombinant *Aspergillus niger*, *Saccharomyces cerevesiae*

chymosin first GM enzyme approved for use in food



# Fungi as food

Quorn mycoprotein, produced from biomass of *Fusarium venenatum* [Ascomycota]



# Fungi as food

Red yeast rice, *Monascus purpureus* [Ascomycota] contains lovastatin?



Soy fermentations, *Aspergillus oryzae*



Tempeh, made with *Rhizopus oligosporus* [Zygomycota]



# Fungi as food

Other fungal food products: vitamins and enzymes

- vitamins: riboflavin (vitamin B2), commercially produced by *Ashbya gossypii*
- chocolate: cacao beans fermented before being made into chocolate with a mixture of yeasts and filamentous fungi: *Candida krusei*, *Geotrichum candidum*, *Hansenula anomala*, *Pichia fermentans*
- candy: invertase, commercially produced by *Aspergillus niger*, various yeasts, enzyme splits disaccharide sucrose into glucose and fructose, used to make candy with soft centers
- glucoamylase: *Aspergillus niger*, used in baking to increase fermentable sugar, also a cause of “baker’s asthma”
- pectinases, proteases, glucanases for clarifying juices, beverages



# Fungi as food

Perigord truffle, *Tuber melanosporum*



Morels, *Morchella* spp.

*Agaricus bisporus*



*Lentinula edodes*



*Boletus edulis*



*Cantharellus formosus*



*Tricholoma magnivelare*



# Fungi as food

Corn smut, *Ustilago maydis*, cuitlacoche, huitlacoche



*Cyttaria darwinii*, pan de indio, llao llao, on *Nothofagus dombeyi*



# Fungi as pharmaceuticals

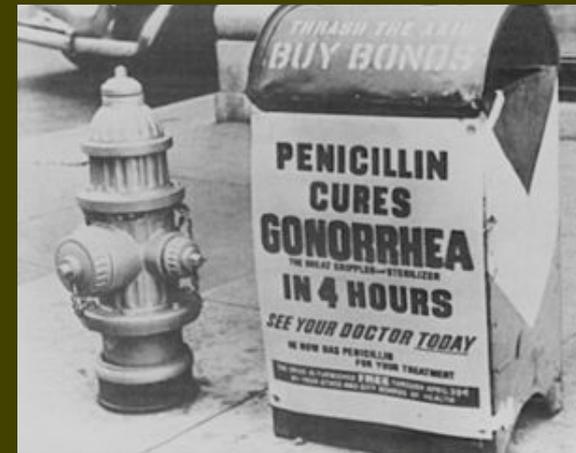
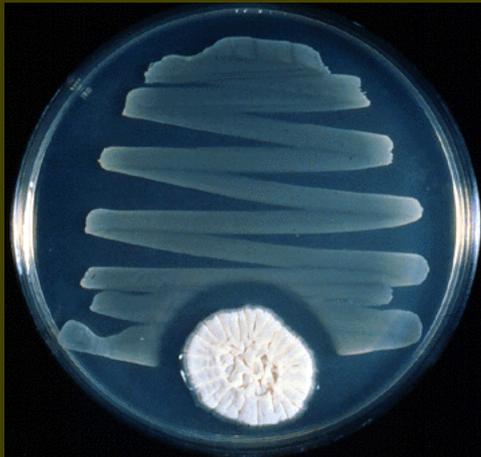
Penicillin, from *Penicillium chrysogenum* and other species

Discovered in 1928 by Alexander Fleming

Inhibits bacterial cell wall synthesis,  $\beta$ -lactam antibiotic

Most widely used antibiotic to treat bacterial infections

Methods developed for mass production of citric acid used



Another  $\beta$ -lactam antibiotic is cephalosporin, first isolated from *Cephalosporium acremonium*

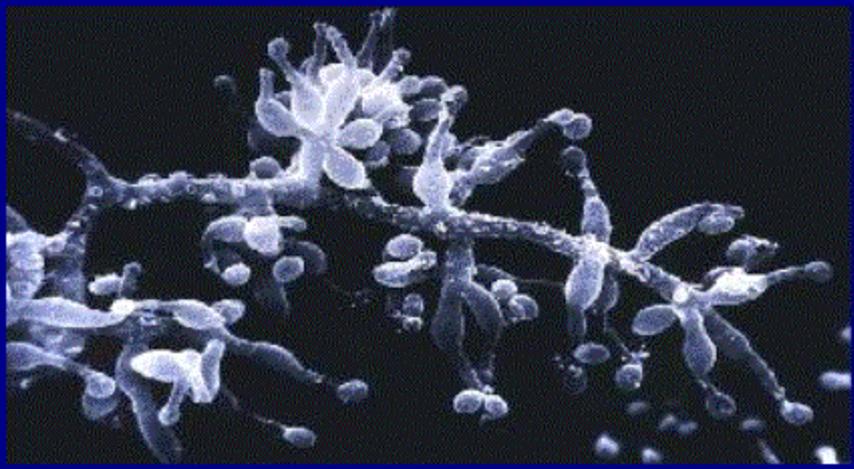
Various modifications of the cephalosporin molecule have resulted in a large number of cephalosporin antibiotics having different action spectra and properties

# Fungi as pharmaceuticals

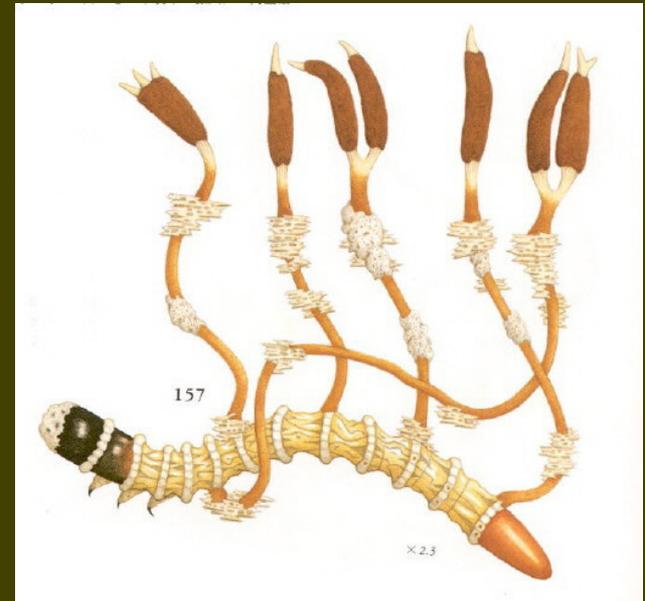
Cyclosporin, from *Tolypocladium inflatum*, asexual state (anamorph) of *Elaphocordyceps subsessilis*, an insect parasite

First investigated for its antifungal properties, it was found to have strong immunosuppressive activity. First non steroid immunosuppressant, now used in organ and bone marrow transplant therapies.

Selectively inhibits T-lymphocytes



*T. inflatum*



*E. subsessilis*

# Fungi as pharmaceuticals

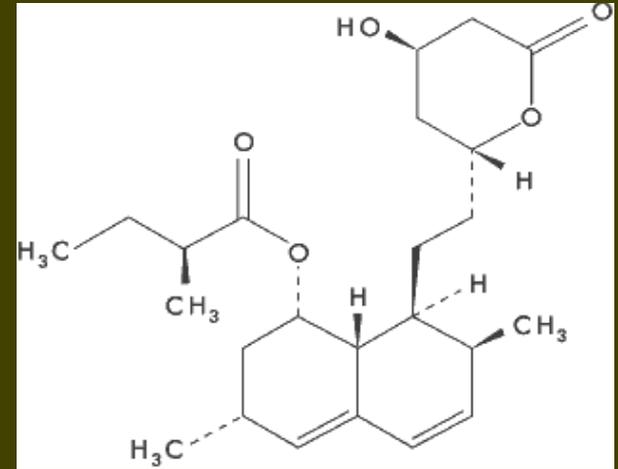
## Antifungal antibiotics

Griseofulvin, from *Penicillium griseofulvum*, used to treat cutaneous fungal infections in humans, pets and livestock. Inhibits fungal mitosis, not used much since development of triazole anti mycotics



# Fungi as pharmaceuticals

## Statins



# Fungi as pharmaceuticals

Beano,  $\beta$ -galactosidase, another useful metabolite from *Aspergillus terreus*



Enjoy the healthy foods you love with Beano.

The only product available that can help prevent gas

beano  
FOOD-BINDING LACTASE SUPPLEMENT  
helps stop gas before it starts!  
30 TABLETS

beano  
FOOD-BINDING LACTASE SUPPLEMENT  
TAKE RIGHT BEFORE YOUR FIRST BITE  
30 TABLETS



# Fungi as pharmaceuticals

## Ergotamine

Consumption of grain contaminated with the sclerotia of *Claviceps purpurea*, ergot, during the middle ages caused various human maladies. One physiological effect of the ergot alkaloids present in the sclerotia is vasoconstriction, and loss of blood circulation to the extremities could result in loss of limbs to gangrene, depicted in the painting of “the beggars” by Pieter Brueghel.



# Pharmaceutical uses of ergot alkaloids

Ergotamine, one of the ergot alkaloids, has been used since 1920 to treat migraine and cluster headache, interacts nonselectively with several neurotransmitter receptors. Ergot derivatives are also under investigation for treatment of Parkinson's disease.

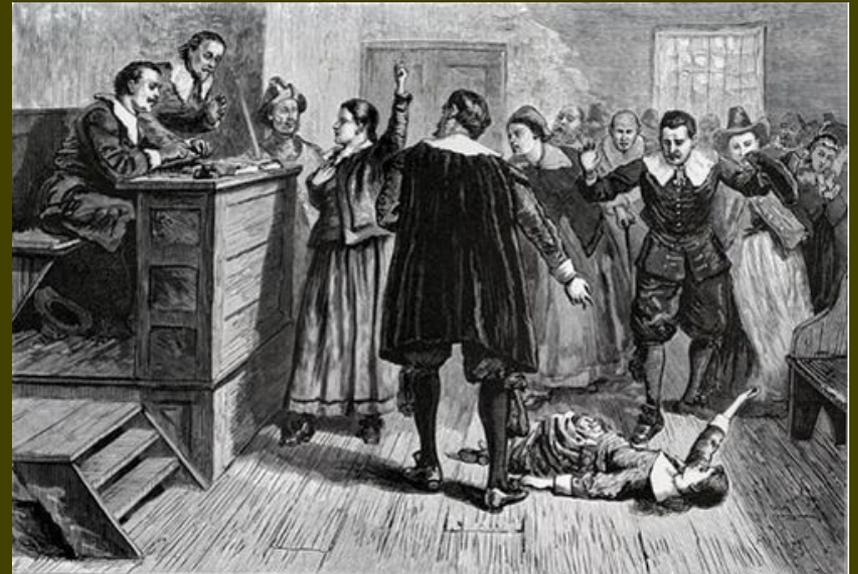
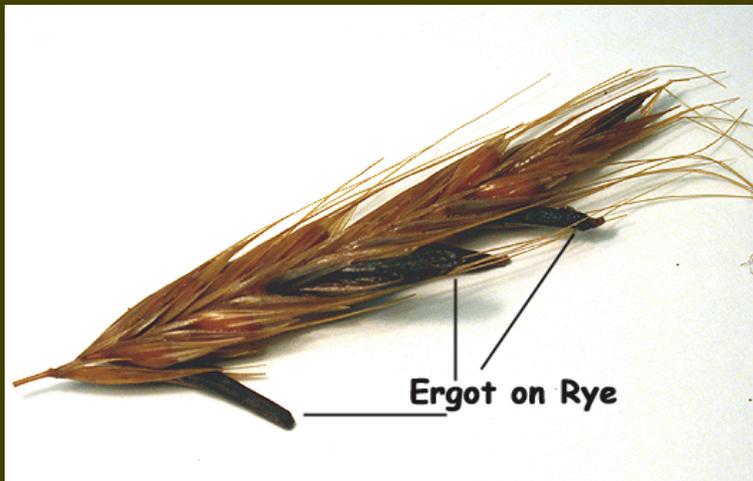


# *C. purpurea* alkaloids

Ergine, lysergic acid hydroxyethylamide (LSD)

Cause of “convulsive ergotism”: tremors, hallucination, sensation of ants crawling on skin (formication), seizures.

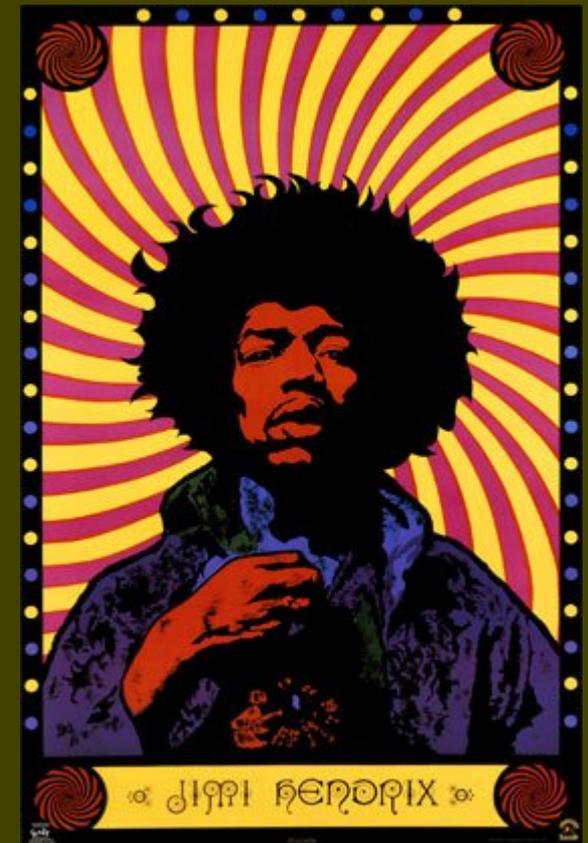
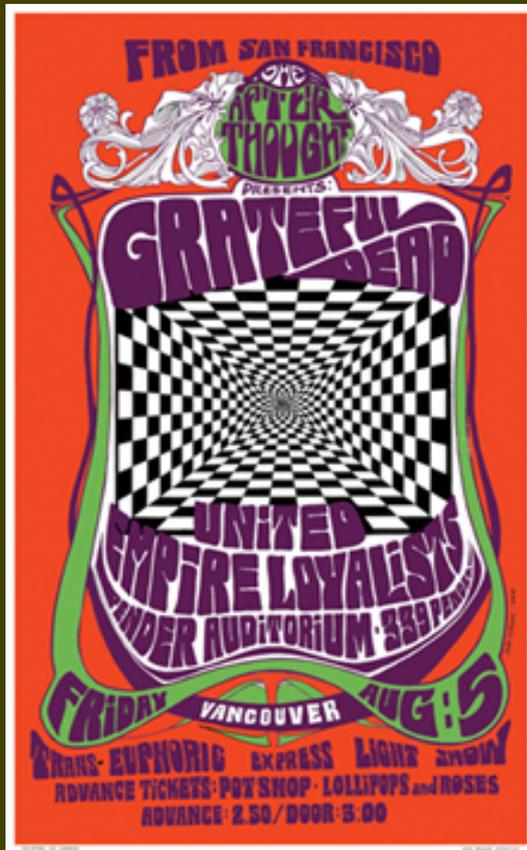
Witchcraft associated with people suffering from ergotism. Accused witches in the Salem trials of 1692 exhibited classic symptoms of convulsive ergotism. Also contemporaneous symptoms in livestock. Geographic distribution of witchcraft trials in Europe 1500 – 1700 occurred in places where rye was a major food source and where conditions were favorable for *C. purpurea*.



# Pharmaceutical uses of ergot alkaloids

LSD psychoactive drug discovered in 1933 by A. Hoffmann, amide derivative of ergot alkaloid lysergic acid Investigated for potential therapeutic potential Also for potential “mind control agent” by CIA and chemical warfare agent

The rest is history!



*Epichloe typhina* (“endophyte”) is a related fungus that causes “choke disease” of grasses. Infected grass plants contain various alkaloids that are suppressive to insect herbivores, also to mammalian herbivores.



## symptoms of endophyte toxicosis



“sleepy grass” (sw USA) and “dunken horse grass” (China) named for their narcotic effects on grazing animals, caused by fungal endophytes

# Fungi in human and animal health

Fungal pathogens, mycotic infections

Cutaneous mycoses, dermatophytes: *Malassezia fufur*, cause of dandruff, tinea, ringworm caused by various keratinophilic fungi



Candidiasis: *Candida albicans*

Systemic mycoses, can be lethal

Histoplasmosis: *Histoplasma capsulatum*

Coccidiomycosis: *Coccidiodes immitis*, *Paracoccidioides brasiliensis*

Cryptococcosis: *Cryptococcus neoformans*, *C. gattii*

Aspergillosis: *Aspergillus fumigatus* and other species

Penicillosis: *Penicillium marneffe*



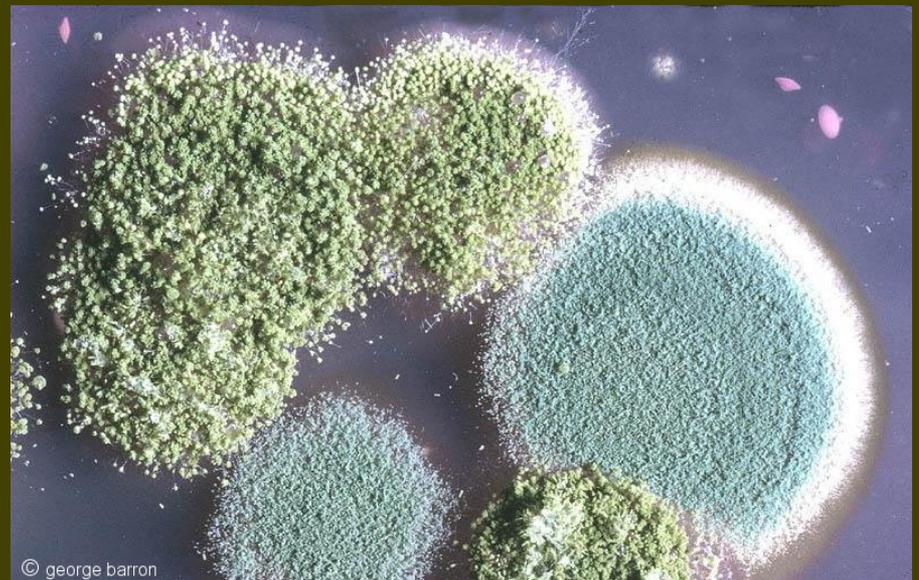
Pneumocystis pneumonia: *Pneumocystis jirovecii*, a major cause of AIDS related mortality



# Fungi in human and animal health

## Mycotoxins in food

- aflatoxin: cause of turkey x disease, liver cancer, hepatitis, Reyes syndrome, *Aspergillus flavus*
- ochratoxin: kidney disease, *Aspergillus ochraceous*, *Penicillium verrucosum*
- fumonisins: cause of esophageal cancer, equine leucoencephalomalacia, *Fusarium verticilloides*
- zearalenones: swine estrogenic syndrome, *Fusarium zeae*
- trichothecenes: alimentary toxic aleukia, various fungus species
- patulin: carcinogen, *Penicillium*, *Aspergillus*, *Byssochlamys* species,
- ergot alkaloids: cause of “St. Anthony’s fire”, gangrenous ergotism



# Once-Abundant Sierra Nevada Frogs May Be Deemed Endangered

Mountain yellow-legged frogs brave icy winters, but they're no match for trout and a virulent fungus disease

by [John Upton](#) — January 23, 2012, 6:57 p.m.  1

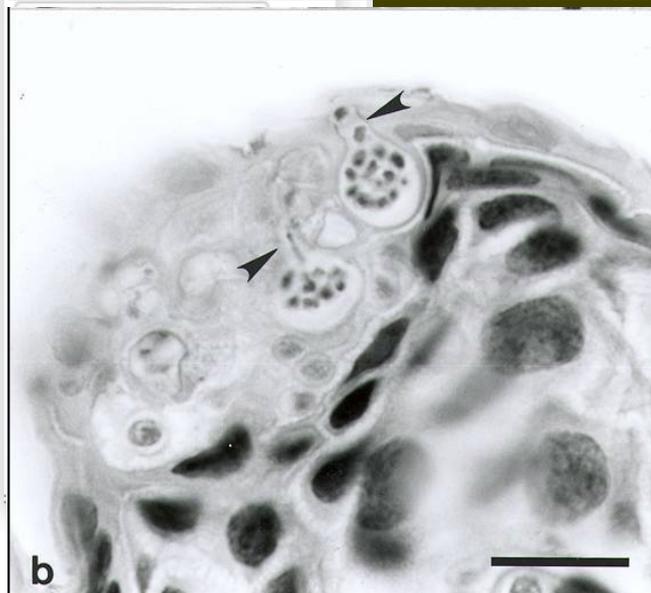
They used to be the most abundant amphibians in the Sierra Nevada, so common that hikers had to take care to avoid squashing them in creek and lake shorelines in warmer months. But now, hibernating deep beneath ice and snow, mountain yellow-legged frogs are spiraling toward extinction, scientists say.

The population of the small, garlic-scented frogs has collapsed so severely — probably by more than 90 percent, according to biologists — that the California Fish and Game Commission will [meet next week](#) to consider listing the species as threatened or endangered. Environmentalists hope the vote will help prompt the federal government to protect the frogs as well.

"This species clearly qualifies on all counts," said Jeff Miller, a conservation advocate at the nonprofit Center for Biological Diversity, [which has been fighting](#) in the courts since 2000 to force the federal and state governments to better protect the frogs. "The evidence is overwhelming."

The three-inch frogs are masterfully evolved to survive the harsh mountain winters and fleeting summers, spending as much as nine months beneath ice. But they have few defenses against a hypervirulent fungus disease that is wiping out amphibian populations around the world, or against nonnative trout that were introduced to their creeks and lakes.

Pollution from the Central Valley, habitat loss, cattle grazing and wildfires are also believed to be taking a toll on the species, which is found only in the Sierra Nevada.



# Amphibian decline

Several causes, but a major one is an invasive fungal pathogen  
*Batrachochytrium dendrobatidis*



Estimated that 32% of world amphibian populations are globally threatened. More than 100 amphibian species have gone extinct since 1980 and nearly 500 are currently considered critically endangered.

# Bat white nose syndrome

## Smokies closes hiking area to protect dying bats

Karen Chávez 11:22 a.m. EDT September 27, 2014



(Photo: Special to the Citizen-Times )

f 48 CONNECT    t 21 TWEET    in LINKEDIN    1 COMMENT    EMAIL    MORE

GREAT SMOKY MOUNTAINS NATIONAL PARK – A devastating decline in the Smokies bat population is forcing the closure of a popular hiking area to help protect bats and humans, park managers say.

The 80 percent drop in the Indiana bat population in the park is most likely because of the deadly, rapidly spreading white-nose syndrome. Infected bats are marked by a white fungal growth on their noses, wings and tail membranes.

The White Oak Sink area, around caves where bats hibernate, will be closed through March 31. Park biologists say closing the area around caves will limit human disturbance to bats and help hikers avoid interactions with bats. It has been identified as one of only 13 sites across the country as critical habitat for the federally endangered Indiana bat.

All 16 caves and two mines in the park, which straddles the mountainous North Carolina-Tennessee border, were closed in 2009, said park wildlife biologist Bill Stiver. The first confirmed presence of white-nose syndrome in the park was in 2010, he said.

"Based on estimates from a hasty survey last winter, we've lost about 80 percent of Indiana bats. This disease is pretty devastating," Stiver said. "We are doing everything we can to both slow the spread of the disease and protect the remaining animals by closing caves and areas near caves to the public."

The area now closed is a popular hiking area of about 450 acres near Cades Cove on the Tennessee side, said Molly Schroer, park spokeswoman. It does not contain any park-maintained hiking trails, and no trails will be closed, she said.



# Fungi in human and animal health

## Mushroom poisoning



*Chlorophyllum molybdites* may be mistaken for edible *Chlorophyllum rhacodes* or *Agaricus* spp.



*Amanita phalloides* is responsible for several deaths every year, often in immigrants from south Asia who mistake this species for an edible Asian *Volvariella* spp.

# Fungi in human and animal health

## Mushroom poisoning



*Inocybe geophyllum*



*Amanita pantherina*



*Amanita muscaria*

Instances of dogs or young children experimentally ingesting poisonous mushrooms are pretty common. Usually the results are not fatal if treated quickly. The mushroom species involved can be varied, but the most common and attractive poisonous species are *Amanita pantherina* and *A. muscaria*. These species are commonly implicated in mushroom poisoning.





# Fungi in industrial processes

“Stone washed denim” actually treated with cellulase from *Trichoderma reesei* to give the appearance of wear



Laundry detergents contain fungal enzymes, proteases and lipases, to remove stains



Xylanase, phytase,  $\beta$ -glucanase added to animal feeds to improve nutritional quality



pullulan: exocellular glucan from *Aureobasidium pullulans*



an edible film used as a base for breath fresheners

also used as a drug delivery agent

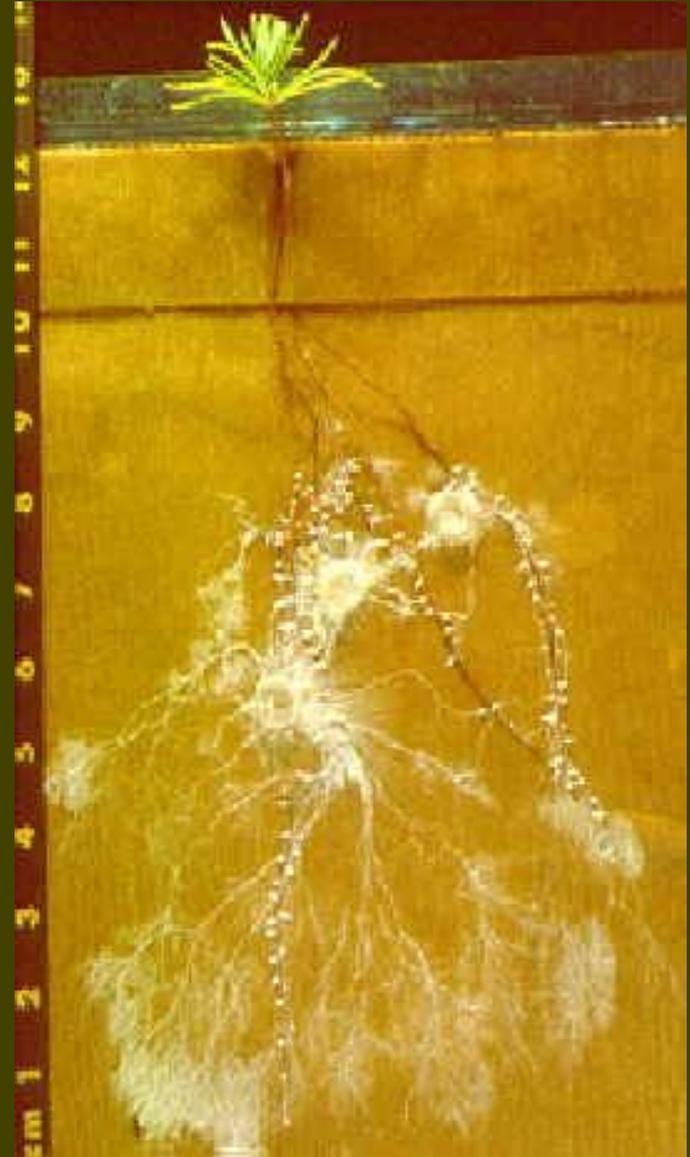


# Fungi in agriculture and forestry

Mycorrhizal fungi are symbiotic with most plants, aid nutrient uptake



Arbuscular mycorrhiza



Ectomycorrhiza

# Fungi in agriculture and forestry

Many important edible mushrooms and truffles are ectomycorrhizal symbionts of forest trees



C. Lefevre



# Fungi in agriculture and forestry

Stem decays provide wildlife habitat



Evelyn Bull - USFS



Evelyn Bull - USFS