

Microbes in the Sub-Nivean Environment

Ken Wilson, Dept. of Ecology and Evolutionary Biology, CU



AF Meyer

14 Feb 09, 30 Jan 10

What we will cover

- The Sub-Nivean environment
- Fungi that grow under the snow
- Results of lab experiments on these “snow molds”
- A brief primer on fungal phylogenetics



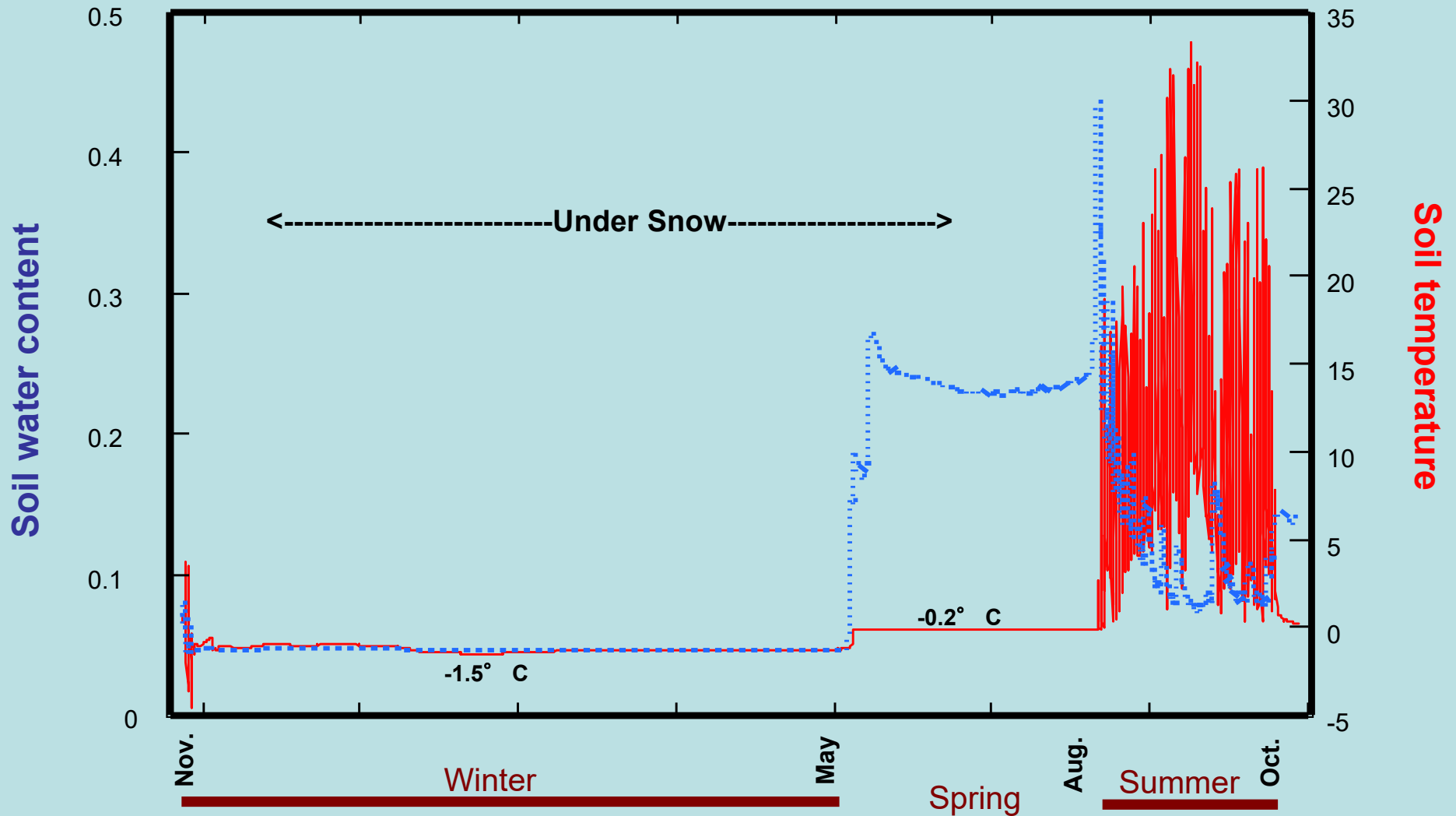
The Sub-Nivean Environment

Life under the snow is not so hostile for microbes

- Stable, “mild” temperature, near 0°C
- Good moisture
- Shielded from UV
- Carbon sources from plant litter



Soil temperatures are moderate and moisture abundant, especially at snow melt



From Ley, et al.. *Biogeochemistry* 68: 313-335 (2004)

Snow Molds thrive under the snow

We have found that a vigorous fungal community is actually growing under the snow

The fungi appear to grow and sporulate under the snow, quickly dying once exposed

Little is know about their life cycle or metabolism



Receding Snow Reveals Mats of Fungi

Fungal communities at snow melt are ephemeral, rapidly disappearing once the snow is gone

Sub-Nivean Snow Molds have been observed in forests and meadows from 12,000 feet in alpine areas down to 5,500 ft in Boulder.





Ephemeral,
rapidly
disappearing
once the snow is
gone

A Niche for Sub-Nivean Snow Molds

Large store of nutrients under the snow from plant litter.

The fungi we studied are ruderal or r-selected species that exploit these high nutrient conditions during snowmelt

Do the sub-nivean snow molds play an important role in mineralizing DOC released from plants and microbes under late winter snow packs?



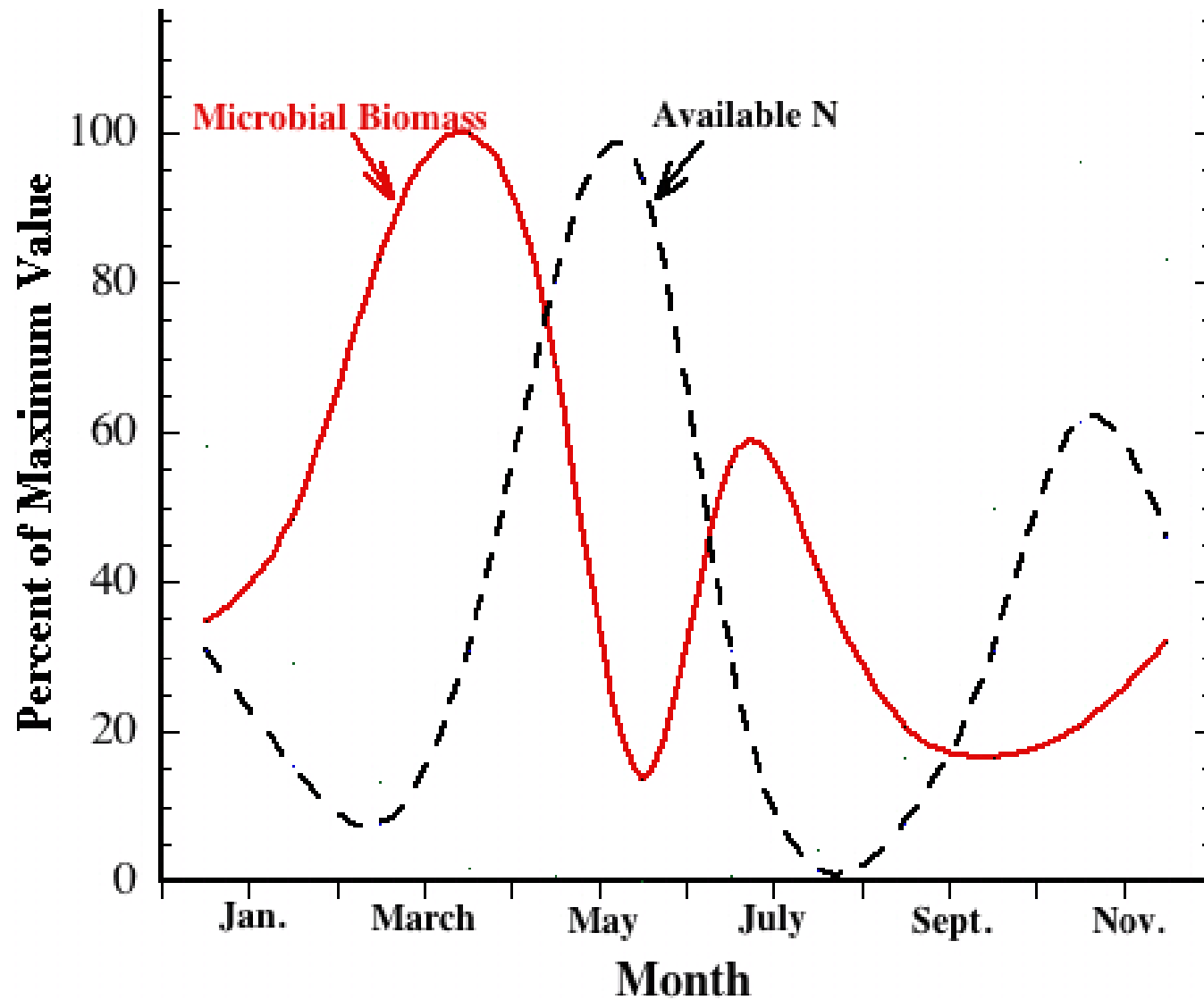
Large Fungal Community Crashes

SEASON	Biomass $\mu\text{g C / g}$ soil	F/B Ratio
Under-snow	363 (18)	15
Snowmelt	244 (21)	7
Summer	125 (32)	7

Schadt et al. 2003 *Science* 301: 1359

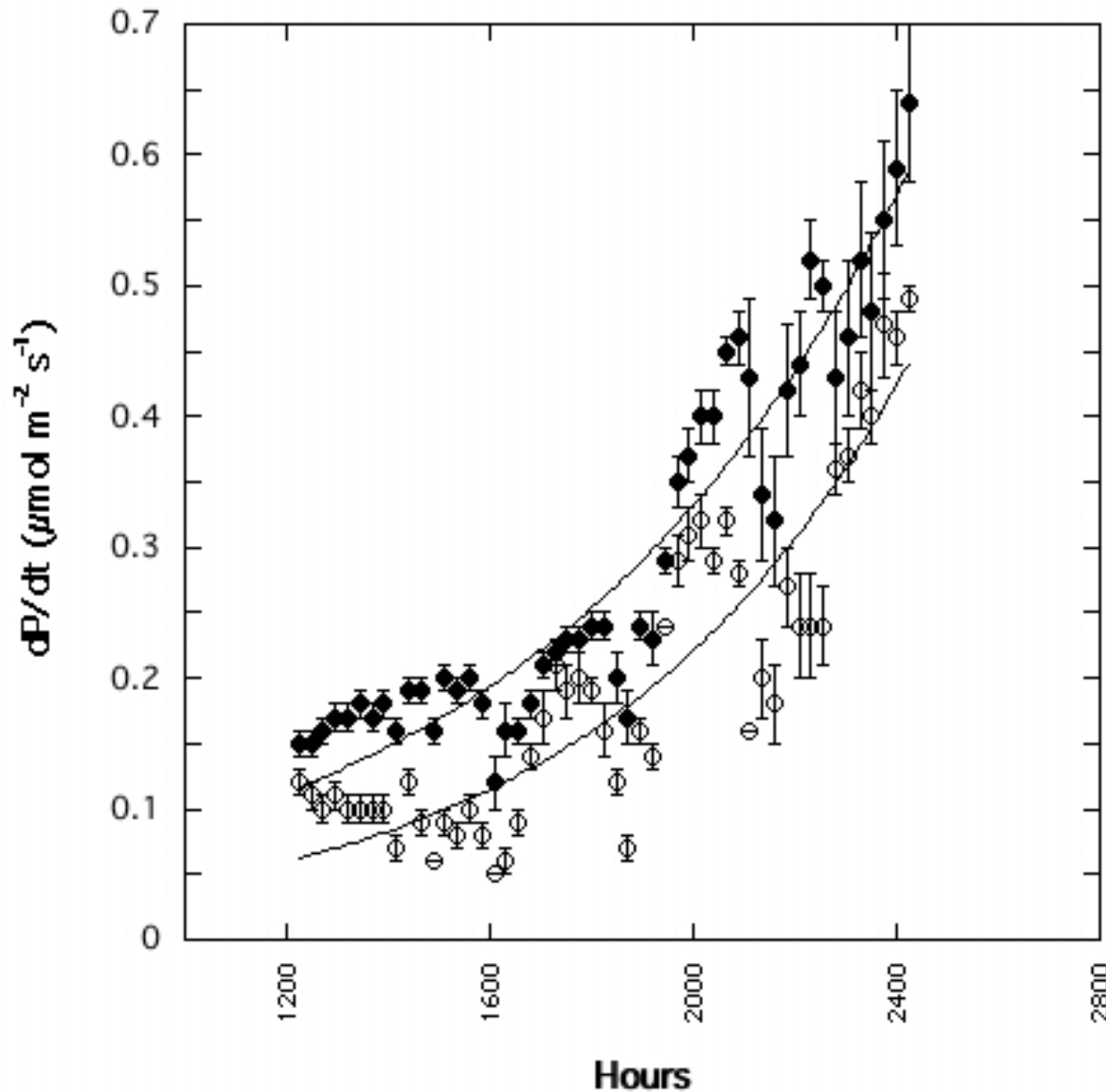
What happens to the disappearing biomass?

Flush of Nutrients



Seasonal fluctuations of microbial biomass and available N in alpine soils

Major Source of CO₂ Respiration



- Under snow soil microbes respire out half of annual carbon fixed by plants
- Highest rates of CO₂ flux out of soils occur just prior to melt out.



What % CO₂ respiration is due to snow molds?

The Larger Issue

Snow Molds may contribute substantially to CO₂ fluxes from beneath the snow

Is exponential CO₂ flux in field during snow melt related to exponential growth of snow molds?

Issue for CO₂ dynamics and global warming



Collection and Initial Culturing

Material was collected from fungal mats and used to inoculate various media types on agar plates.

Soil samples were collected from dry meadow and forest locations and used to inoculate various media types on agar plates.



Fungal Isolations

- Plates were incubated in the dark at 4°C
- Some plates were incubated anaerobically at 4°C
- Fungi were subcultured to isolate pure strains
- Several isolates resembled fungi seen in the field



Growth Rate Experiment

Growth rate experiments were conducted on four isolates that had been sequenced.

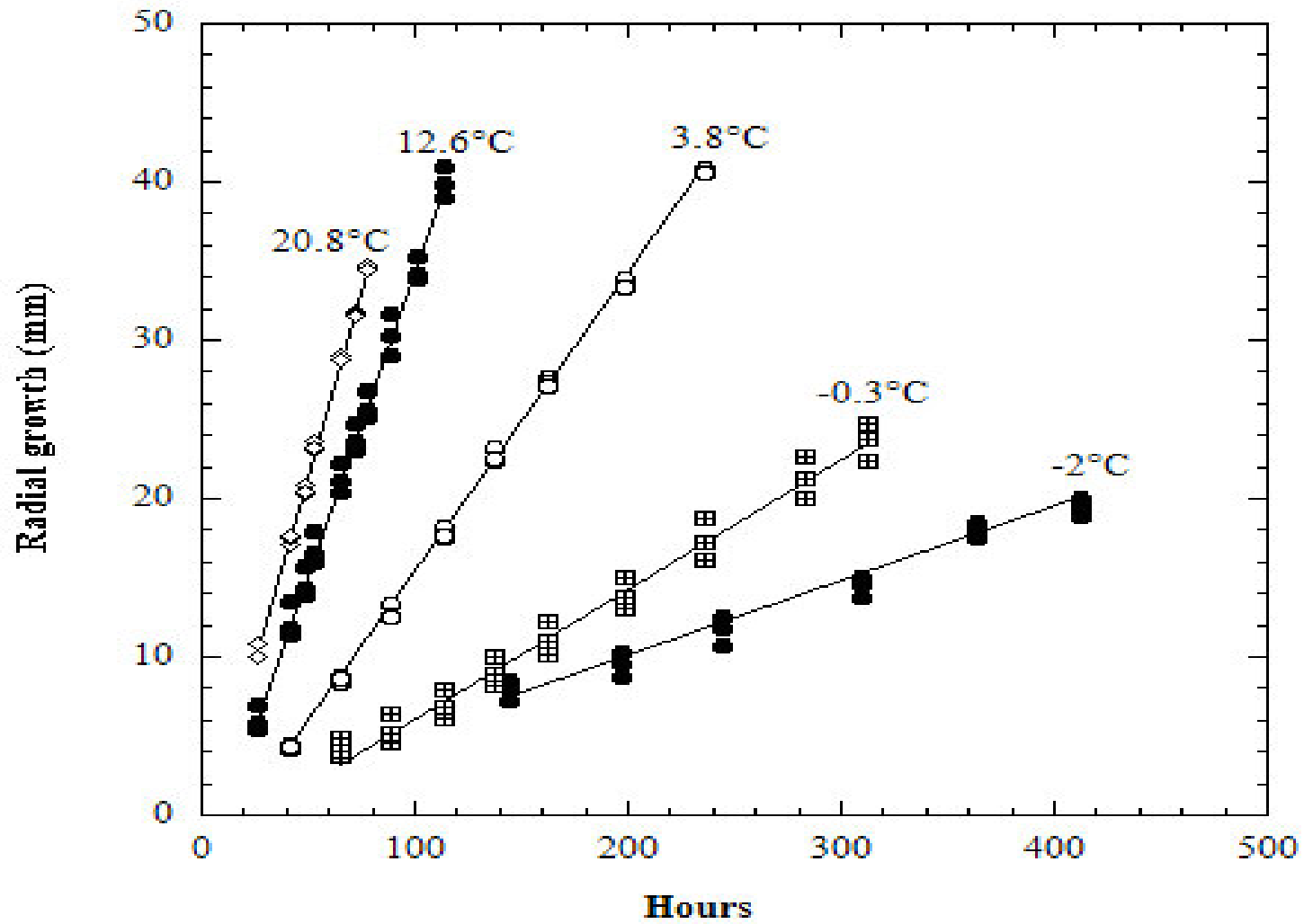
Controlled growth rates were recorded at -2°C , 0°C , 4°C , 13°C , 21°C , 25°C , 28°C and 30°C

Three replicates of each isolate at each temperature

Growth recorded at regular intervals, depending on temperature

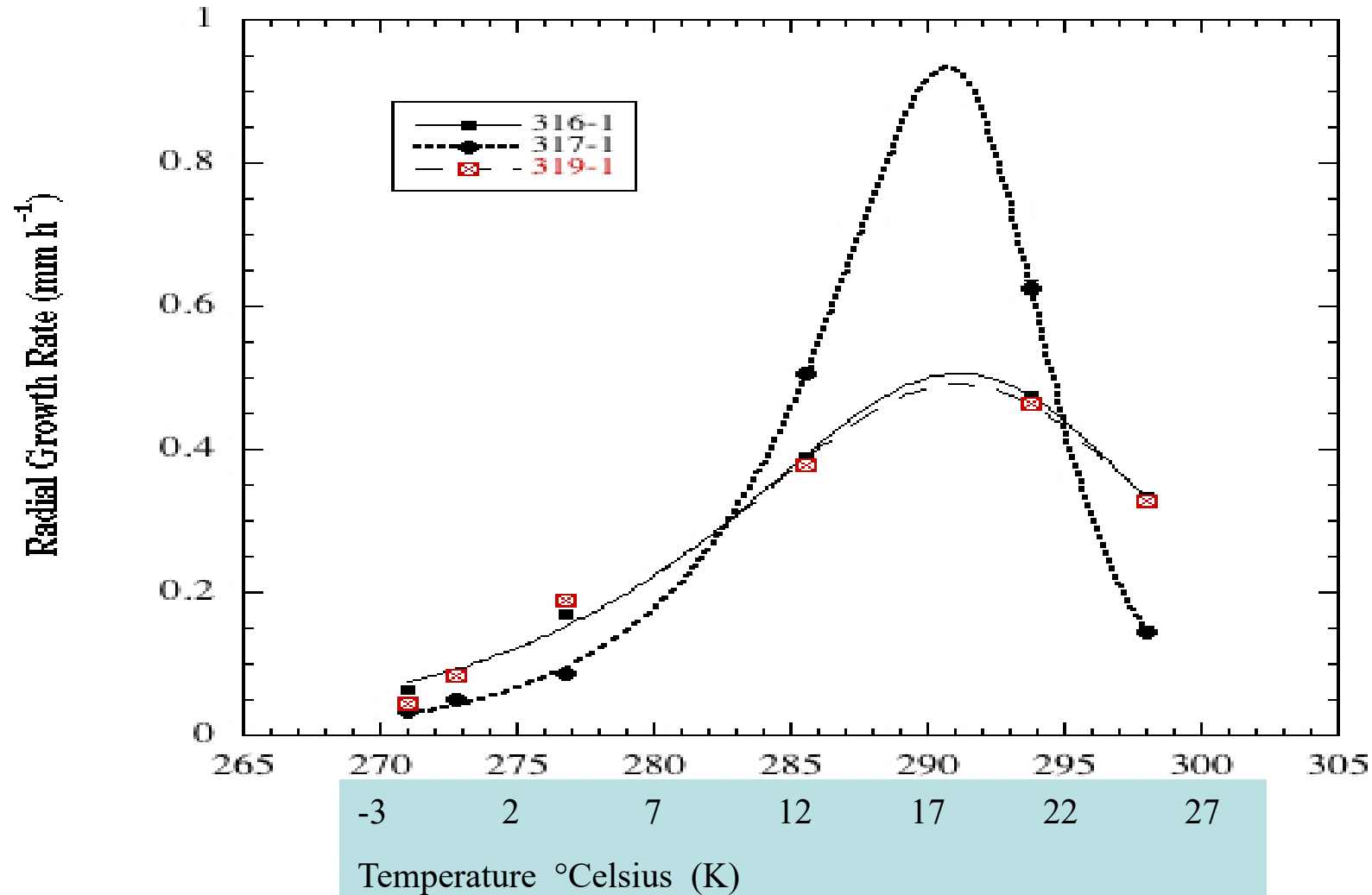
Measured radial hyphal extension

Growth Profiles for Isolate 319-1

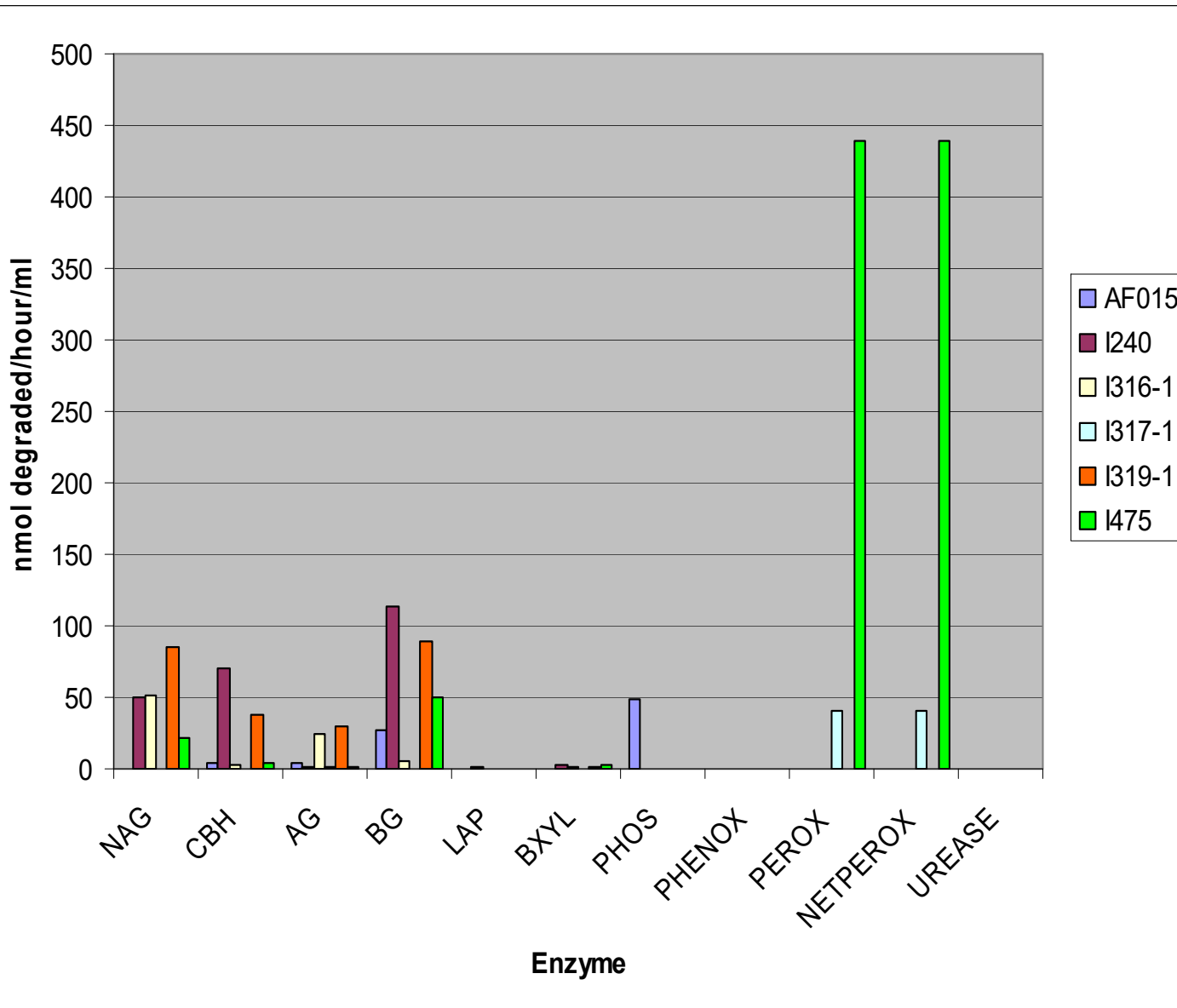


Growth Rates for three isolates

May be the fastest growing fungi at cold temperatures ever recorded



What are they eating?



NAG: chitinase indicative of cell wall turnover

CBH: Cellobiosidase – an exo-cellulase

AG: α Glucosidase – exo-cellulase starch degrading

BG: β Glucosidase – exo-cellulase hydrolysis of terminal short chain oligomers

Phos: Acid Phosphatase – mineralizes organic P into phosphate

Perox: Peroxidase – oxidative enzyme used as a lignolytic enzyme

Other fungi contribute to under snow respiration



Next Steps with Sub-Nivean Snow Molds

Verify that the fungi observed in the field are the same as fungi grown in the lab.

Why do some isolates have such high Q_{10} values at low temperature?

How do snow molds react to tree die-off?

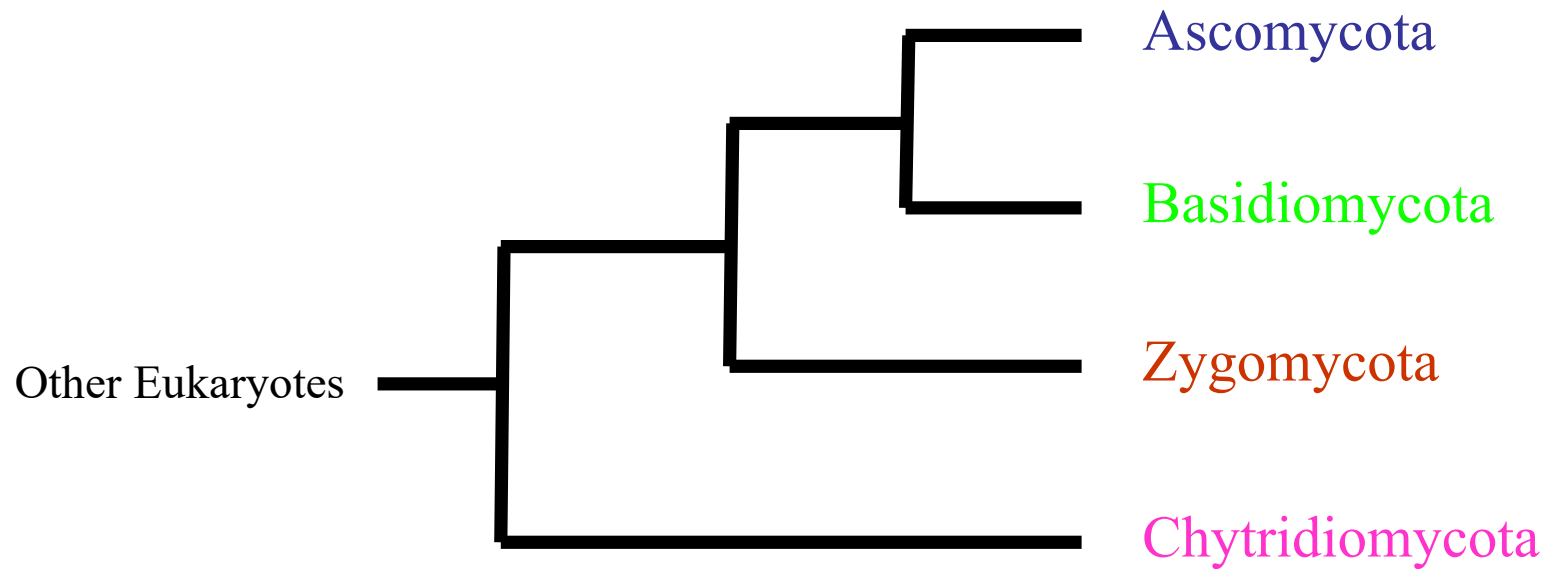
Are there any sub-nivean snow molds that can grow anaerobically?

Why do the sub-nivean snow molds die when they are not covered by snow? (UV, dry out, etc.?)

Do snow molds fractionate C^{13} from C^{12} in characteristic ways?

What are the yield coefficients of snow molds?

Historical Fungal Phylogenetic Tree

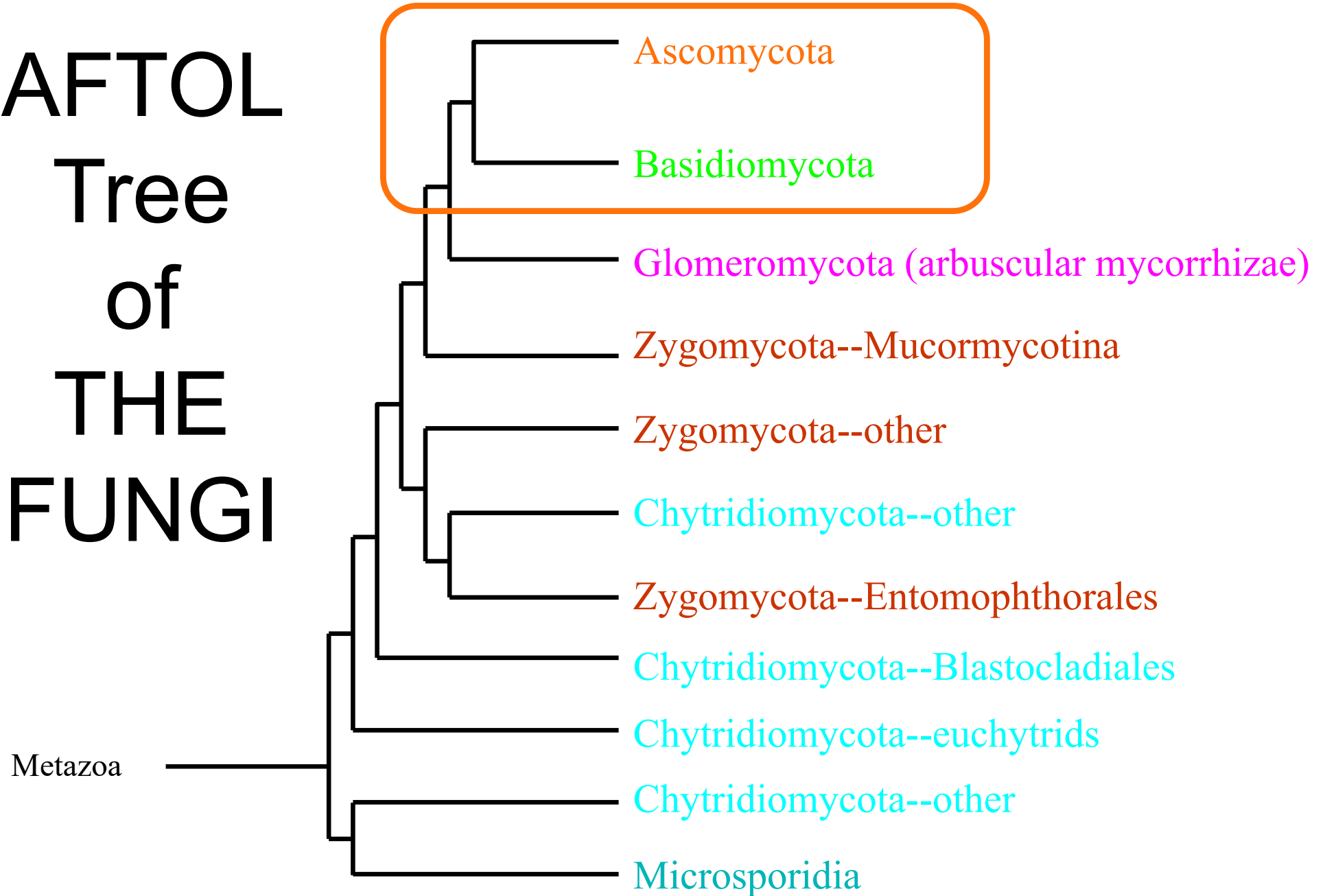


Morphology based

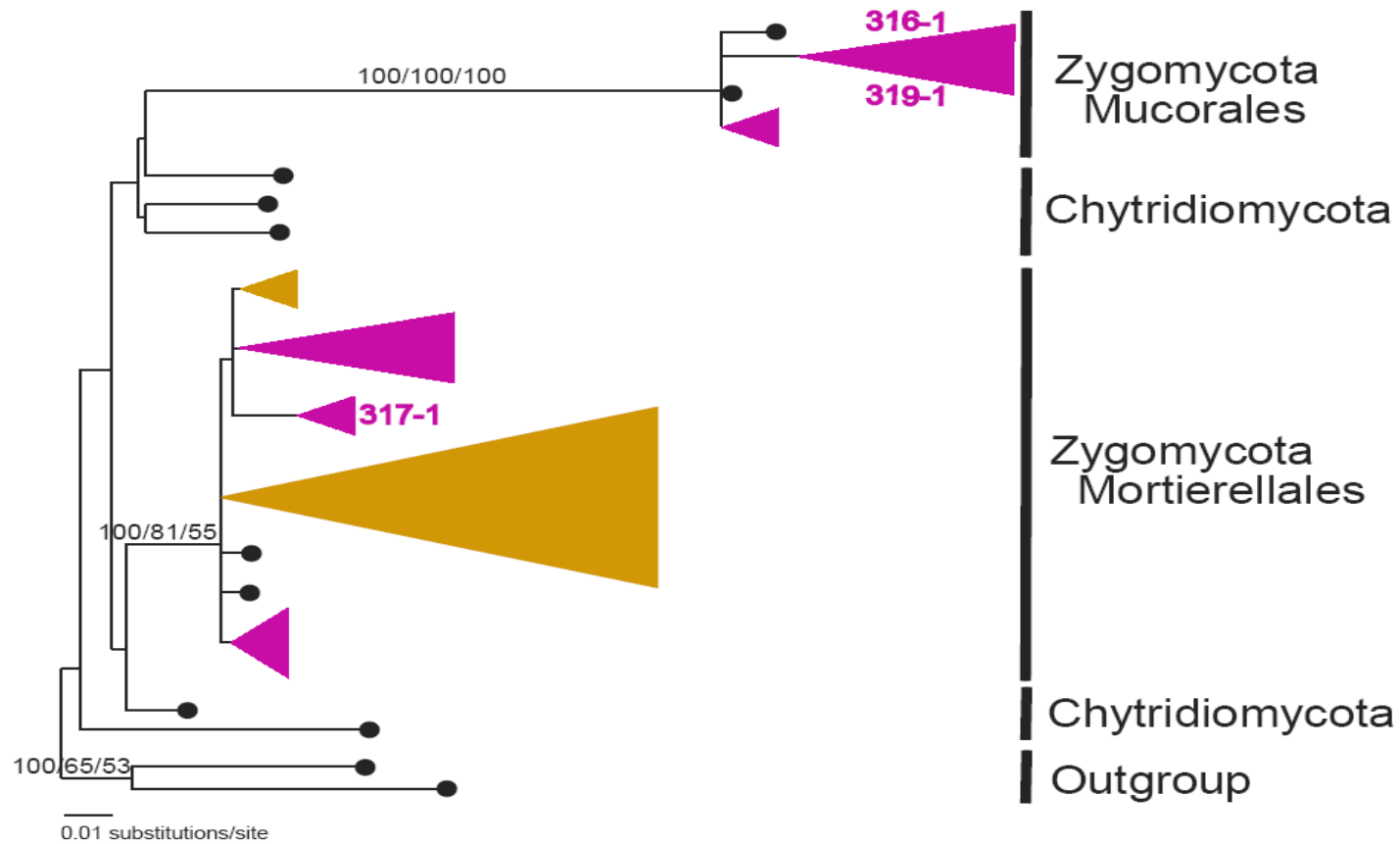
AFTOL

- ‘Assembling the Fungal Tree Of Life’
- Multi-university effort to determine phylogeny
- Using 6 genes of 200 fungi
- Some morphologic groupings hold (Ascos, Basidios) - monophyletic
- Some morphologic groups don’t stand up (Zygos, Chytrids) - polyphyletic
- Convergent evolution of morphology

AFTOL Tree of THE FUNGI



Phylogeny of Sub-Nivean Snow Molds



Courtesy of A. Meyer