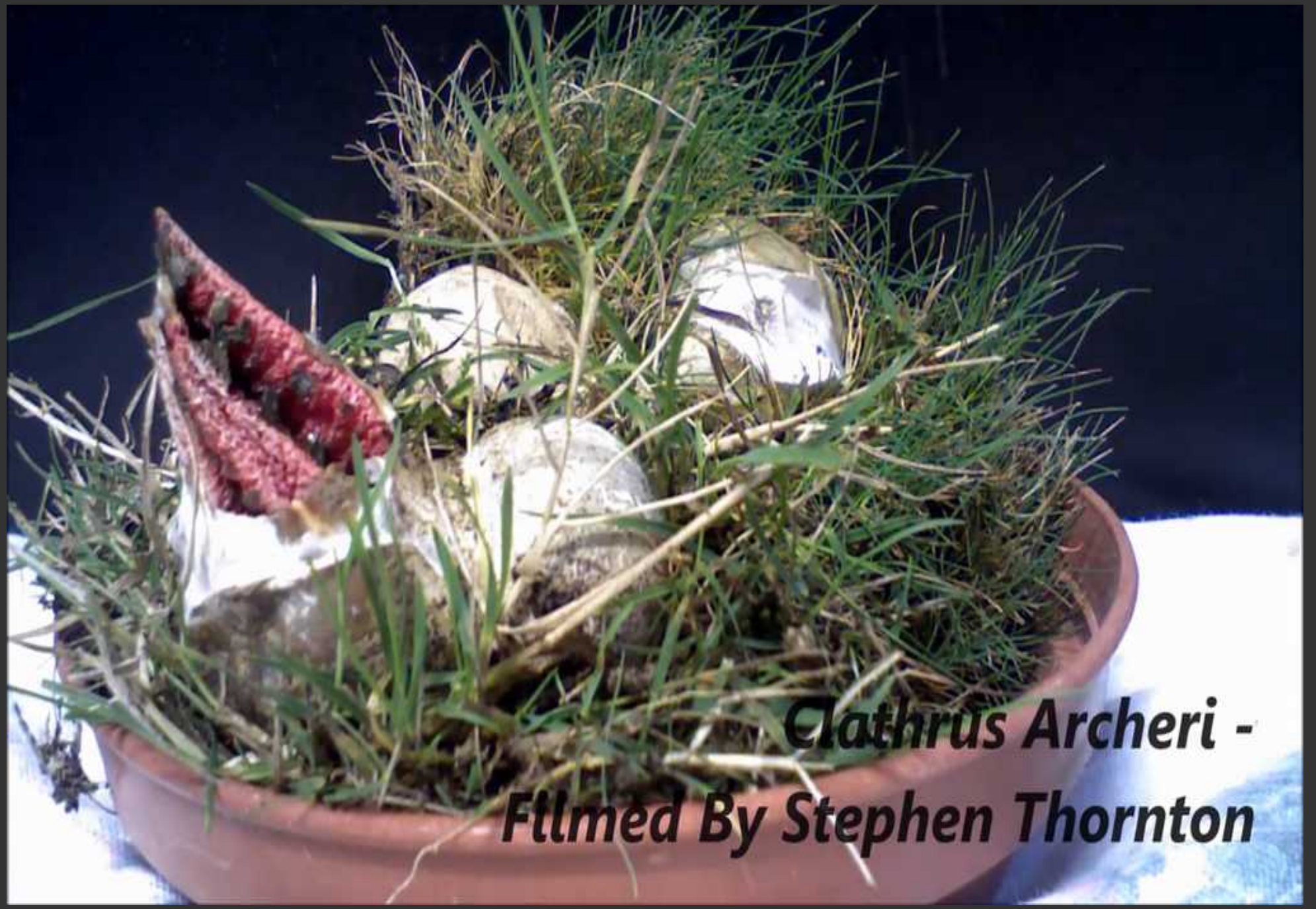
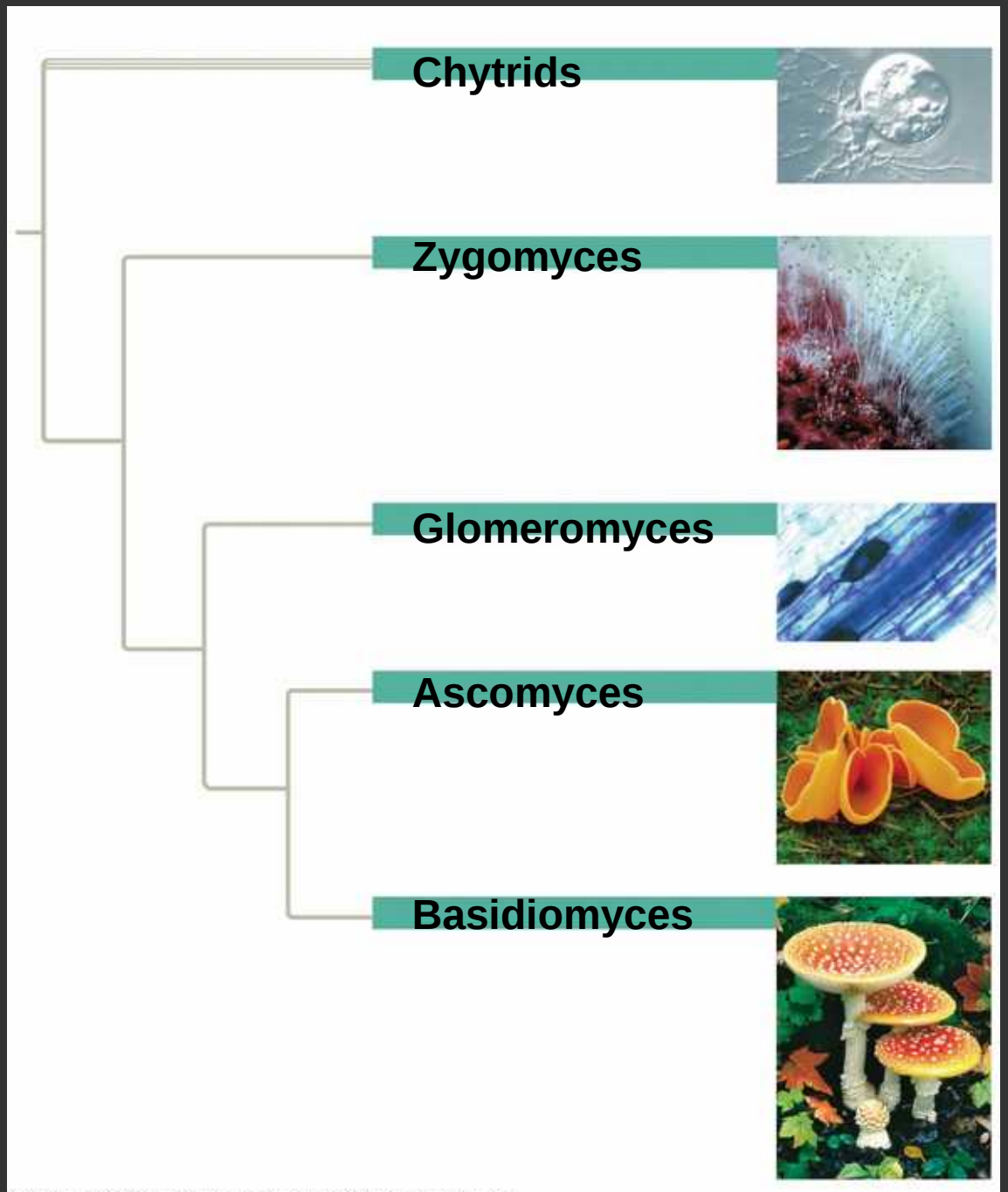
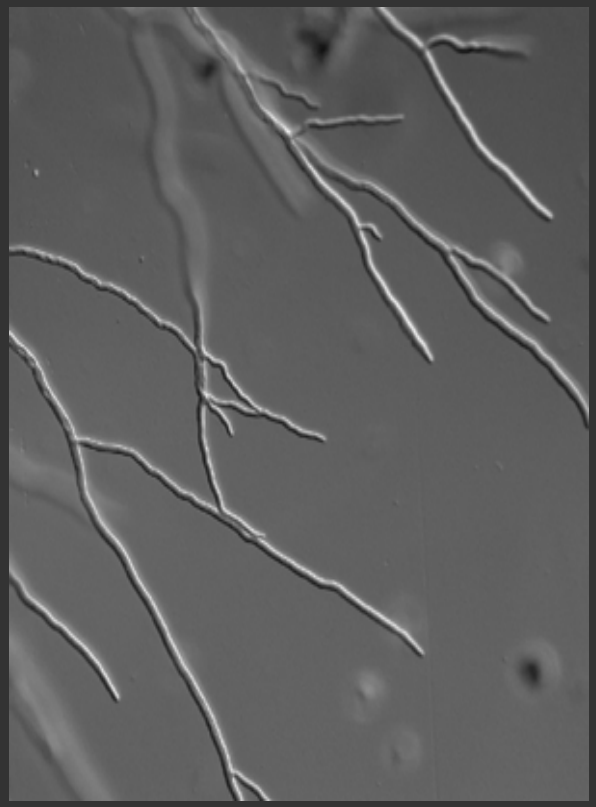

Clathrus Archeri -
Fllmed By Stephen Thornton

Major fungal groups

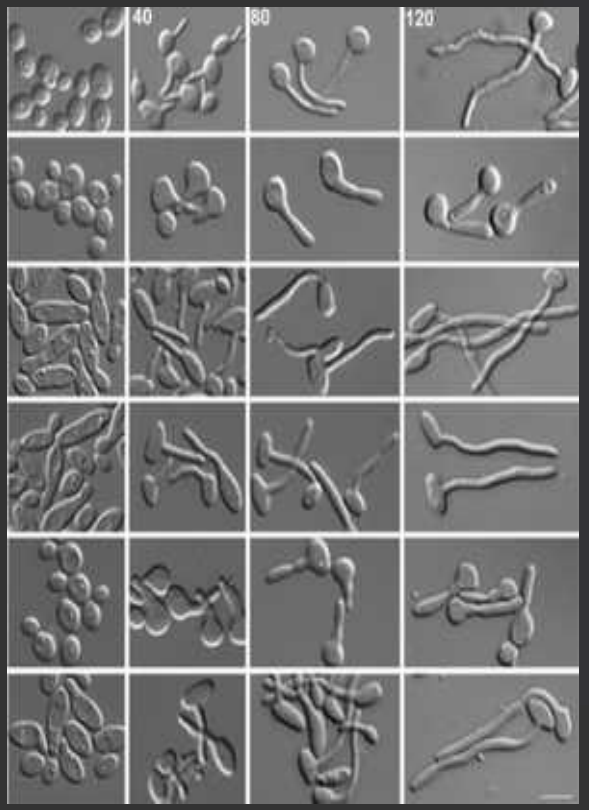


Fungal growth habits

Yeast



Filamentous



Dimorphic

Fungal growth habits

Yeast

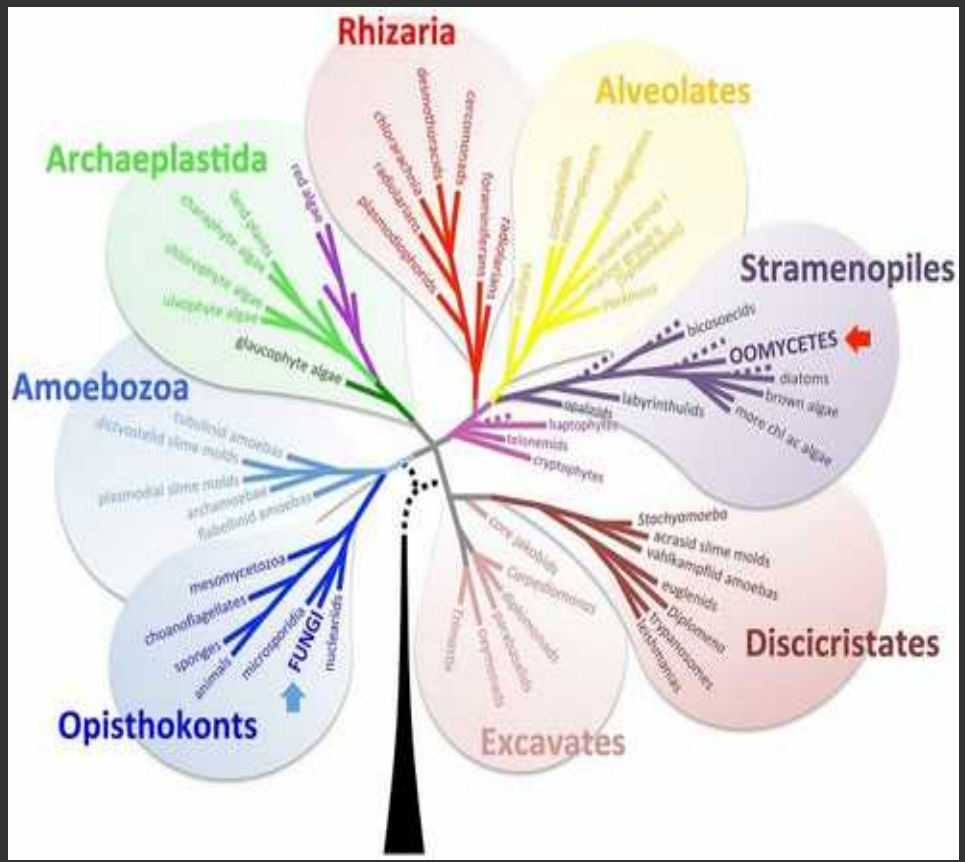
Filamentous

Dimorphic

Fungi are heterotrophs

...where does the carbon come from?

Autotroph



Heterotrophs

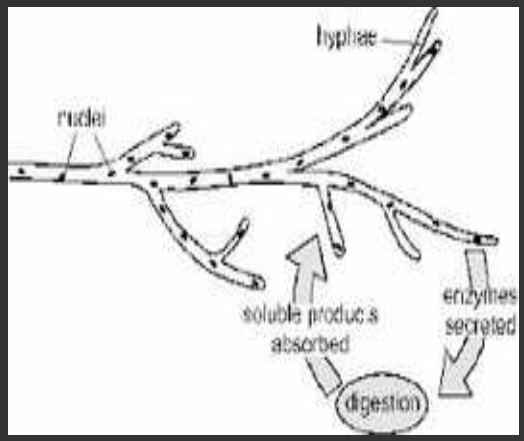
Fungi are lysotrophic heterotrophs

...where do they break down C sources?

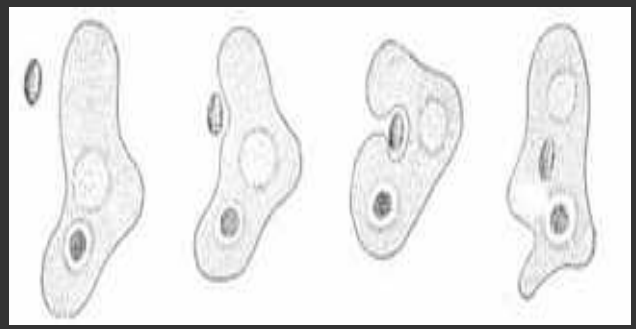
Autotroph

Heterotroph

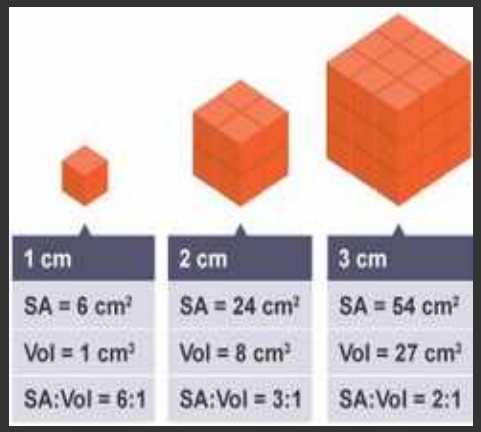
Lysotrophy



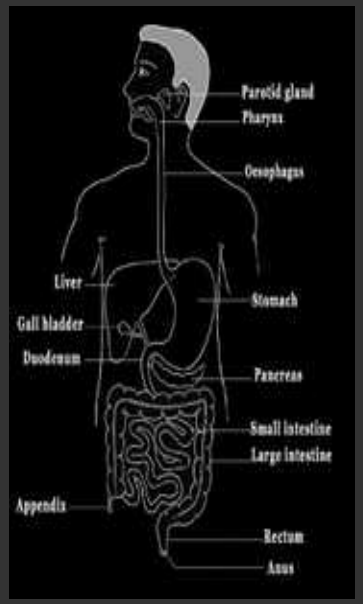
Phagotrophy



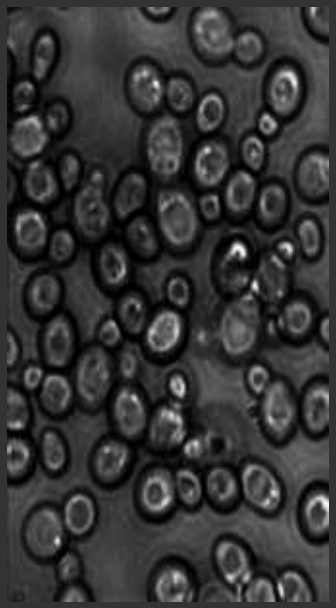
Lysotrophs have constrained "body types"



Surface-to-Volume ratio is important



Tube

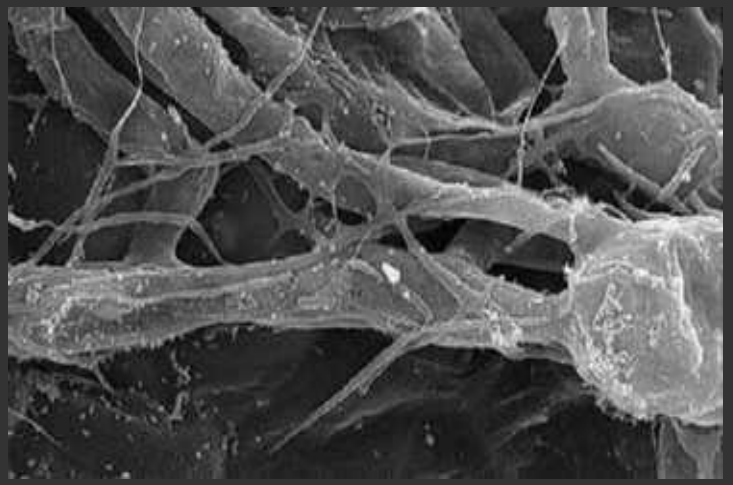


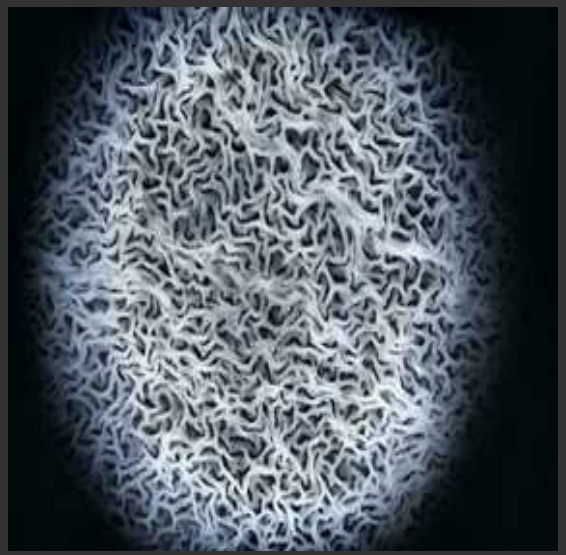
Tiny blob

Filamentous

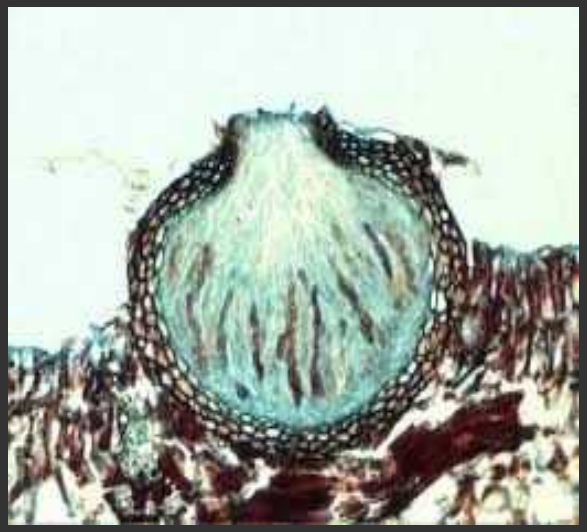
Filamentous growth in fungi arose at least three independent times

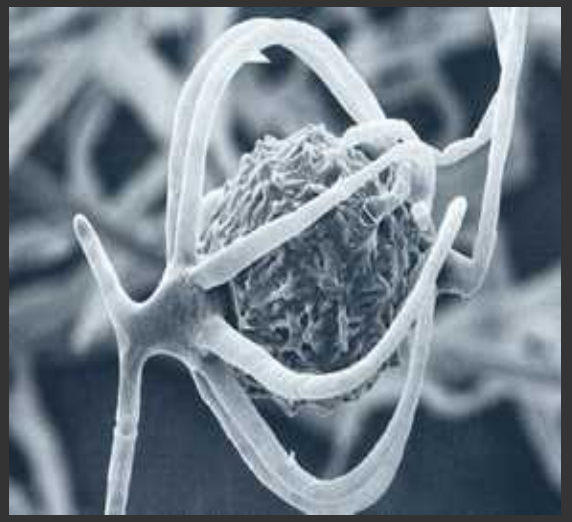
Fungal filaments penetrate and surround their food sources (hyphae)





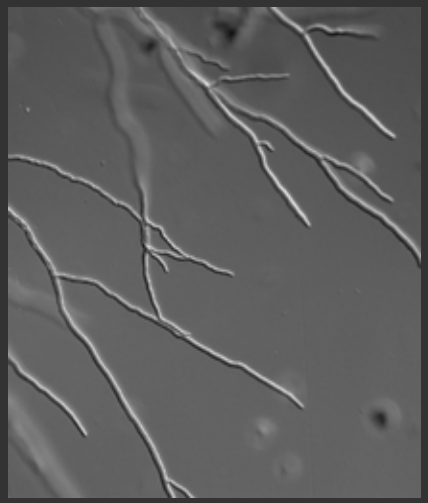
Hyphae give rise to a stunning variety of macrostructures



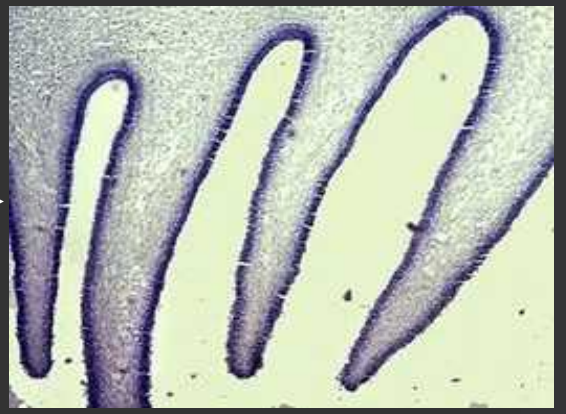


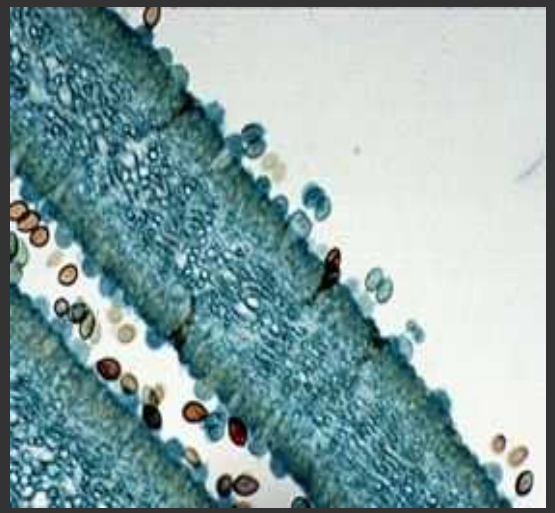
With enough hyphae, anything is possible

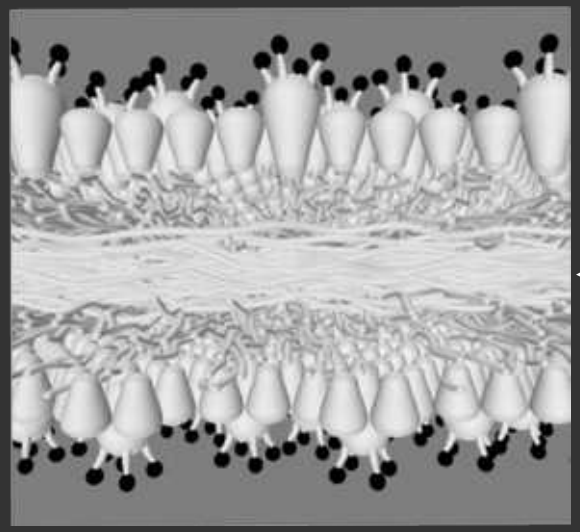
With enough hyphae, anything is possible



With enough hyphae, anything is possible







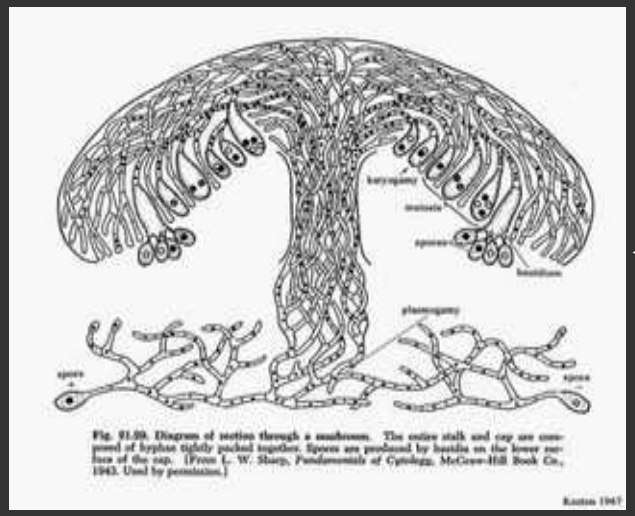


Fig. 81.09. Diagram of section through a mushroom. The entire stalk and cap are composed of hyphae tightly packed together. Spores are produced by basidia on the lower surface of the cap. (From L. W. Sharp, *Fundamentals of Cytology*, McGraw-Hill Book Co., 1943. Used by permission.)

Kaston 1947

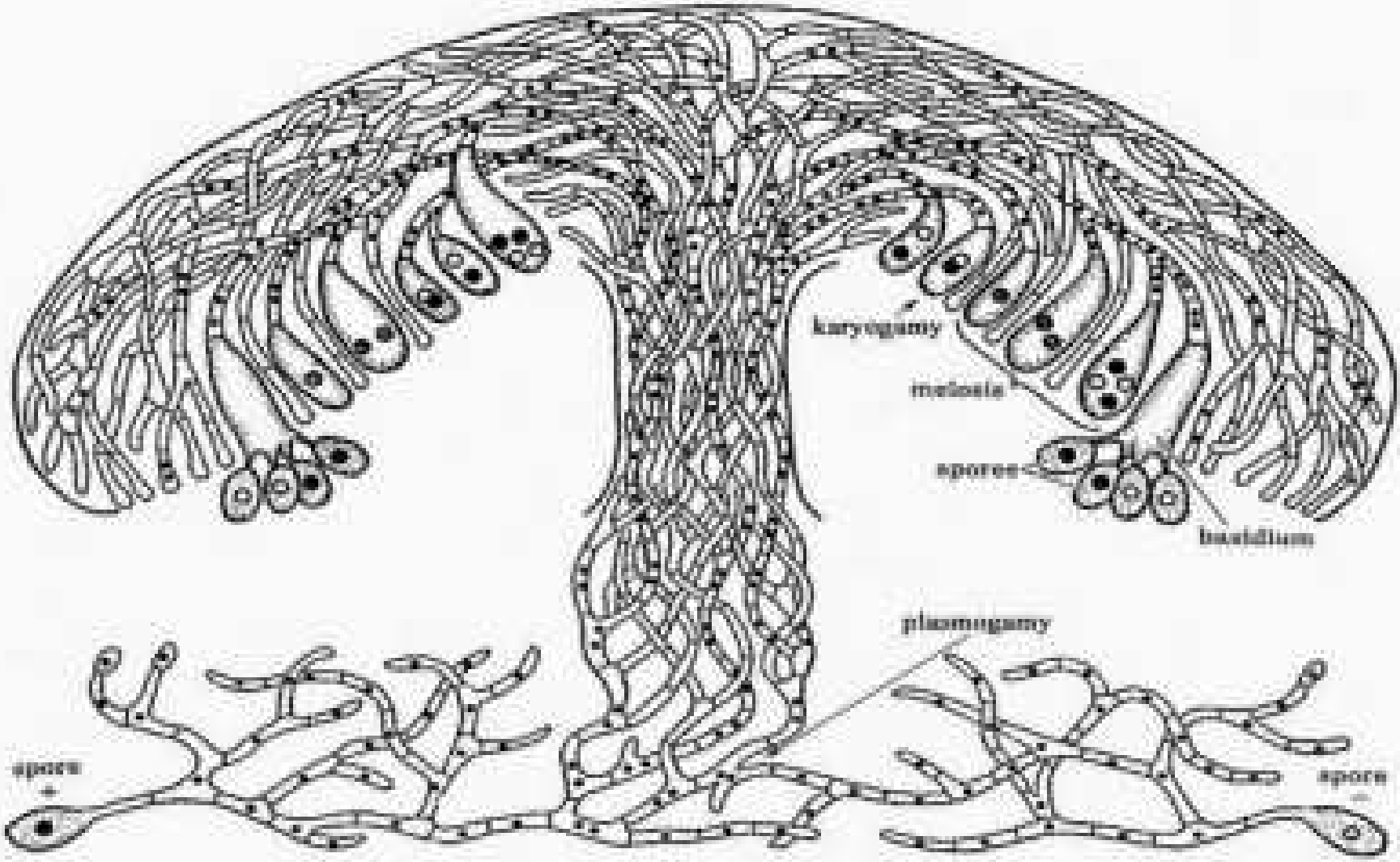
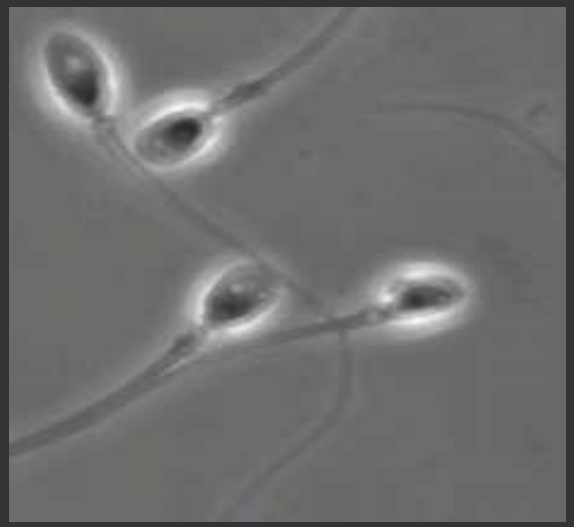


Fig. 21.29. Diagram of section through a mushroom. The entire stalk and cap are composed of hyphae tightly packed together. Spores are produced by basidia on the lower surface of the cap. [From L. W. Sharp, *Fundamentals of Cytology*, McGraw-Hill Book Co., 1943. Used by permission.]

Mushrooms are made of vegetative hyphae

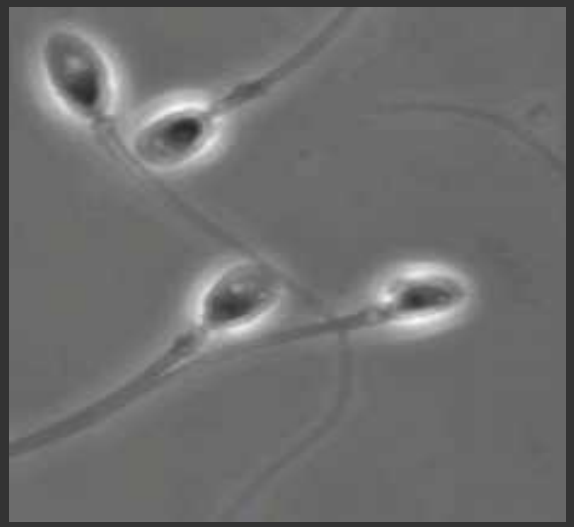
Morphological identification requires looking at the right life cycle stages



Which of these is a human?
Which of these is a dog?

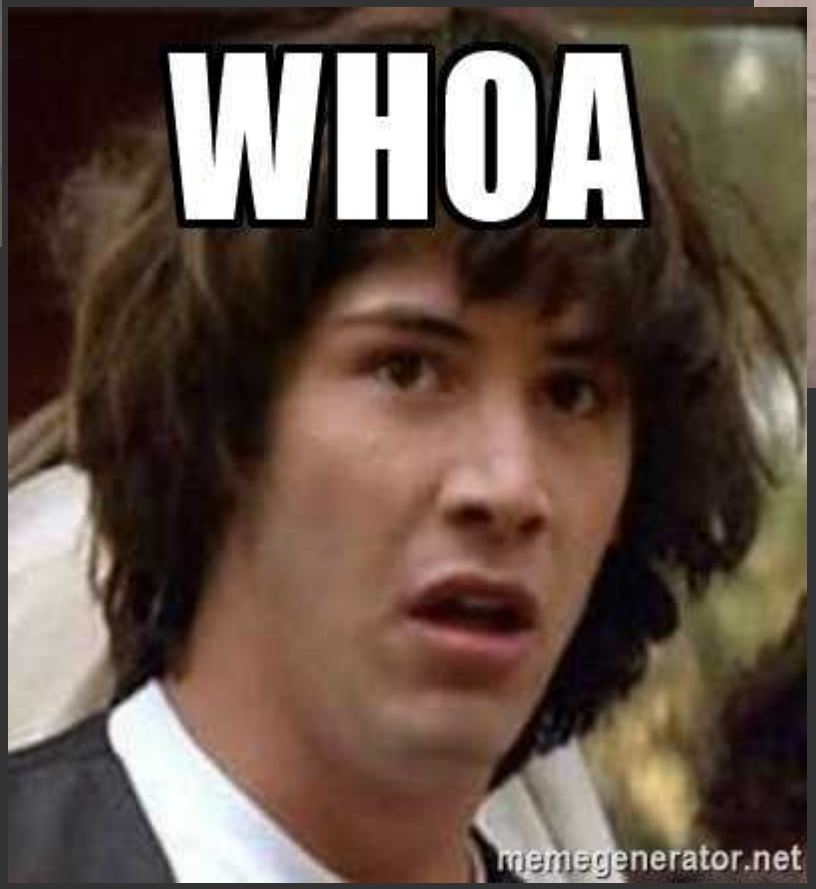
Morphological identification requires looking at the right life cycle stages

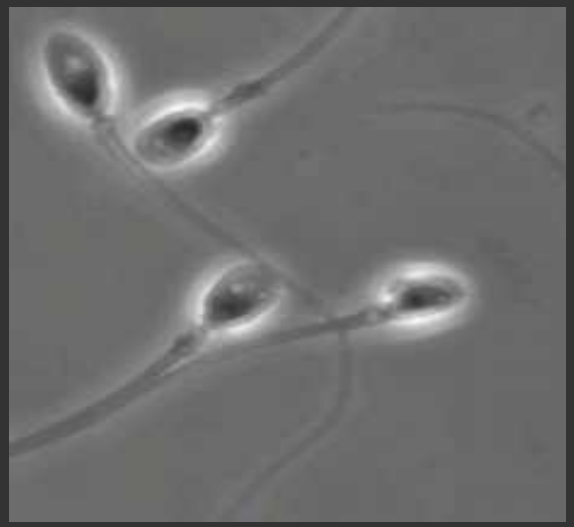
Fungus



Dog

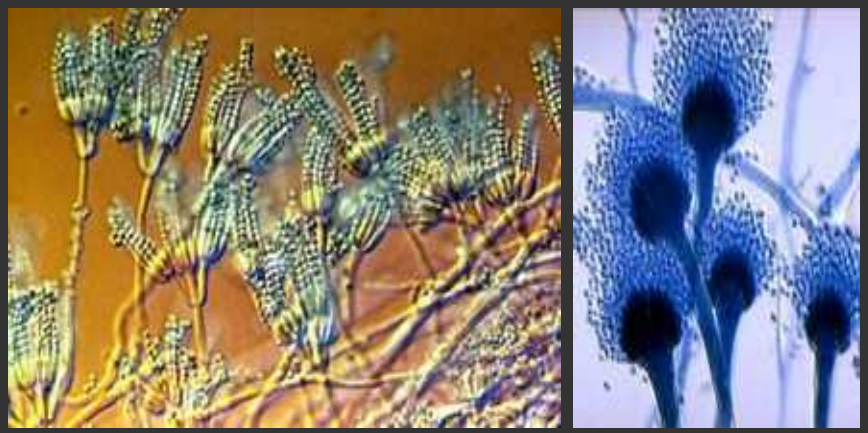
Morphological identification requires looking at the right life cycle stages



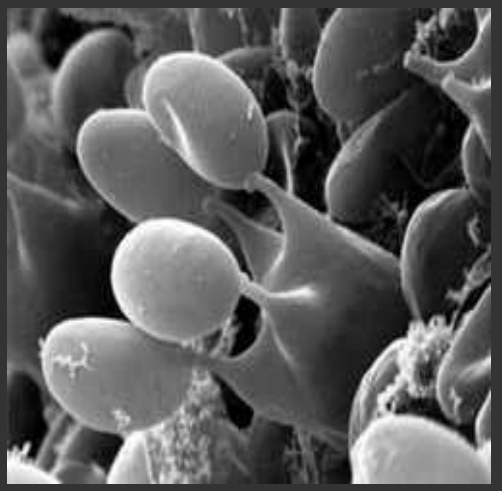


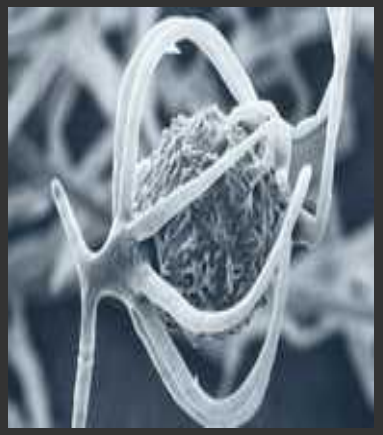
Reproductive structures

Asexual structures



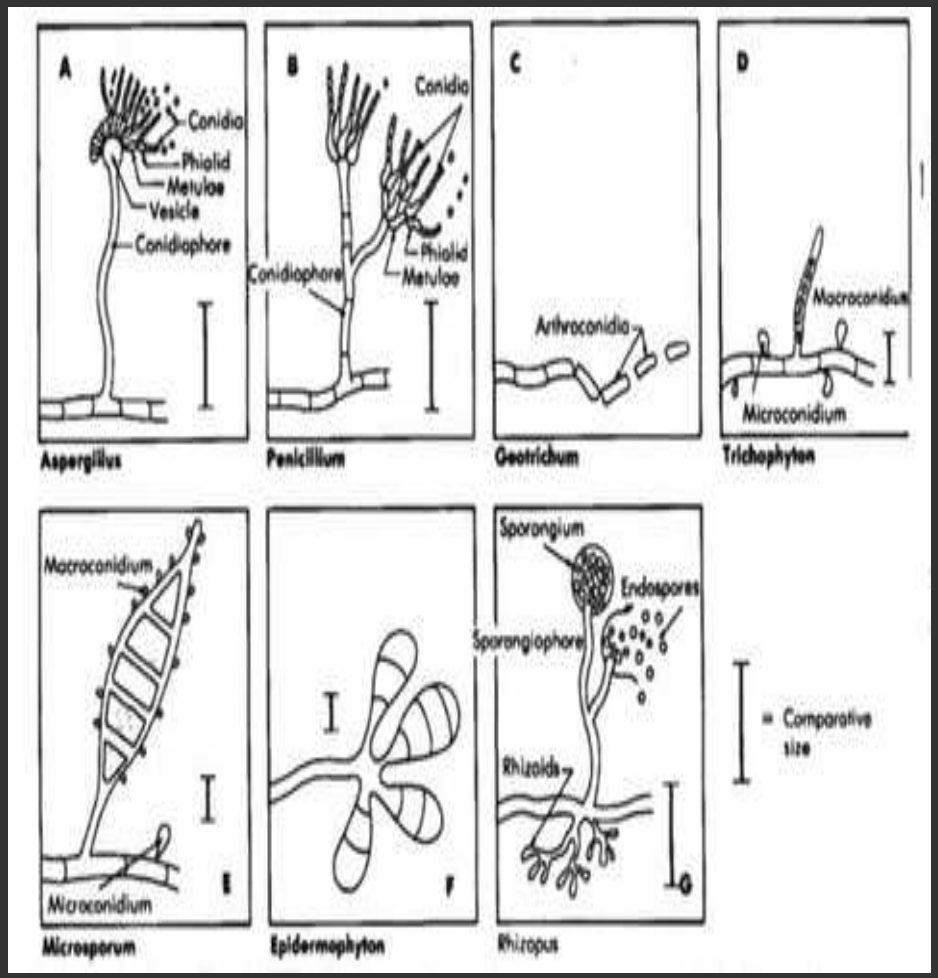
Sexual structures

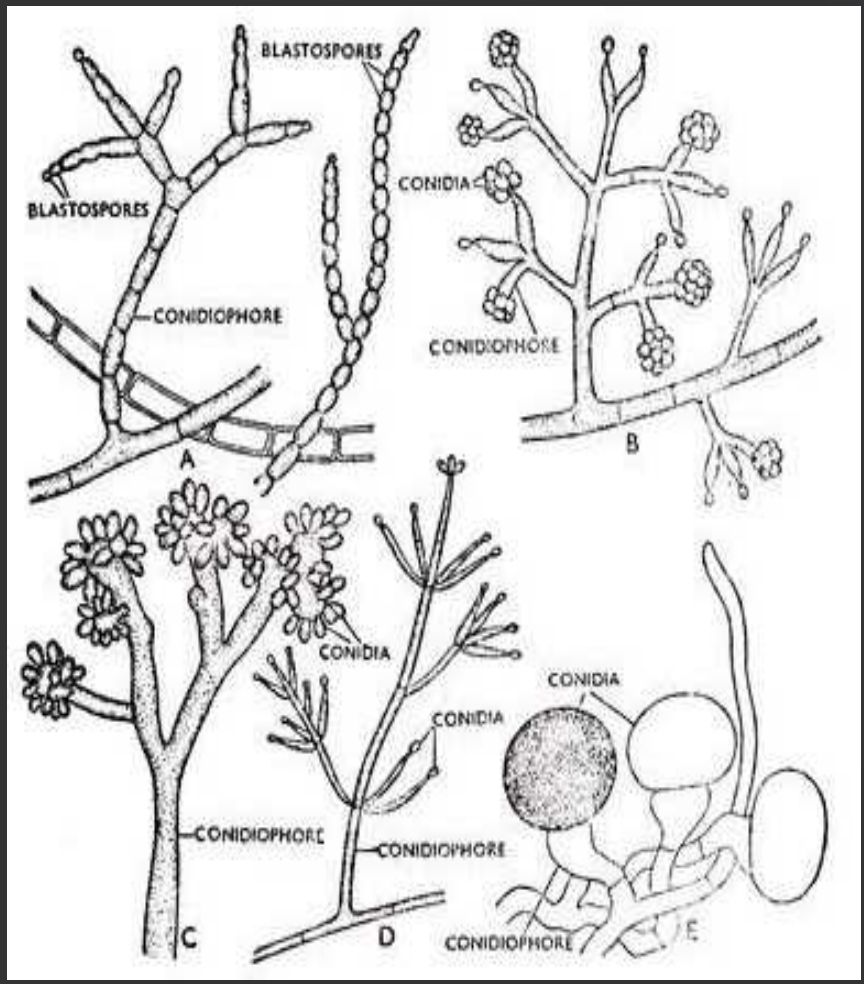




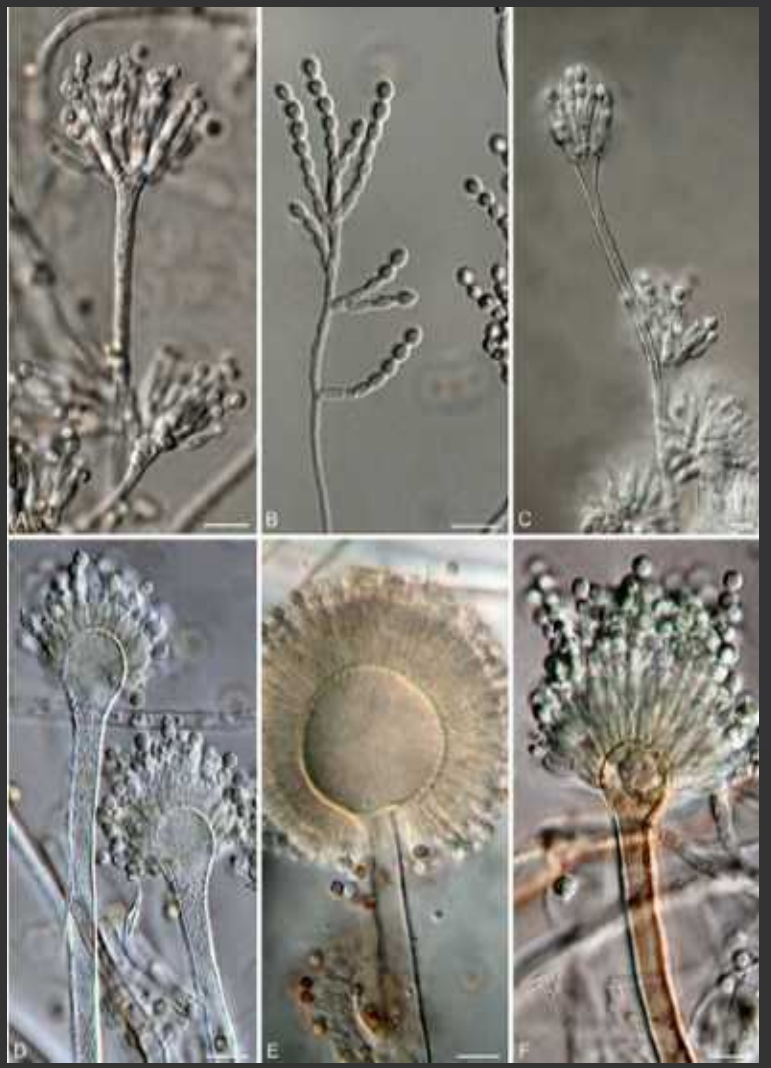
Sexual macro-structures

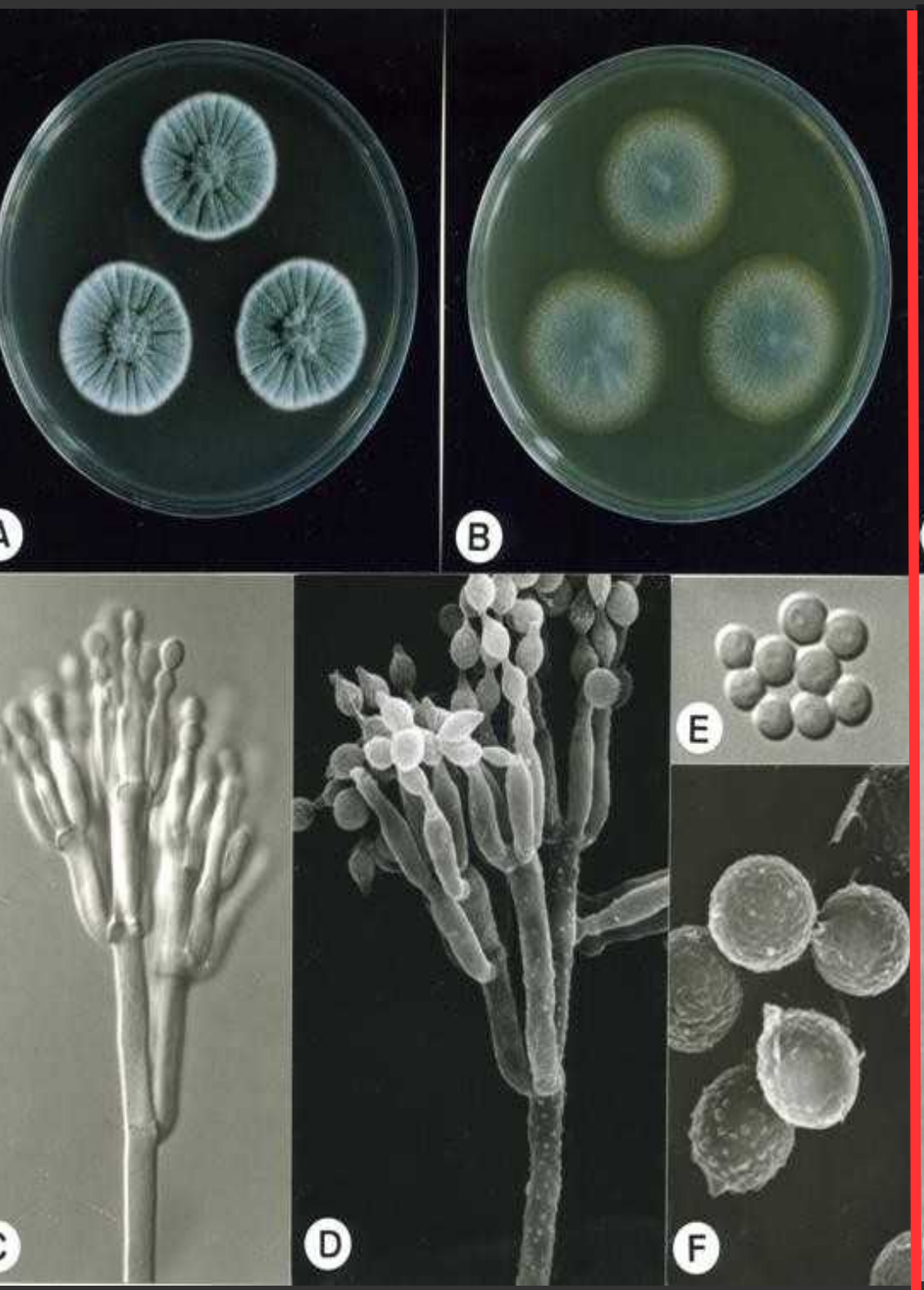
Asexual macro-structures

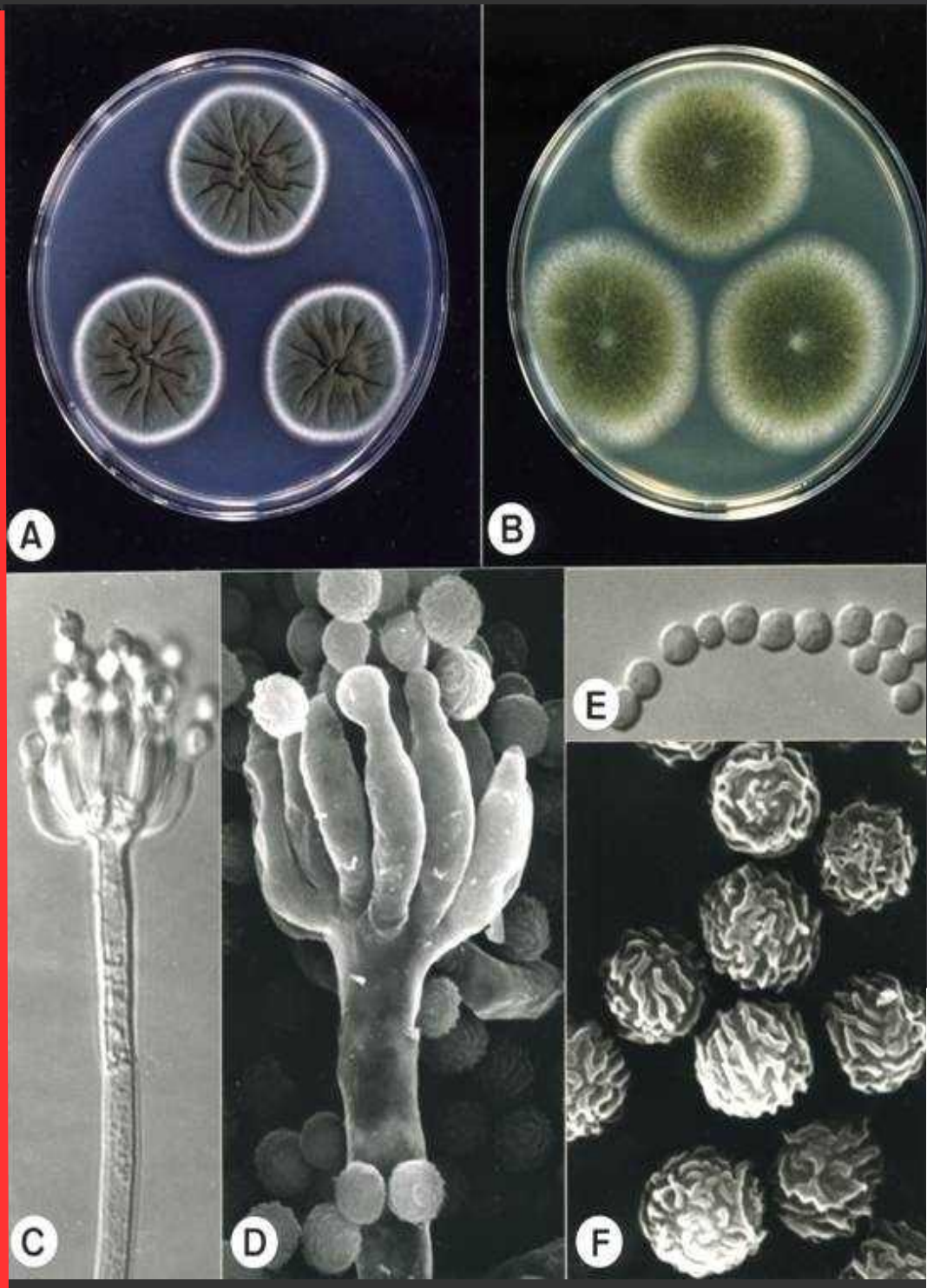




Asexual macro-structures

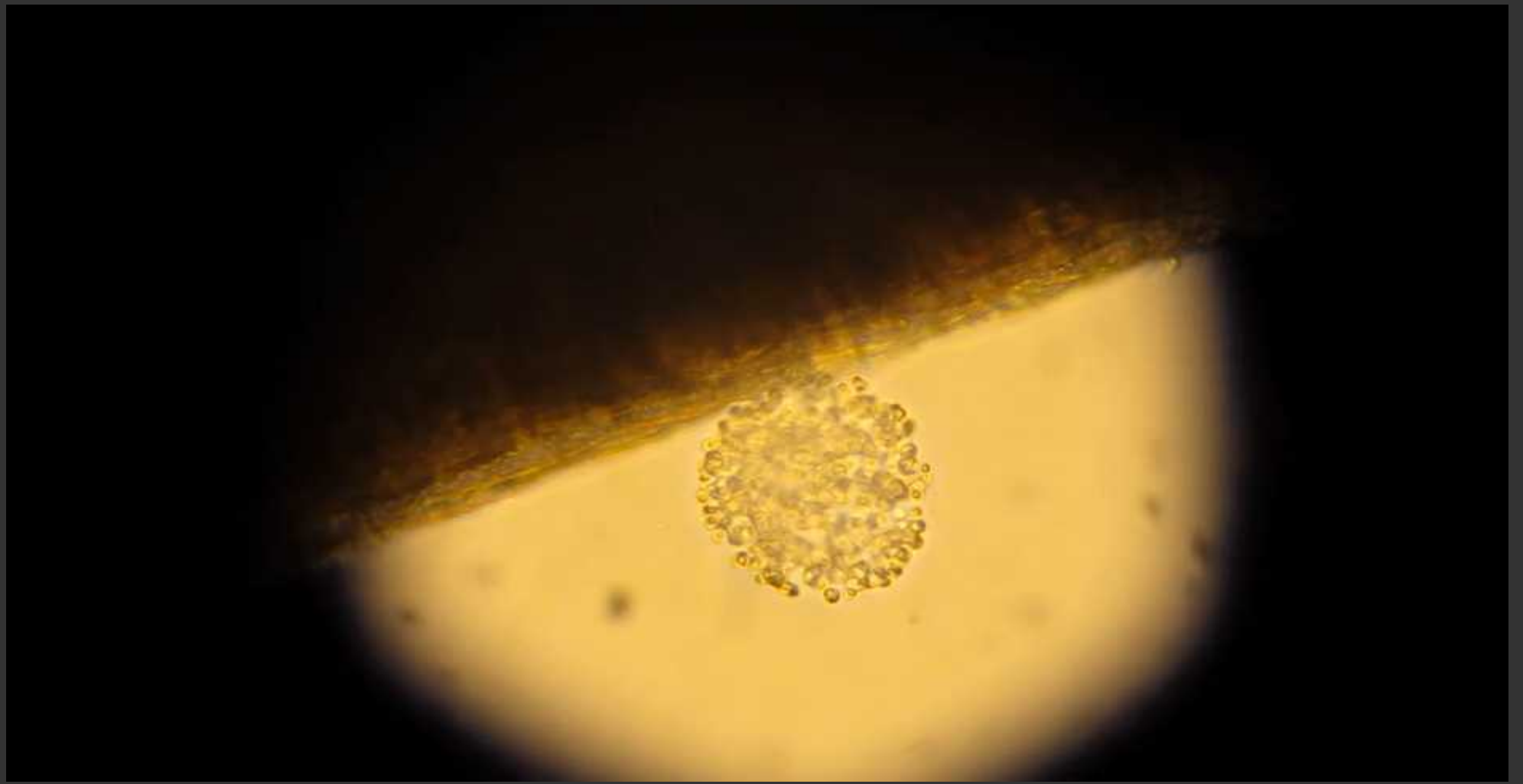



A
B
C
D
E
F

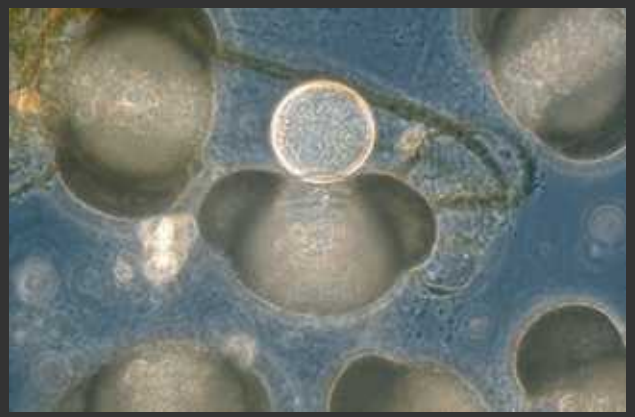

A
B
C
D
E
F

Fungal Phylum	Distinguishing Features of Morphology and Life Cycles	
Chytridiomycota (chytrids)	Flagellated spores	
Zygomycota (zygote fungi)	Resistant zygosporangium as sexual stage	
Glomeromycota (arbuscular mycorrhizal fungi)	Form arbuscular mycorrhizae with plants	
Ascomycota (sac fungi)	Sexual spores (ascospores) borne internally in sacs called asci; ascomycetes also produce vast numbers of asexual spores (conidia)	
Basidiomycota (club fungi)	Elaborate fruiting body (basidiocarp) containing many basidia that produce sexual spores (basidiospores)	

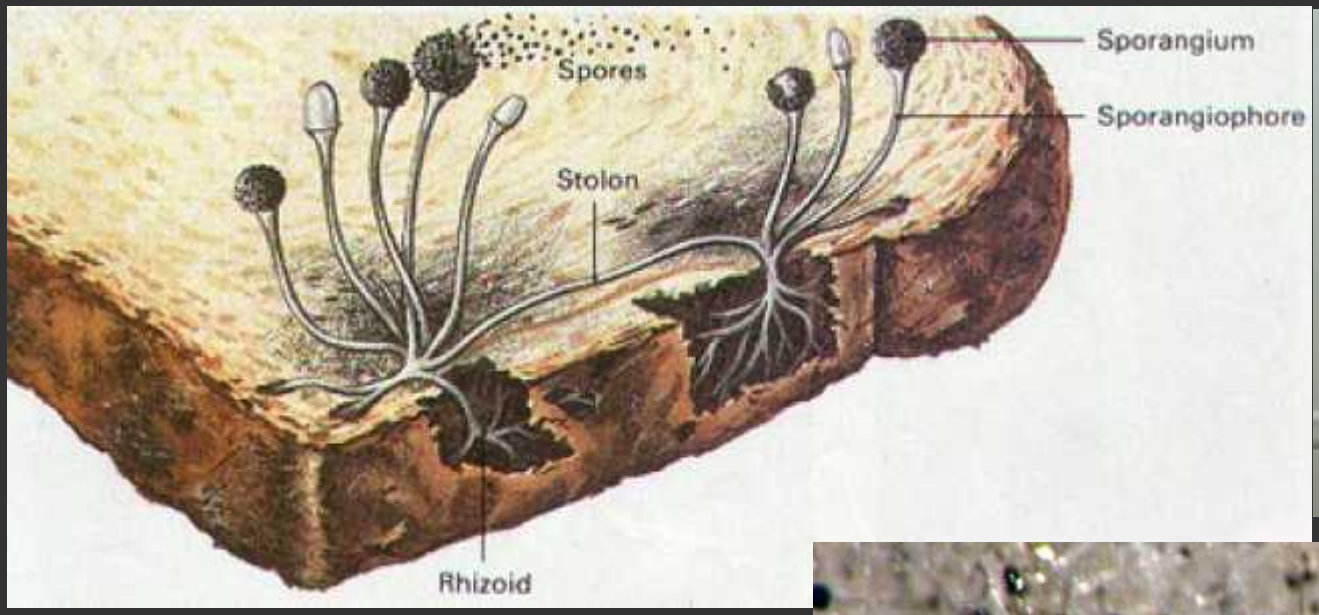
Chytrids

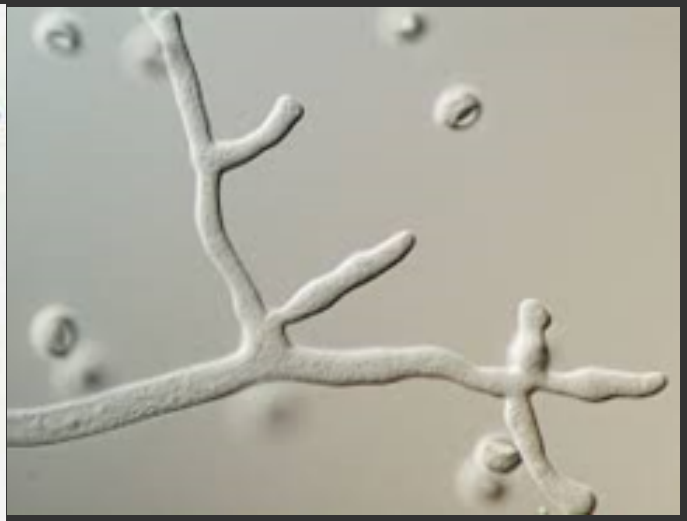


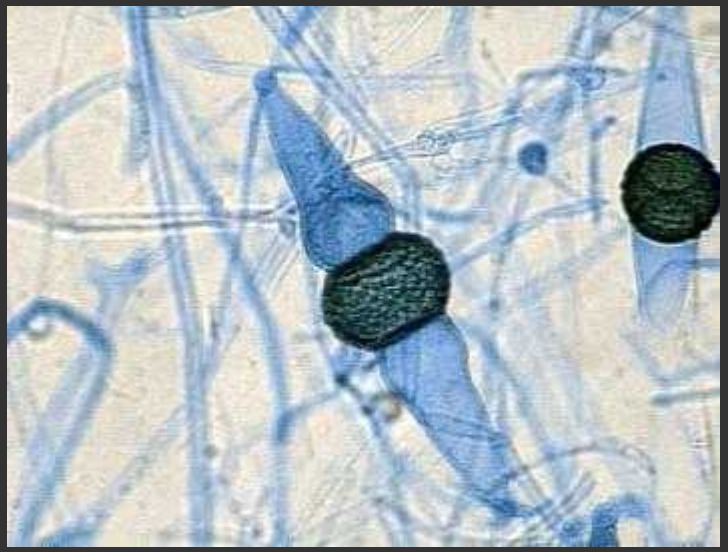
Chytrids vs Amphibians



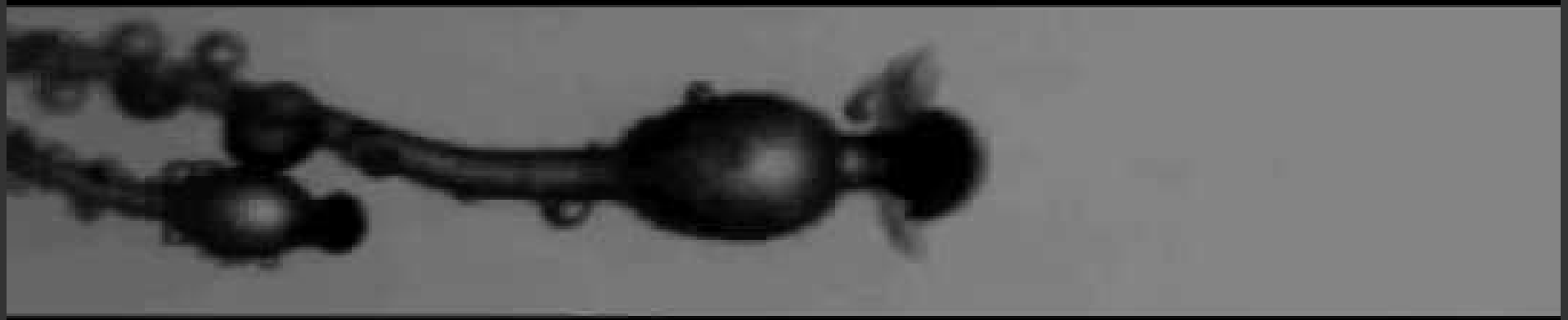
Zygomycetes



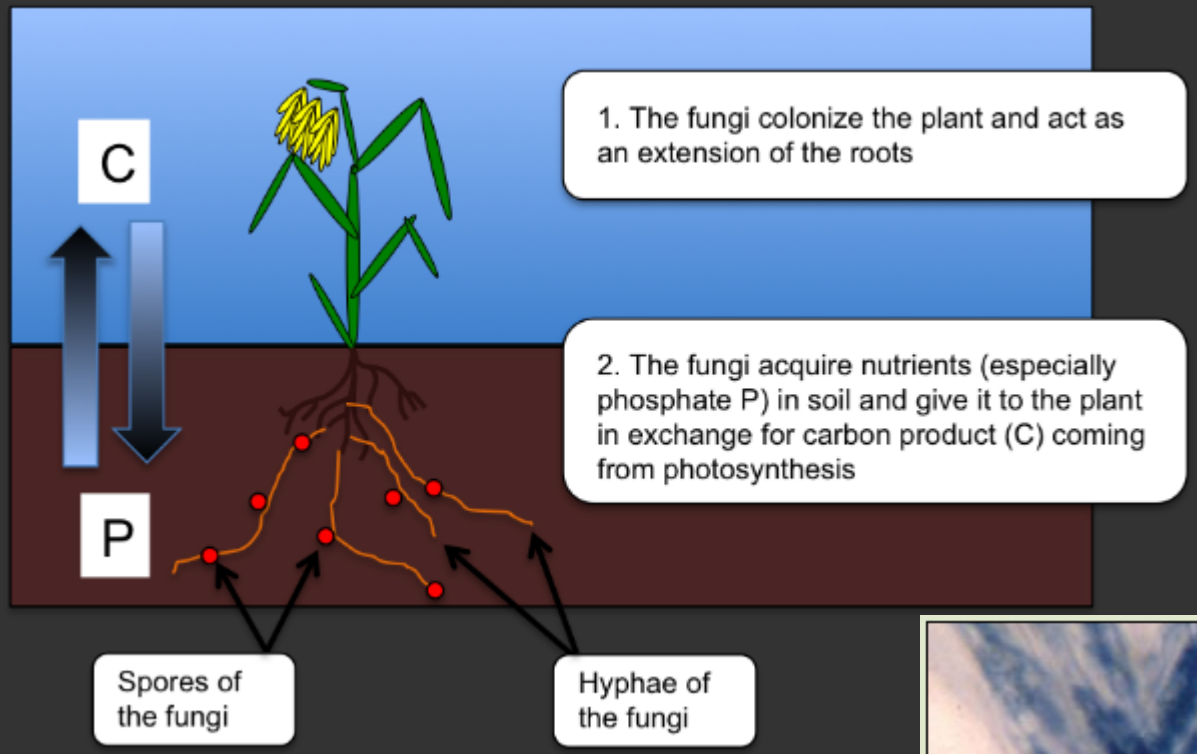


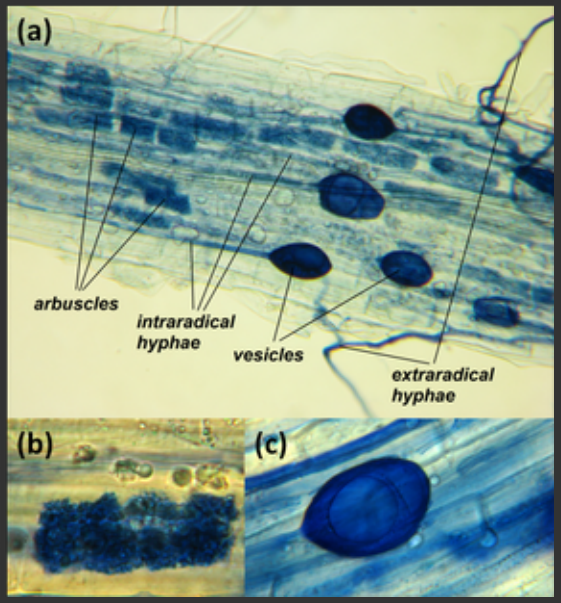


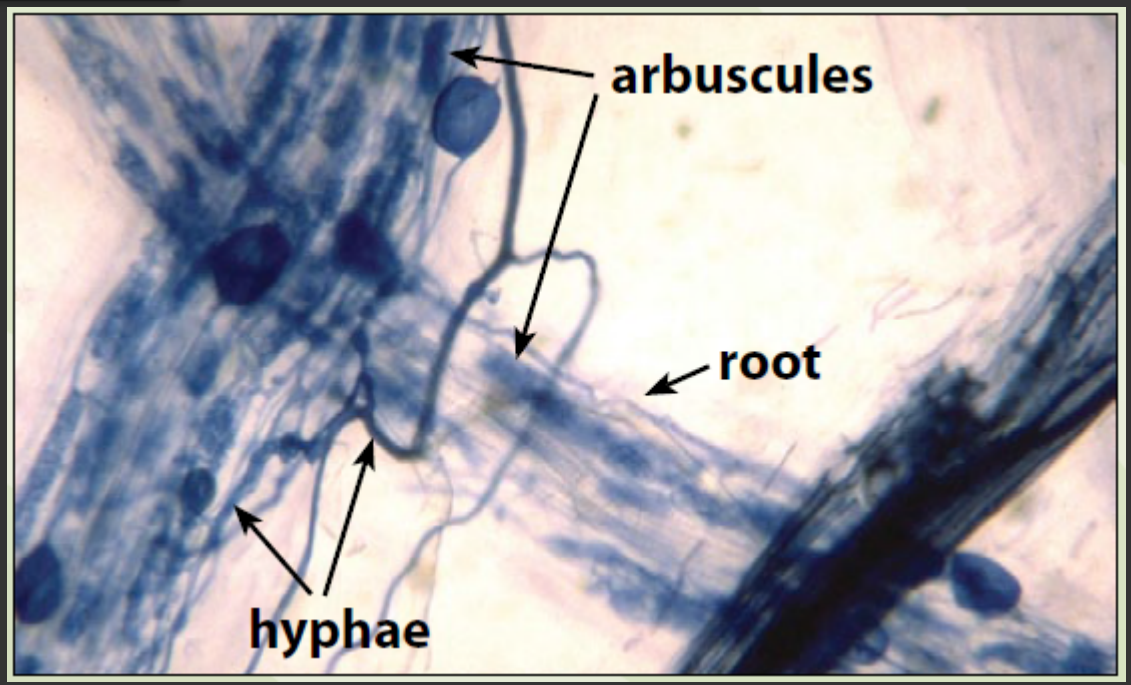
Zygomycetes



Glomeromycetes



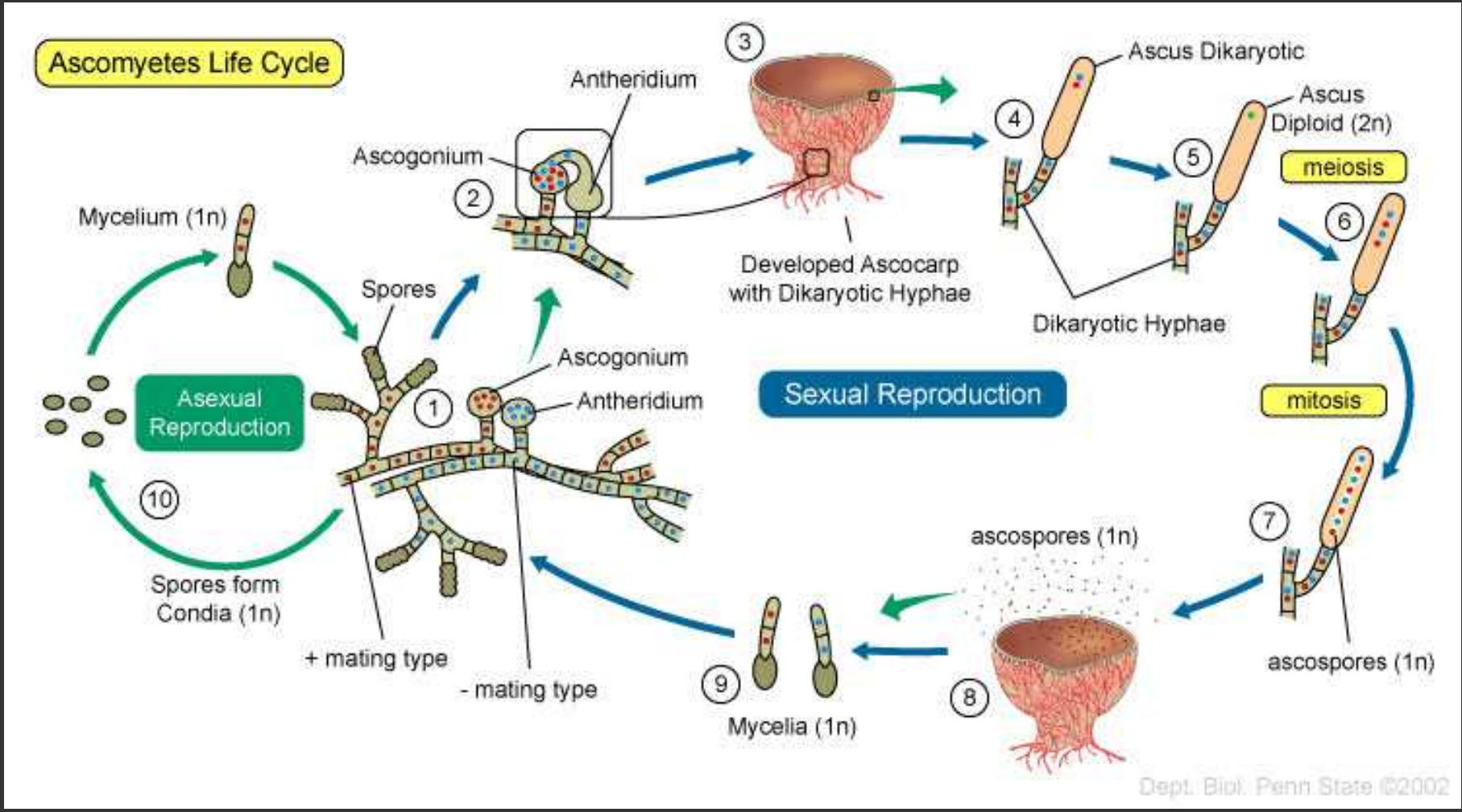




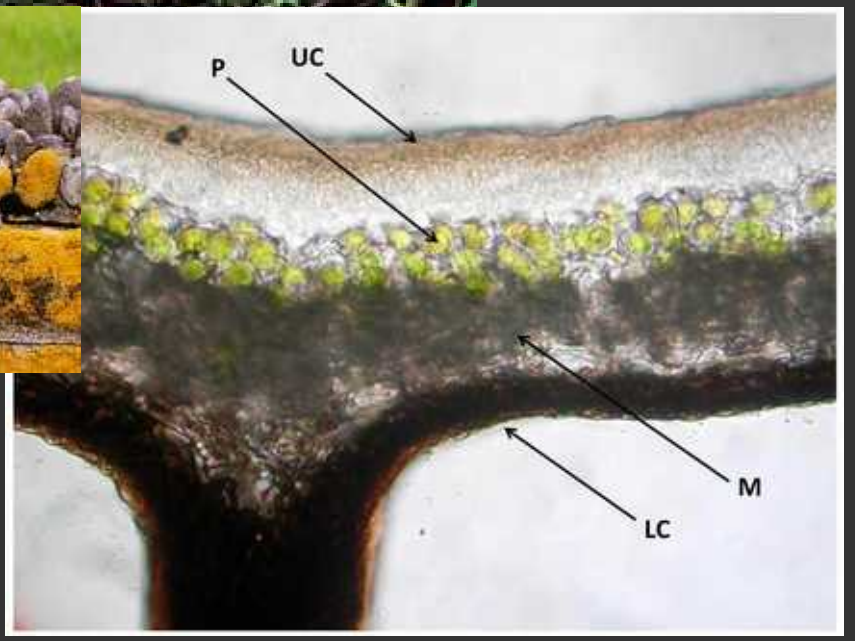
Arbuscular mycorrhizal fungi (AMF)

80% of all plants on earth have symbioses with AMF

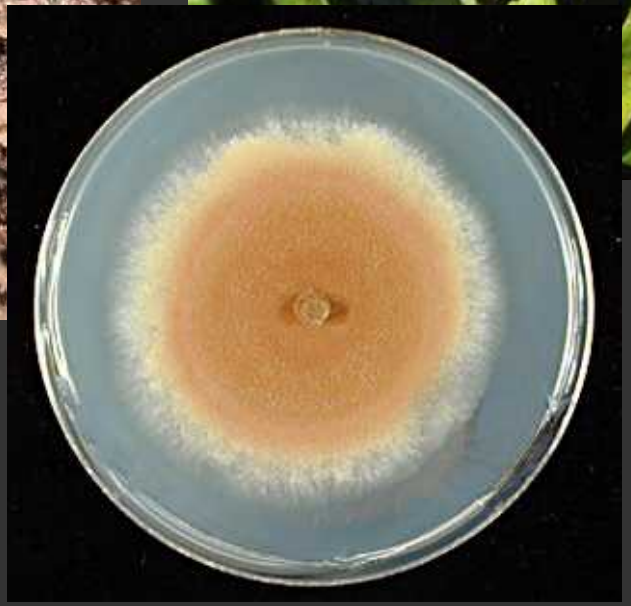
Ascomycetes



Ascomycetes

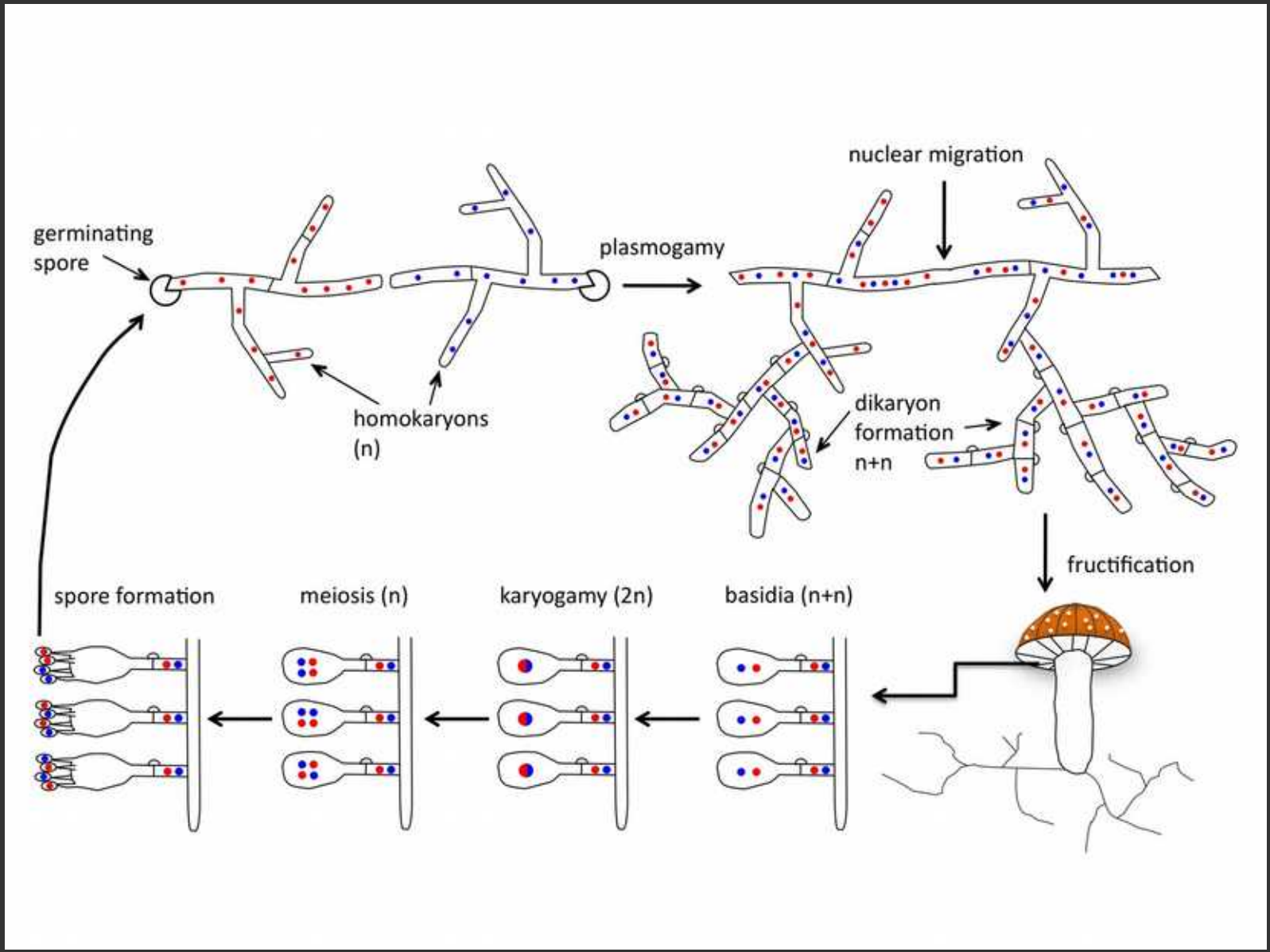


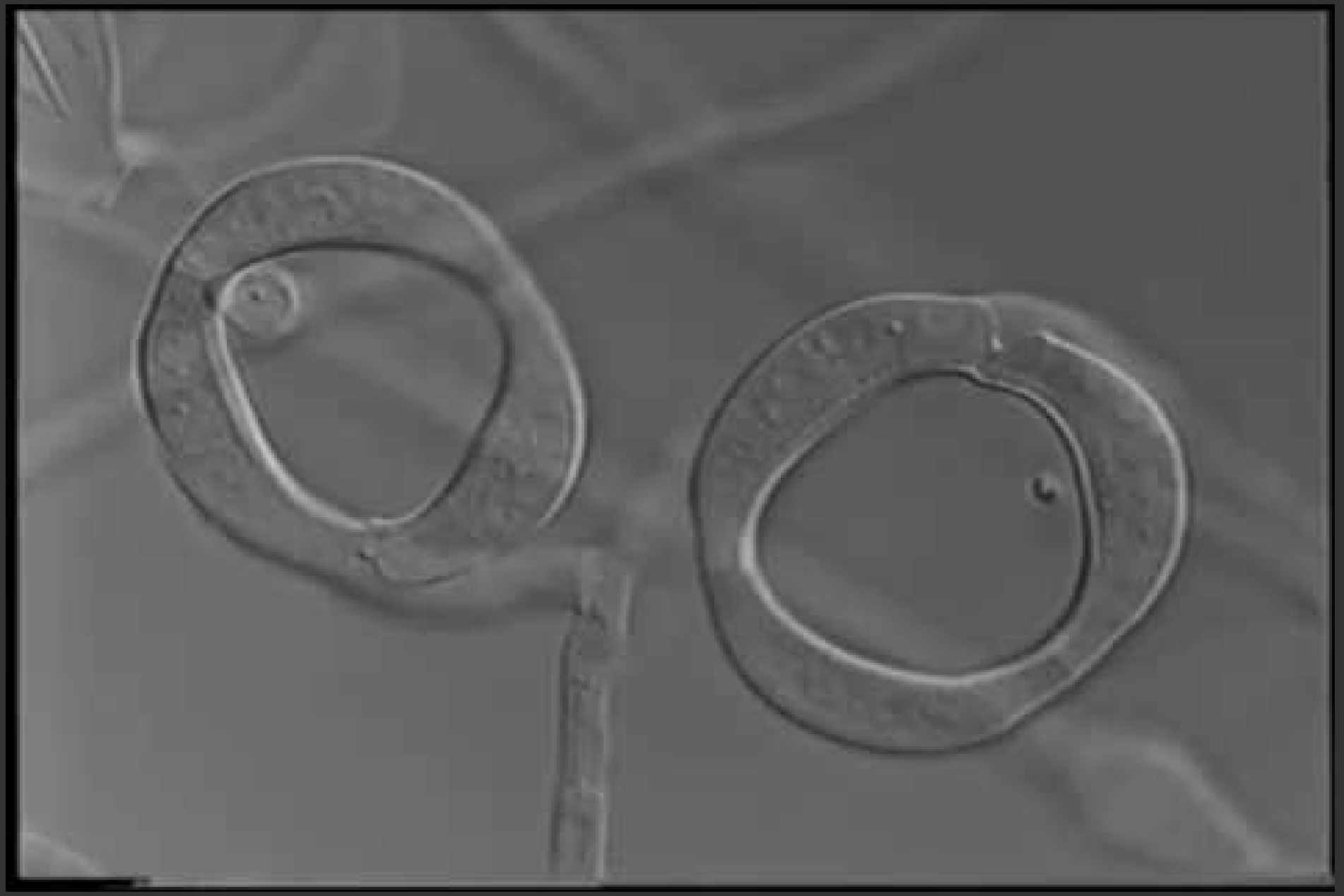
Lichens: Fungi farming green things



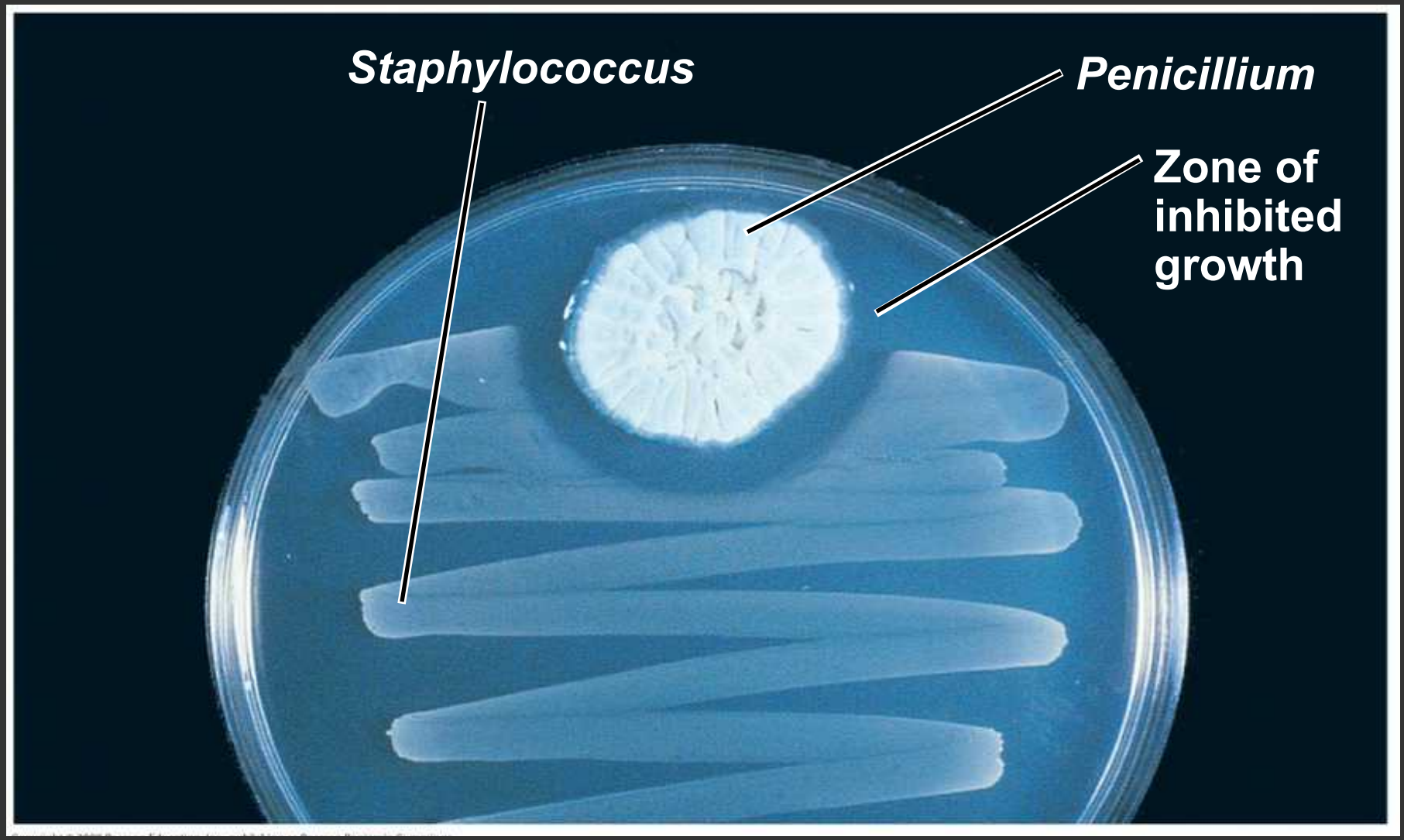

BBC

Basidiomycetes





Medicine from fungi

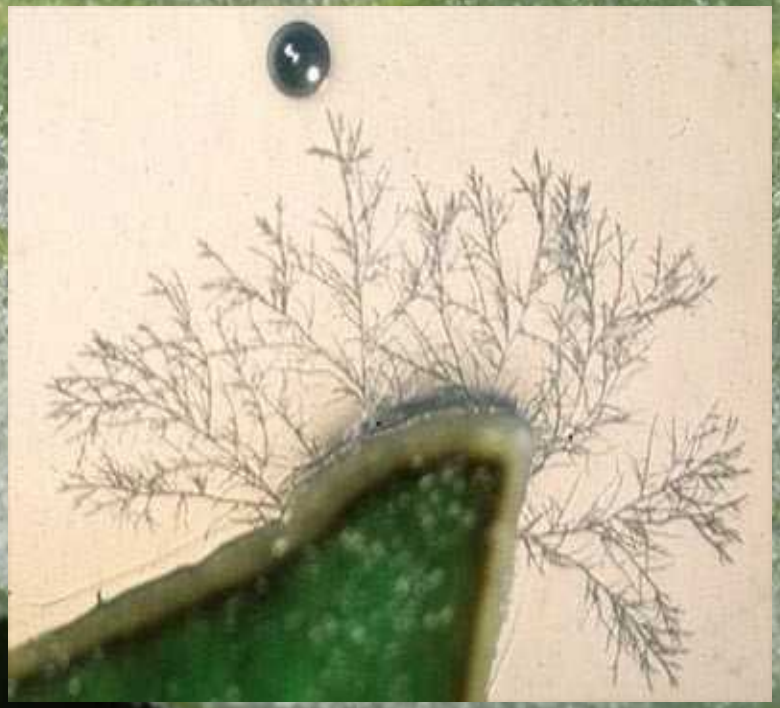


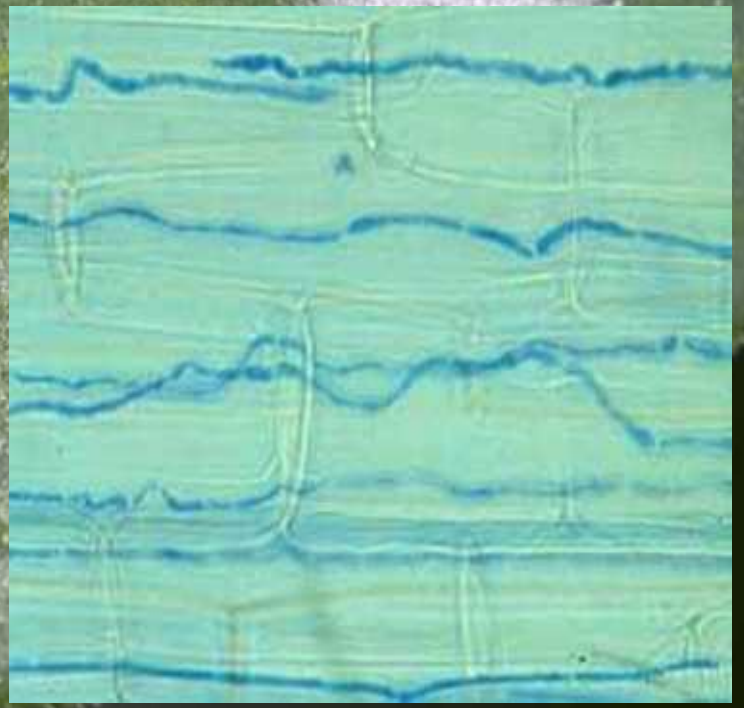
Probiotics for endangered plants: plant conservation from a fungal perspective


MAUNA LOA
OBSERVATORY


NORM
B1
NORM
B2
NORM
A2
NORM
A3

Inside every leaf, there are dozens or even *hundreds* of different fungi





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Genome Res. 2010 Oct; 20(10): 1411–1419. PMCID: PMC2945190
doi: 10.1101/gr.107987.110

Reshaping the gut microbiome with bacterial transplantation and antibiotic intake

Chaysavanh Manichanh,[1,5] Jens Reeder,[2] Prudence Gibert,[1] Encarna Varela,[1] Marta Llopis,[1] Maria Antolin,[1] Rodenc Guigo,[3] Rob Knight,[2,4] and Francisco Guarner[1]

METHODOLOGY | OPEN ACCESS

Stool substitute transplant therapy for the eradication of *Clostridium difficile* infection: 'RePOOPulating' the gut

Elaine O Petrof[†] ✉, Gregory B Gloor[†], Stephen J Vanner, Scott J Weese, David Carter, Michelle C Daigneault, Eric M Brown, Kathleen Schroeter and Emma Allen-Vercoe
[†]Contributed equally

Microbiome 2013, 1:3 | DOI: 10.1186/2049-2618-1-3
Received: 20 March 2012 | Accepted: 18 July 2012 | Published: 9 January 2013

Fecal Transplant for Recurrent Clostridium difficile Infection in Children With and Without Inflammatory Bowel Disease

Russell, George H.*; Kaplan, Jess L.*; Youngster, Ilan†; Baril-Dore, Mariah*; Schindelar, Lili*; Hohmann, Elizabeth‡; Winter, Harland S.*

Journal of Pediatric Gastroenterology & Nutrition:
May 2014 - Volume 58 - Issue 5 - p 588–592
doi: 10.1097/MPG.0000000000000283
Original Articles: Hepatology and Nutrition

10,320 research papers on human microbiome in the past year alone.

5,460 of those are about transplantations.

"Pro-biotics"

RESEARCH ARTICLE | OPEN ACCESS | OPEN PEER REVIEW

Towards microbiome transplant as a therapy for periodontitis: an exploratory study of periodontitis microbial signature contrasted by oral health, caries and edentulism

Alex E. Pozhitkov ✉, Brian G. Leroux, Timothy W. Randolph, Thomas Beikler, Thomas F. Flemmig and Peter A. Noble

BMC Oral Health 2015, 15:125 | DOI: 10.1186/s12903-015-0109-4
Received: 4 June 2015 | Accepted: 6 October 2015 | Published: 14 October 2015

Fecal Microbial Transplant Effect on Clinical Outcomes and Fecal Microbiome in Active Crohn's disease

David L. Suskind, MD,[1] Mitchell J. Brittnacher, PhD,[2] Ghassan Wahbeh, MD,[1] Michele L. Shaffer, PhD,[1] Hillary S. Hayden,[2] Xuan Qin, PhD,[3] Namita Singh, MD,[4] Christopher J. Damman, MD,[5] Kyle R. Hager, Heather Nielson, and Samuel I. Miller, MD[2,5,6,7]

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Reshaping the gut microbiome with bacterial transplantation and antibiotic intake

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METHODOLOGY | OPEN ACCESS

Stool substitute transplant therapy for the eradication of *Clostridium difficile* infection: 'RePOOPulating' the gut

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Fecal Transplant for Recurrent Clostridium difficile Infection in Children With and Without Inflammatory Bowel Disease

Russell, George H.*; Kaplan, Jess L.*; Youngster, Ilan†; Baril-Dore, Mariah*; Schindelar, Lili*; Hohmann, Elizabeth‡; Winter, Harland S.*

Journal of Pediatric Gastroenterology & Nutrition:
May 2014 - Volume 58 - Issue 5 - p 588–592
doi: 10.1097/MPG.0000000000000283
Original Articles: Hepatology and Nutrition

RESEARCH ARTICLE | OPEN ACCESS | OPEN PEER REVIEW

Towards microbiome transplant as a therapy for periodontitis: an exploratory study of periodontitis microbial signature contrasted by oral health, caries and edentulism

Alex E. Pozhitkov ✉, Brian G. Leroux, Timothy W. Randolph, Thomas Beikler, Thomas F. Flemmig and Peter A. Noble

BMC Oral Health 2015, 15:125 | DOI: 10.1186/s12903-015-0109-4
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Fecal Microbial Transplant Effect on Clinical Outcomes and Fecal Microbiome in Active Crohn's disease

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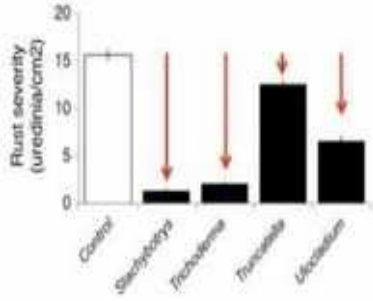
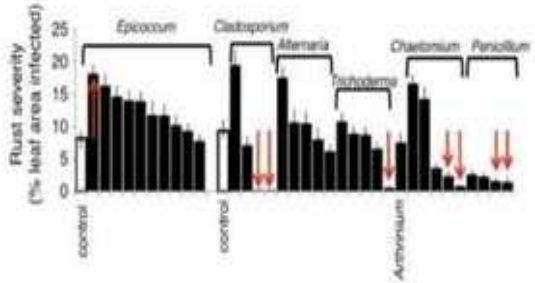
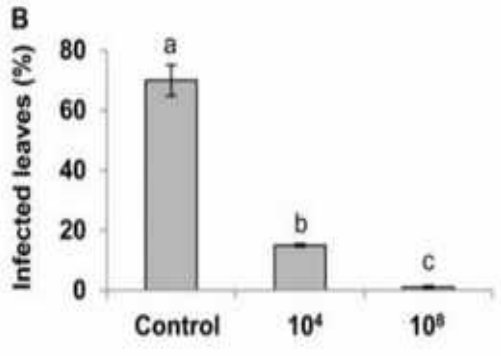
Fungal endophytes modify plant disease



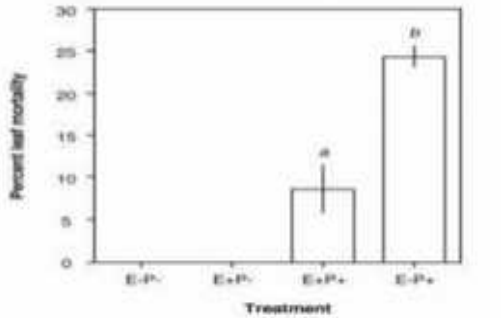
Raghavendra and Newcombe, 2013



Busby, *et al.,* 2015



Buxdorf, *et al.,* 2013



Arnold, *et al.,* 2003

Phyllostegia kaalaensis

- **O'ahu endemic**
- **Extant only in two greenhouse populations**
- **Ecological extinction blamed on habitat loss, feral ungulates, and invasive pathogens**
- **Greenhouse populations dependent on regular applications of fungicides**
- **Outplanting efforts typically fail within months**
- **New approaches needed**

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Neoerysiphe galeopsidis disease progression

~30 Days

Study Design Overview

Phyllostegia hirsuta

Filtered (100 µm)

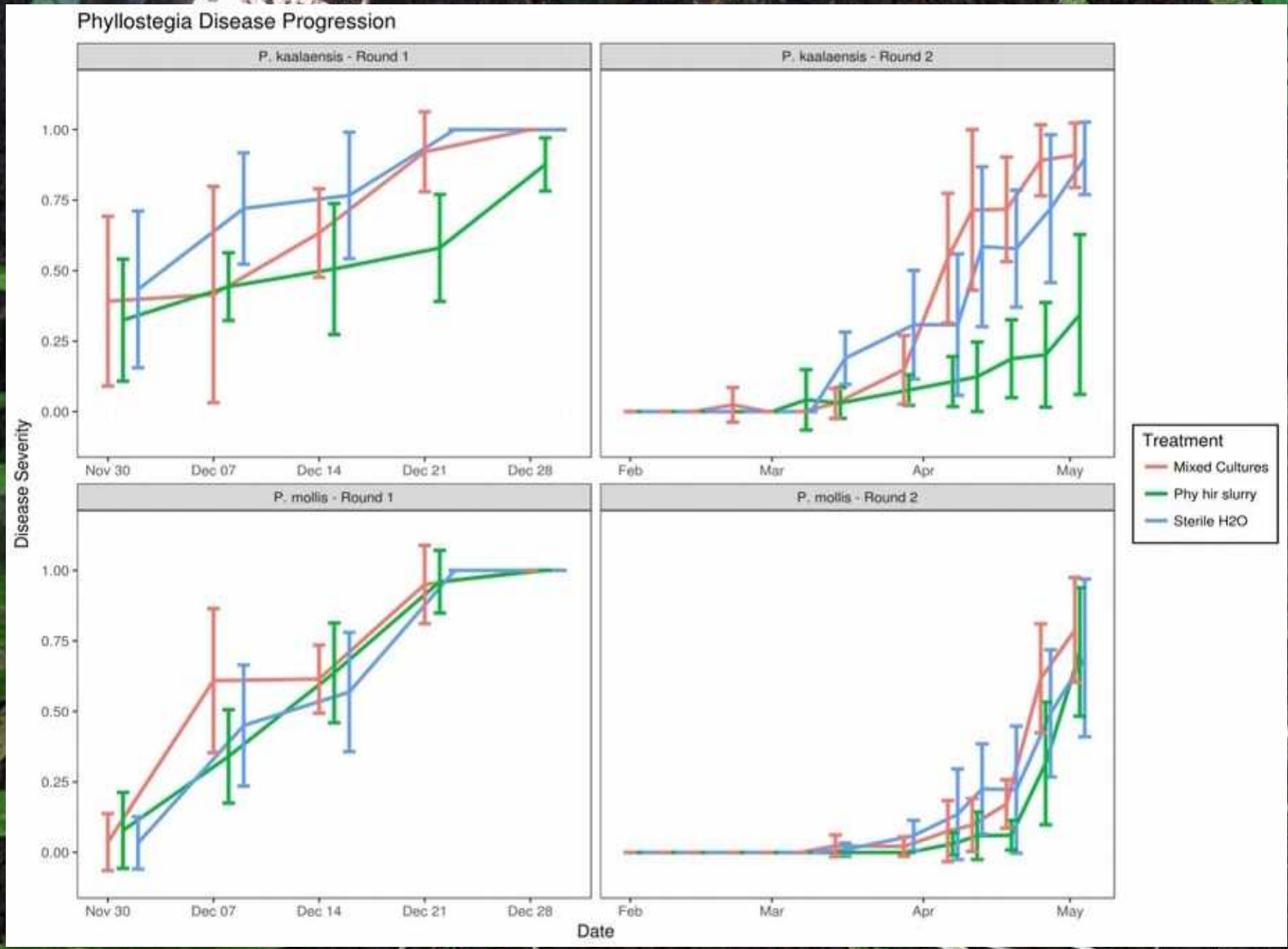
Leaf Slurry from healthy wild relative

Sterile H2O

Fungal isolates from *P. hirsuta*

Cultured isolates from wild relatives

Slurry from wild relatives decreased disease severity



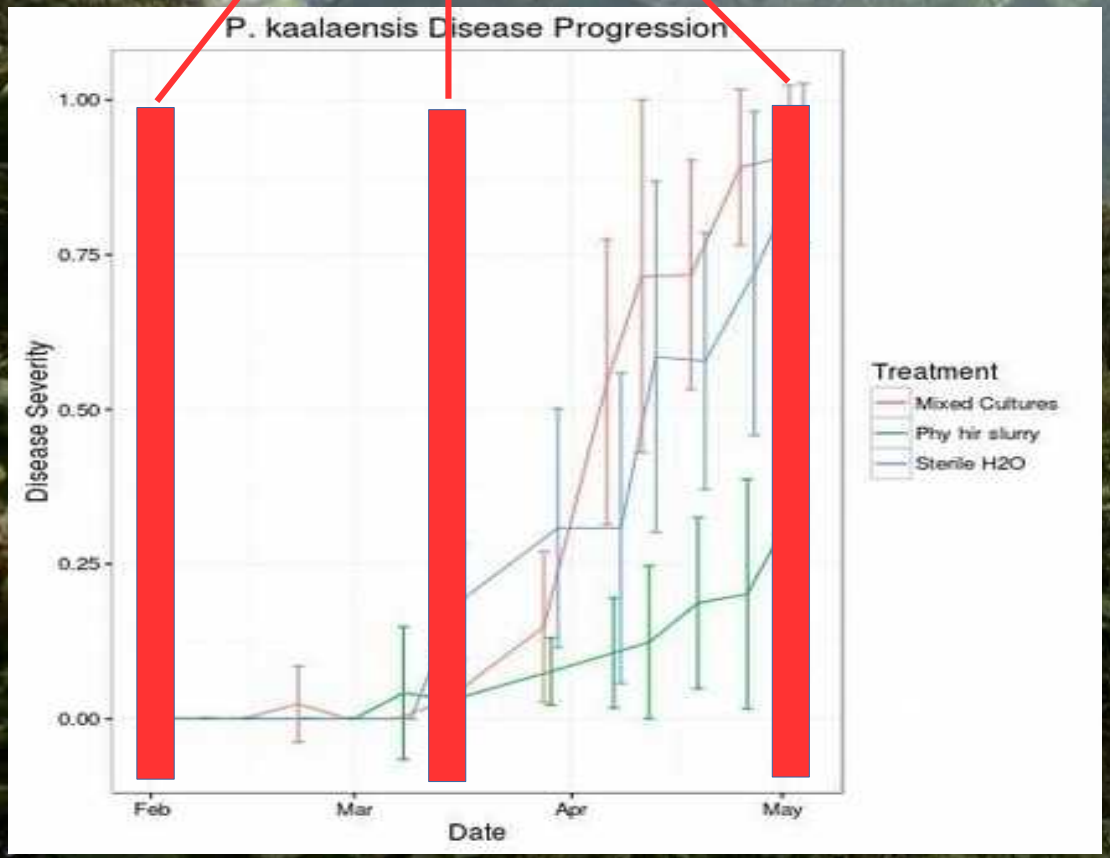
ITS Amplifications

Paired-End
Illumina MiSeq

Merge reads

Extract ITS1 Region

Pick OTUs
Assign taxonomy



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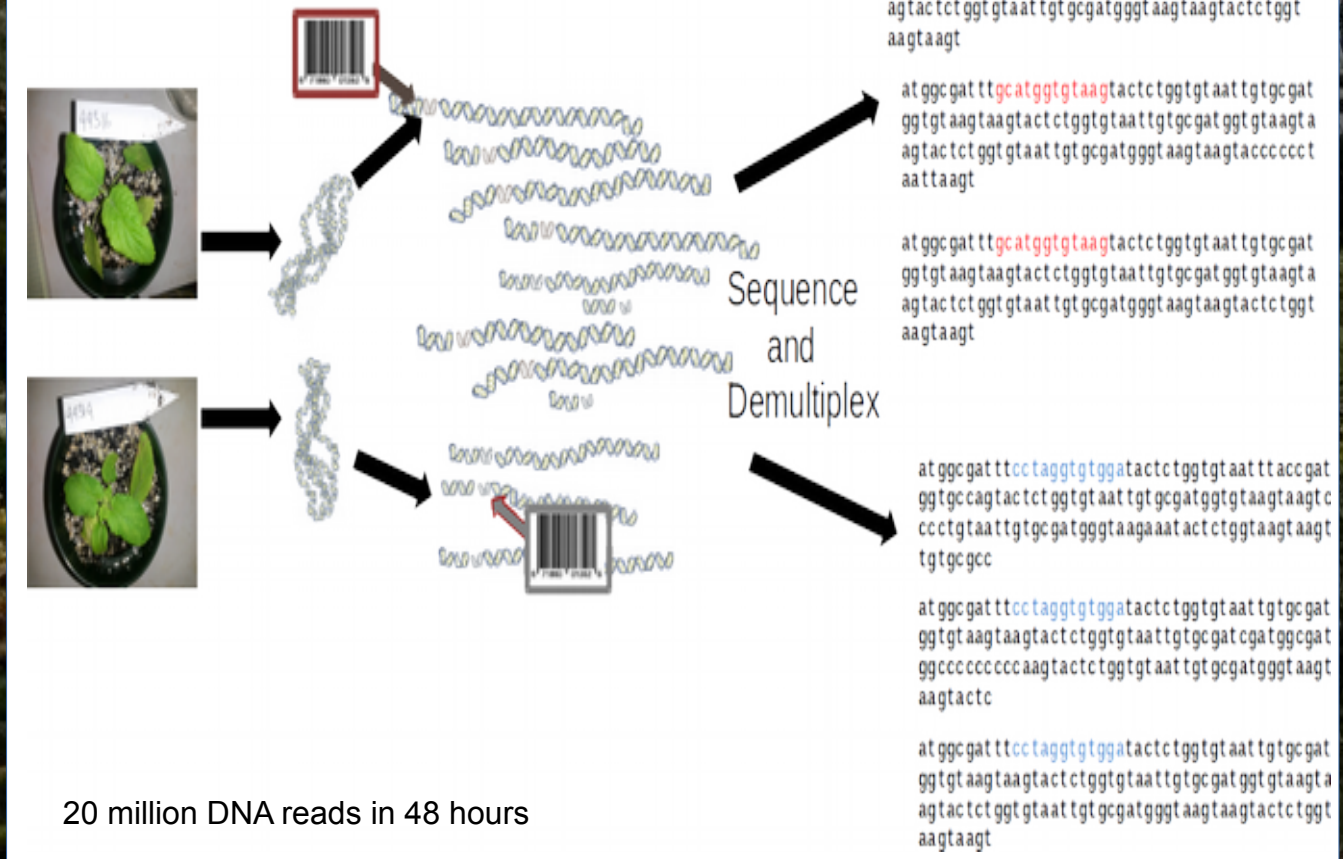
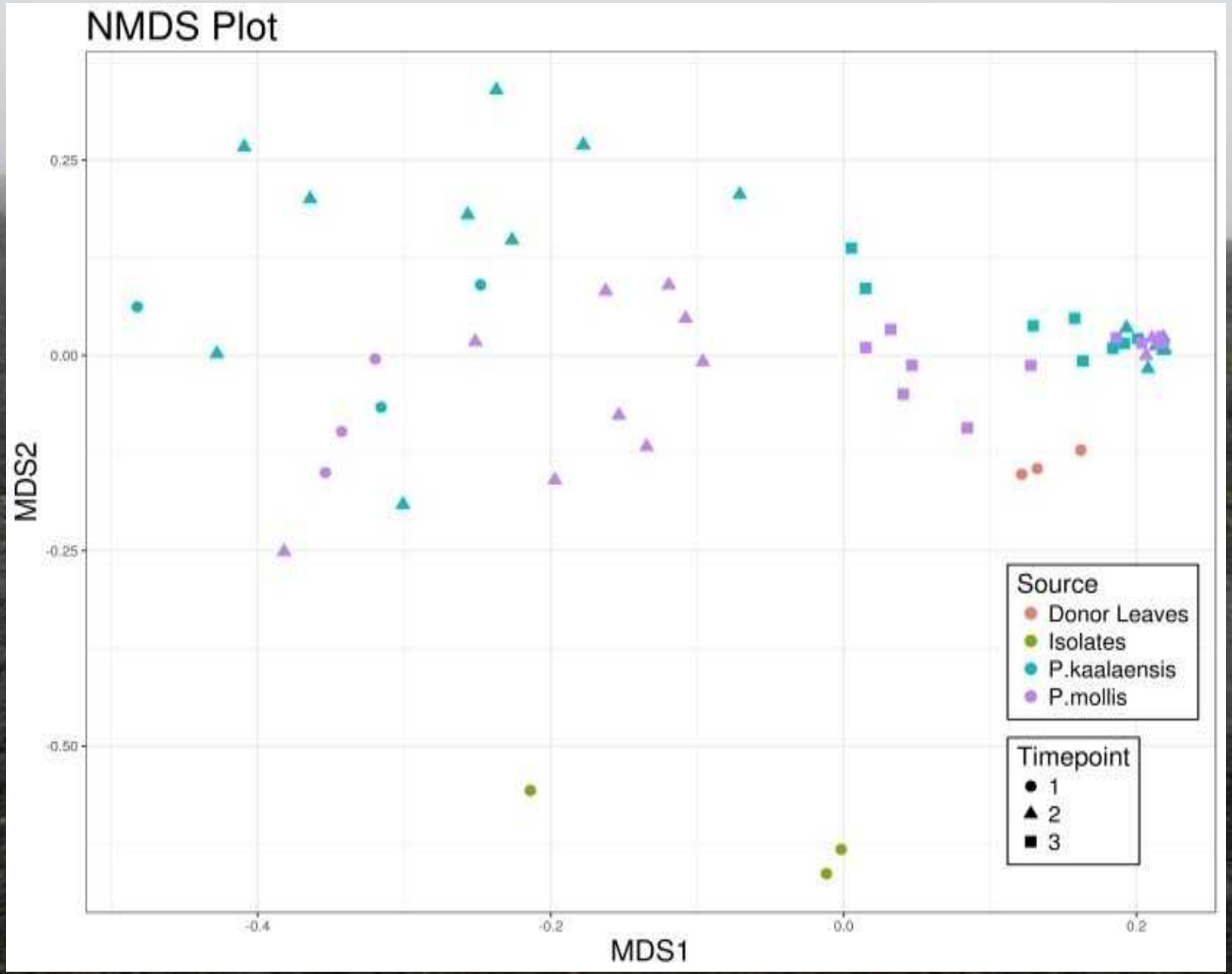


20 million DNA reads in 48 hours

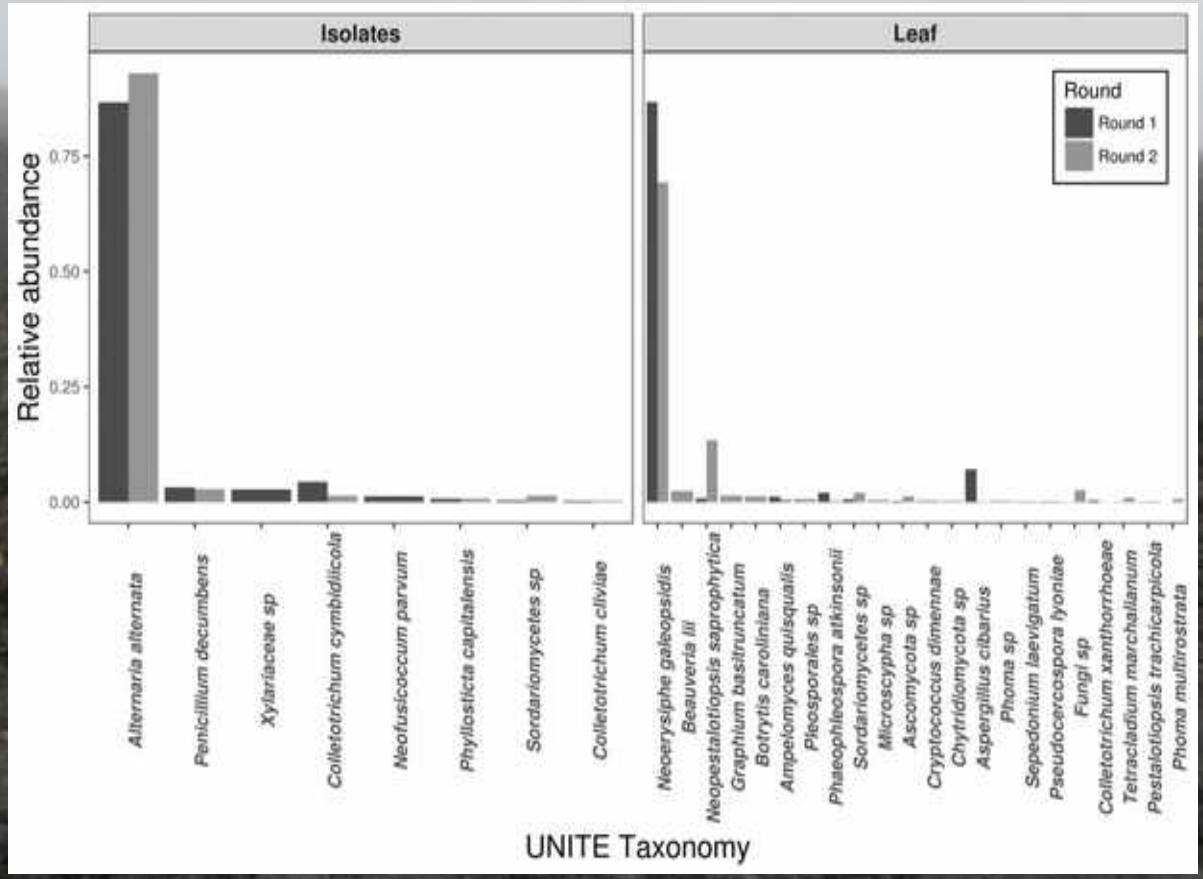
"Species" Abundance Table

	A	B	C	D	E	F
1	OTU_ID	Sample1	Sample2	Sample3	Sample4	Sample5
2	Species1	2	0	0	0	0
3	Species2	0	1	0	0	0
4	Species3	0	0	3	0	0
5	Species4	0	758	0	1	87
6	Species5	15	0	0	0	3
7	Species6	3929	1890	1520	3238	1803
8	Species7	0	0	0	0	0
9	Species8	0	0	0	0	4
10	Species9	0	0	233	0	0
11	Species10	0	0	0	0	455
12	Species11	18	3	0	4543	0
13	Species12	0	0	0	0	0
14	Species13	91	0	0	34	0
15	Species14	0	11	0	0	46
16	Species15	0	0	0	0	0

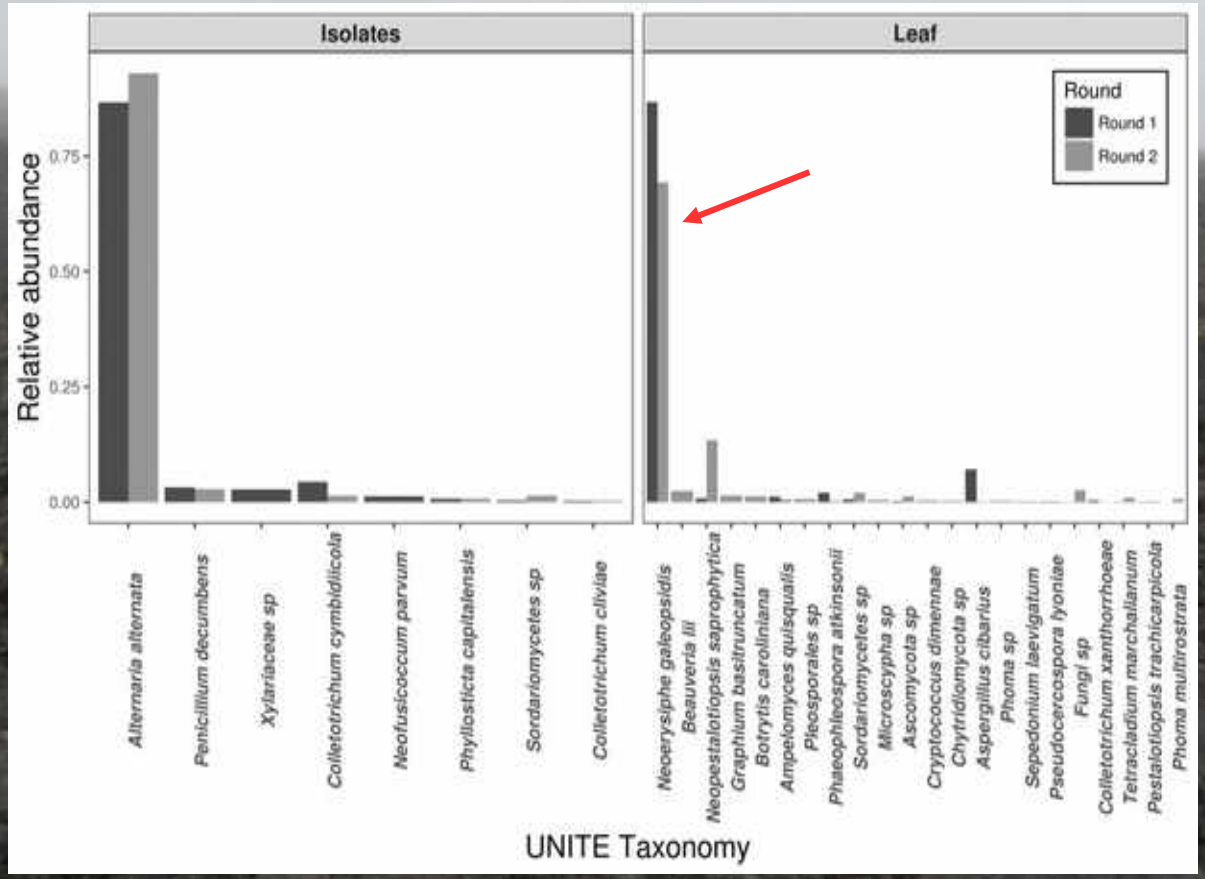
OTU = Operational Taxonomic Unit


NMDS Plot
MDS2
MDS1
0.25
0.00
-0.25
-0.50
-0.4
-0.2
0.0
0.2
Source
Donor Leaves
Isolates
P.kaalaensis
P.mollis
Timepoint
1
2
3

So, who was in that beneficial leaf slurry inoculum?

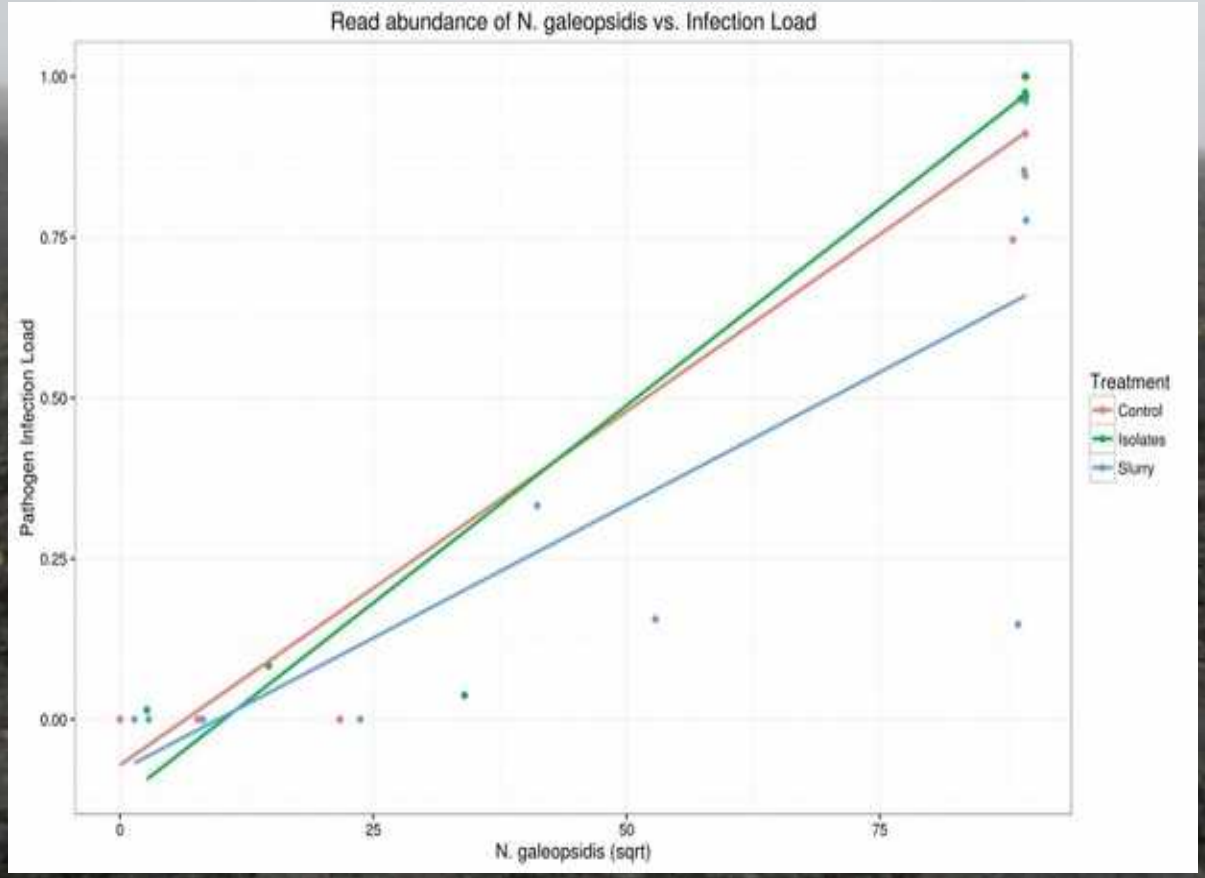


So, who was in that beneficial leaf slurry inoculum?



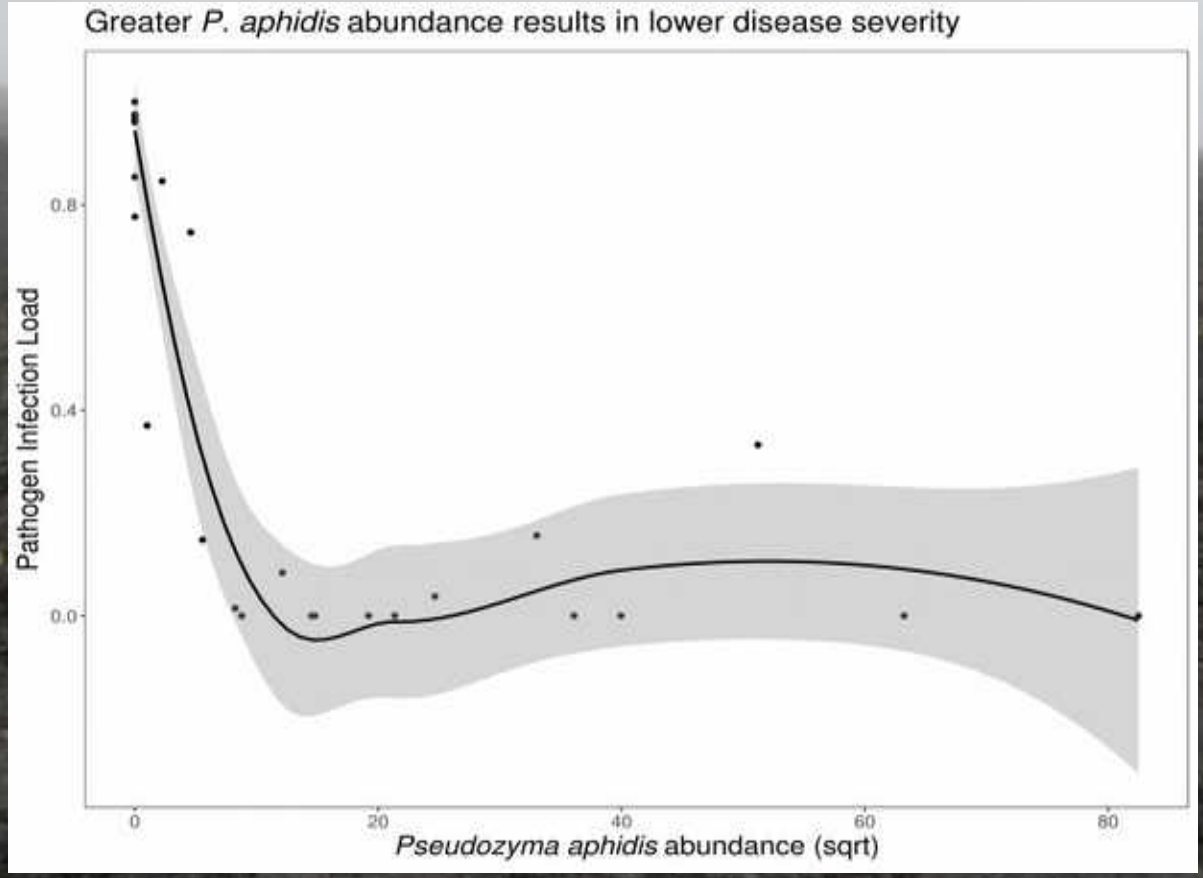
Turns out, it was mostly the pathogen we were trying to prevent!
(*N. galeopsidis*)

Two species were significantly associated with infection severity

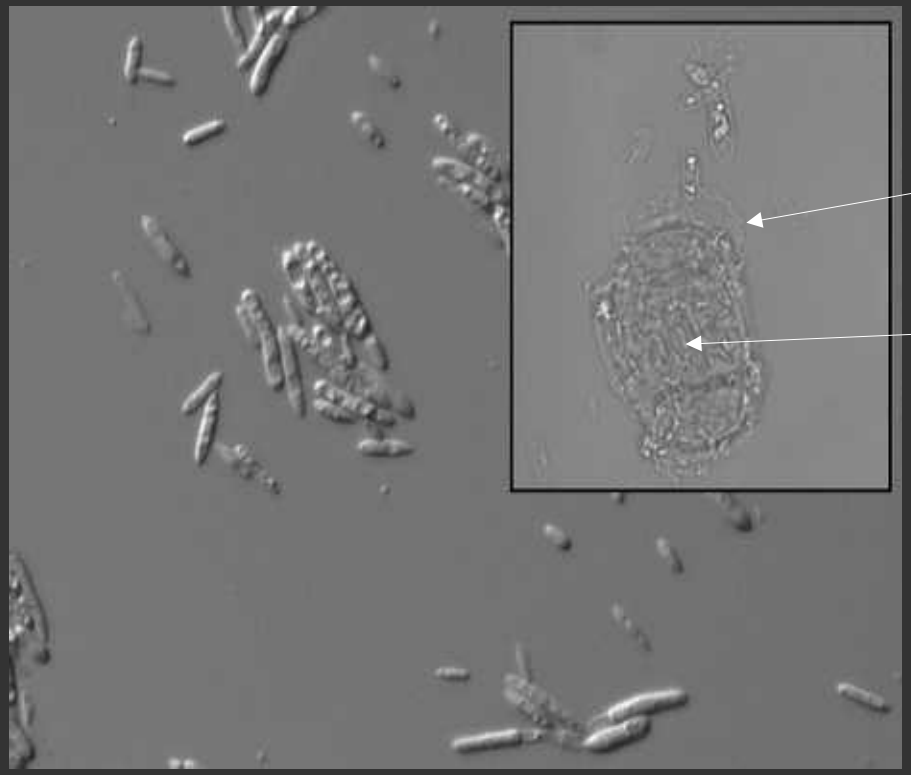


Neoerysiphe galeopsidis, the pathogen, obviously

Two species were significantly associated with infection severity



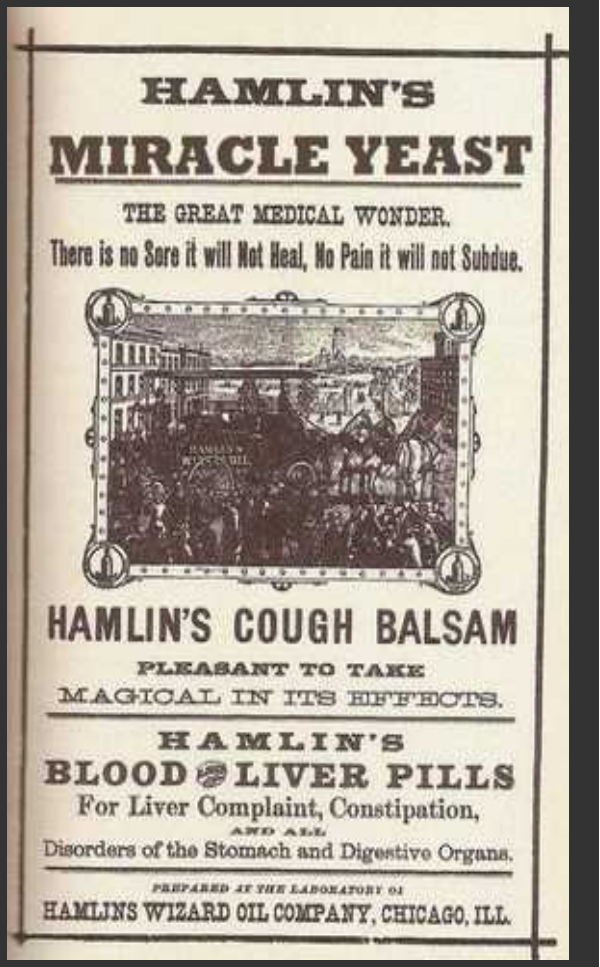
...And a little yeast, *Pseudozyma aphidis* that seemed to prevent infection!



Clement-Mathieu et al., 2007, Fungal Ecology

P. aphidis attacking

Pathogen spore



Clement-Mathieu et al., 2007, Fungal Ecology



Endophytes saved this critically endangered plant (for now)

Where are the oldest fungal cells found?

Where is meiosis happening?

How does the fact that fungi are lysotrophic relate to what you are seeing?

Describe the common ancestor of fungi and metazoans.

How can we be sure that humans and neanderthals interbred?

Draw the (sexual) life cycle of an ascomycete or basidiomycete

Label ploidy levels, locations of karyogamy, meiosis, and plasmogamy