



Fungi - The Superheroes of Our Future

Sandra Tuszynska (PhD)

Fungi

- What are they?
- Ecosystem function
- Decontamination
- Design and Tech
- The Mycology Research project





Forgotten heroes

2.4 b.y.a Protostolites

450 mya algae + fungi = plants

Dissolve rock

Decomposed organic matter

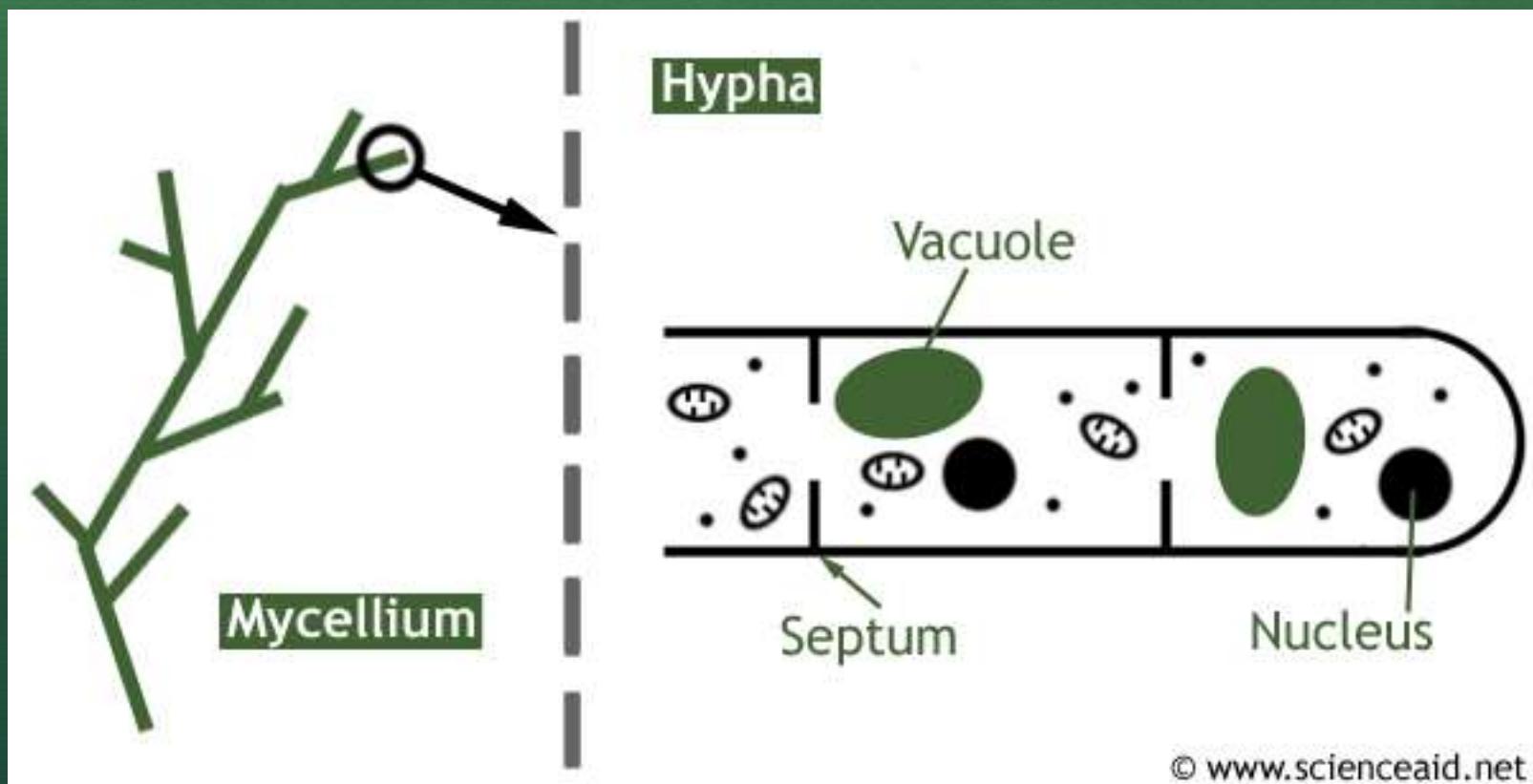
Made first soils

Mushrooms = Flowers

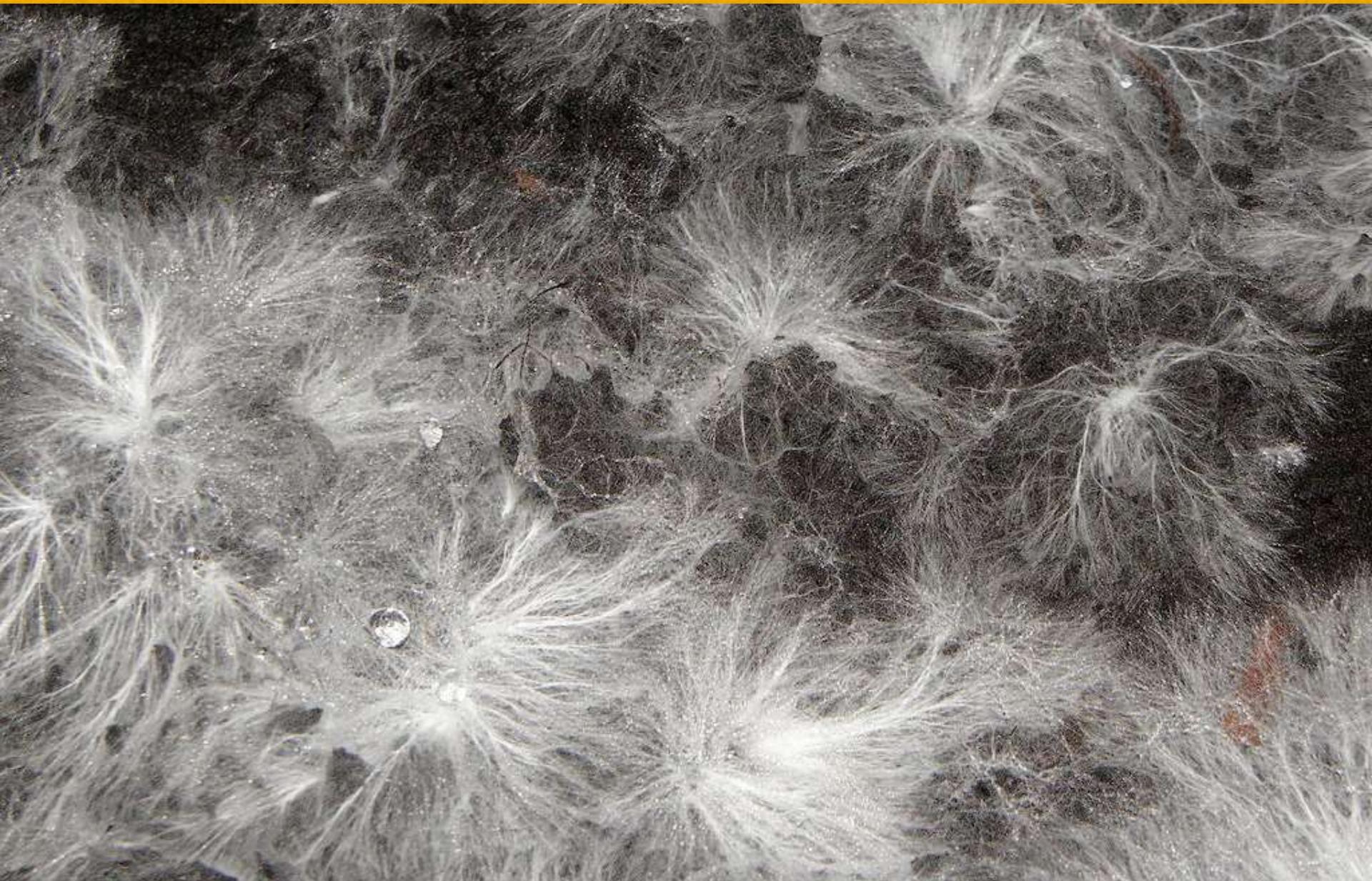


Fungi kingdom 1969

Animal or plant?



The superpowers of the fractal web



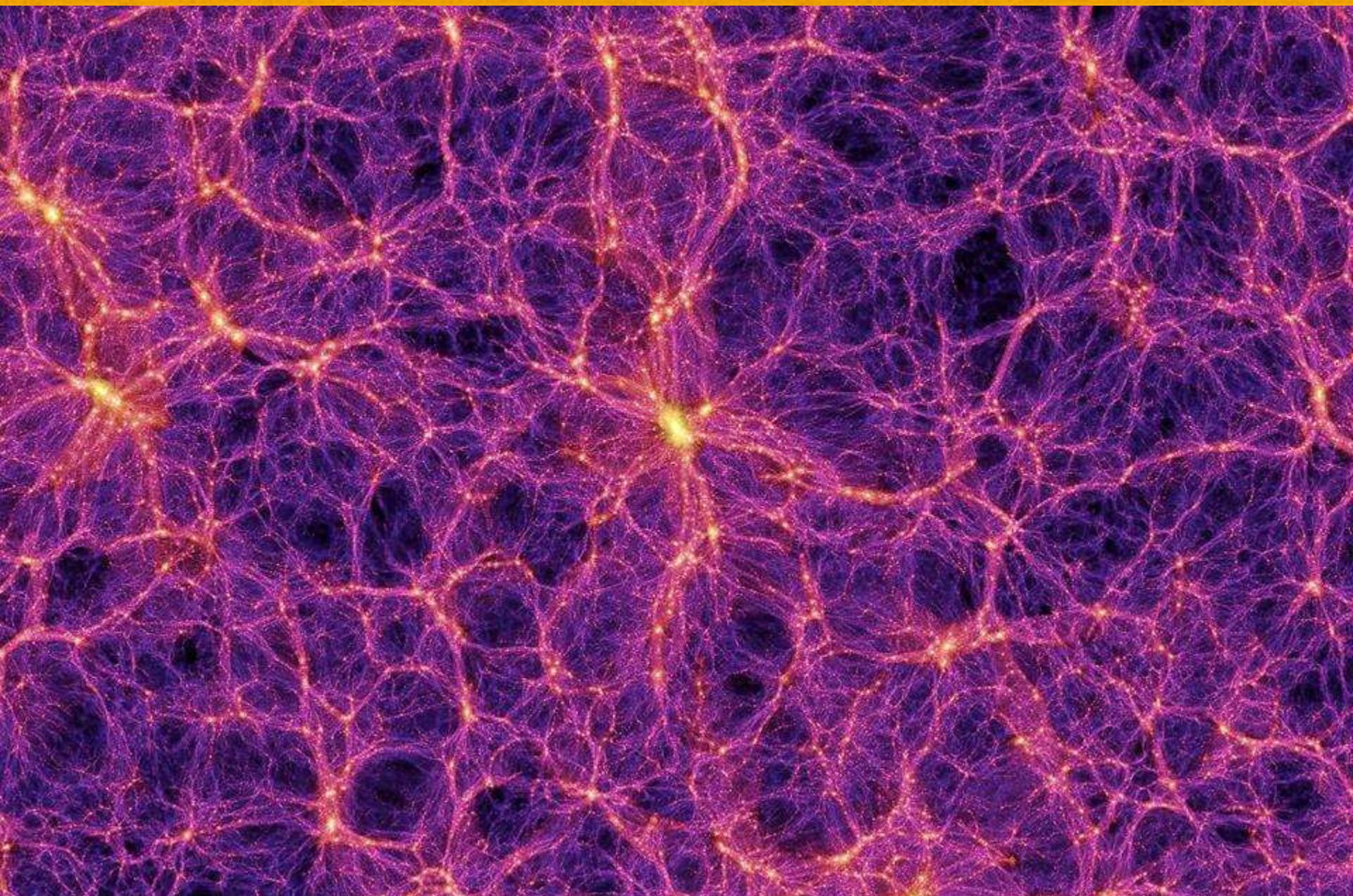
The Neuron Web



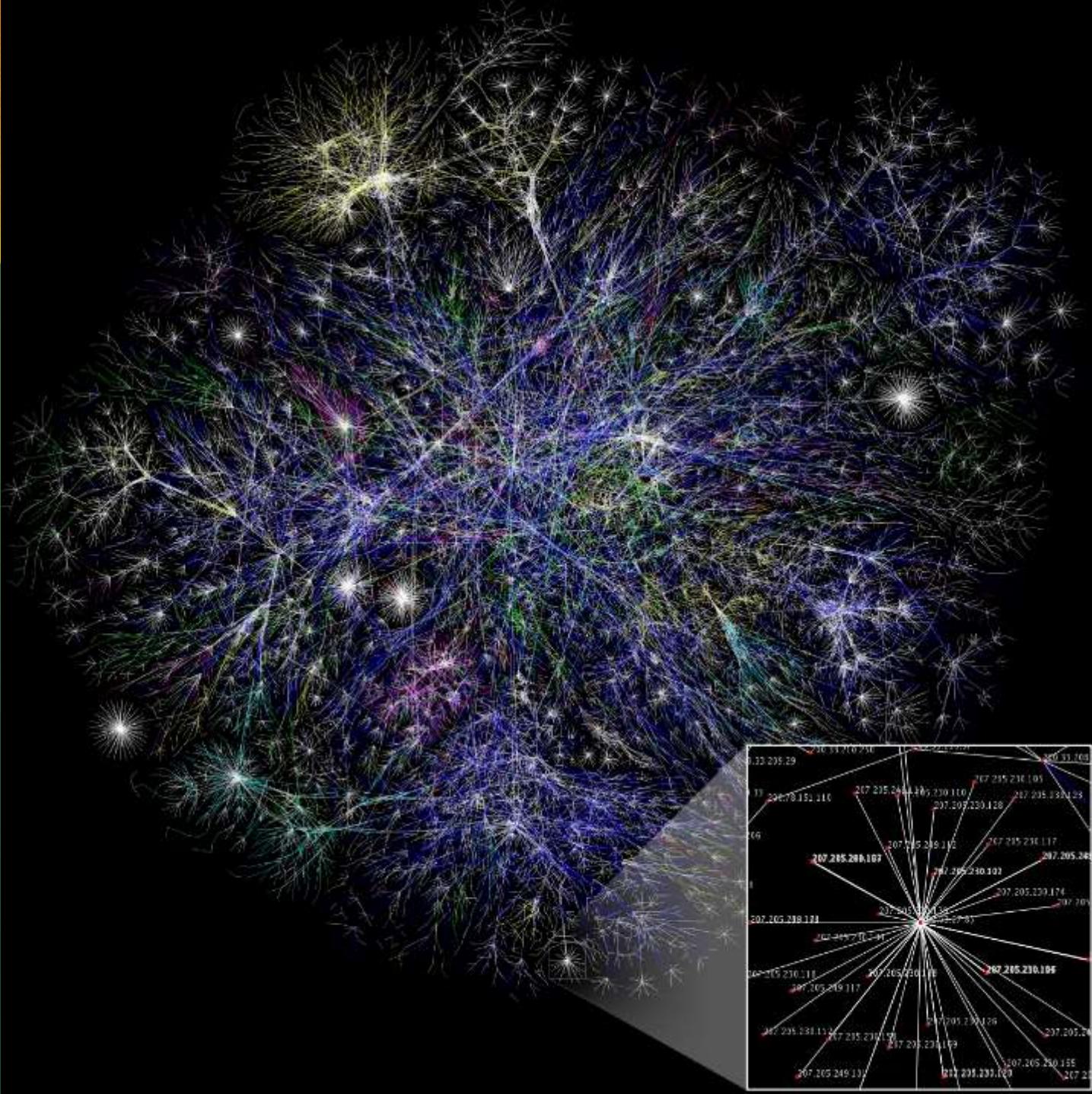
Tree Web



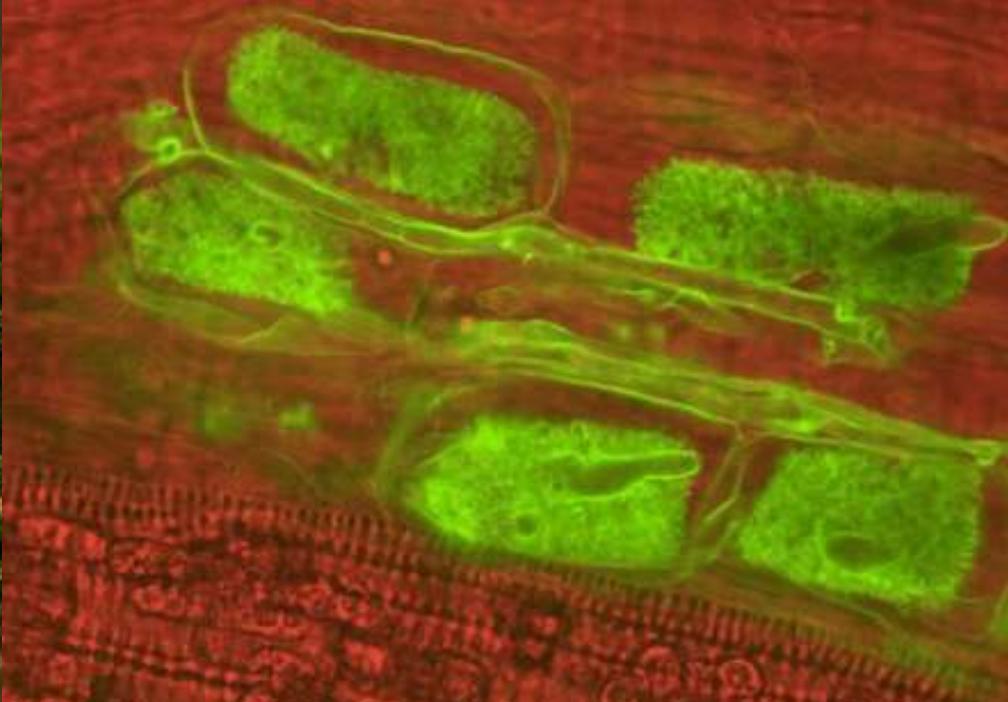
The Cosmic Web



W
W
W



Fungi Types



Root Fungi



Endophytes

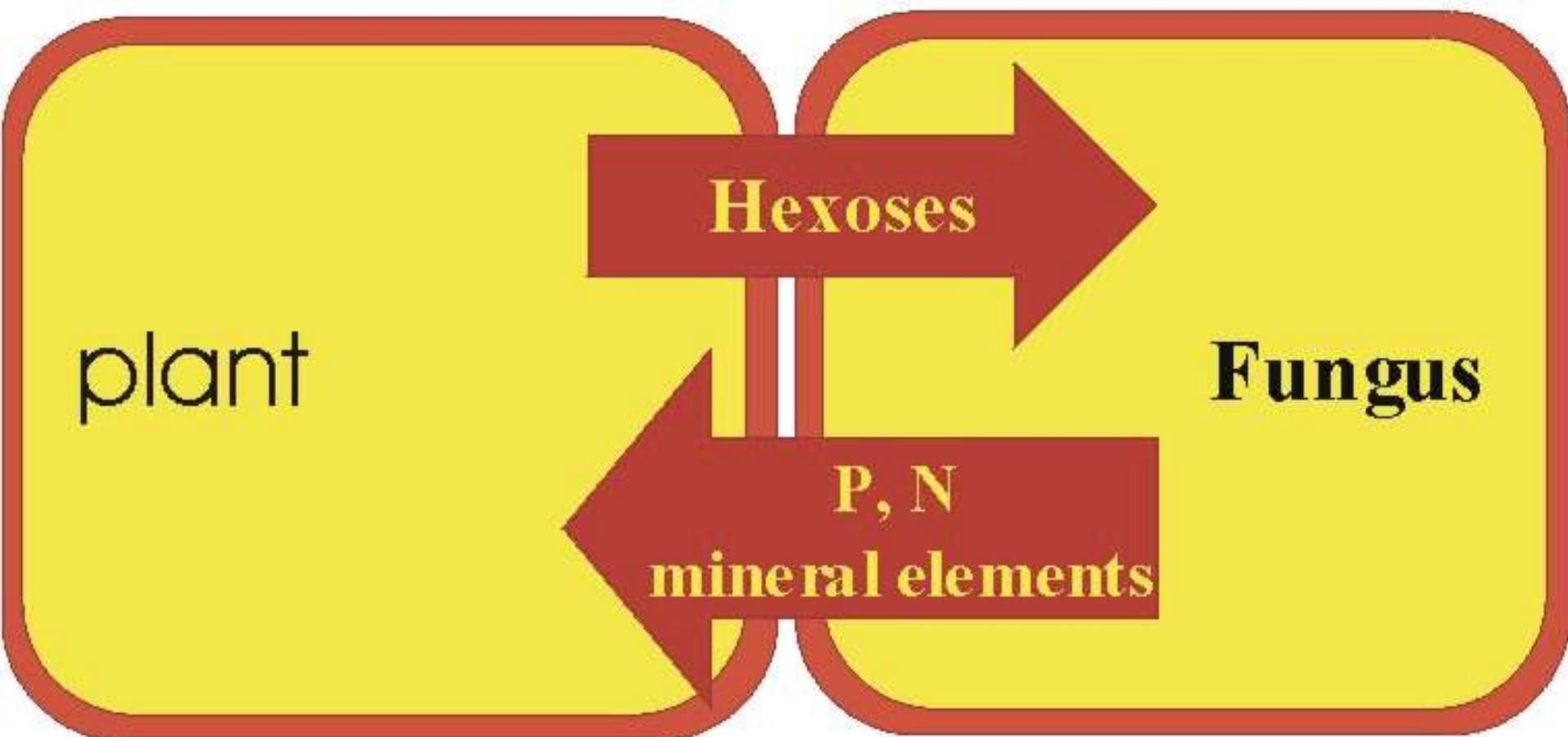
Decomposers

Root Fungi (Mycorrhizal)

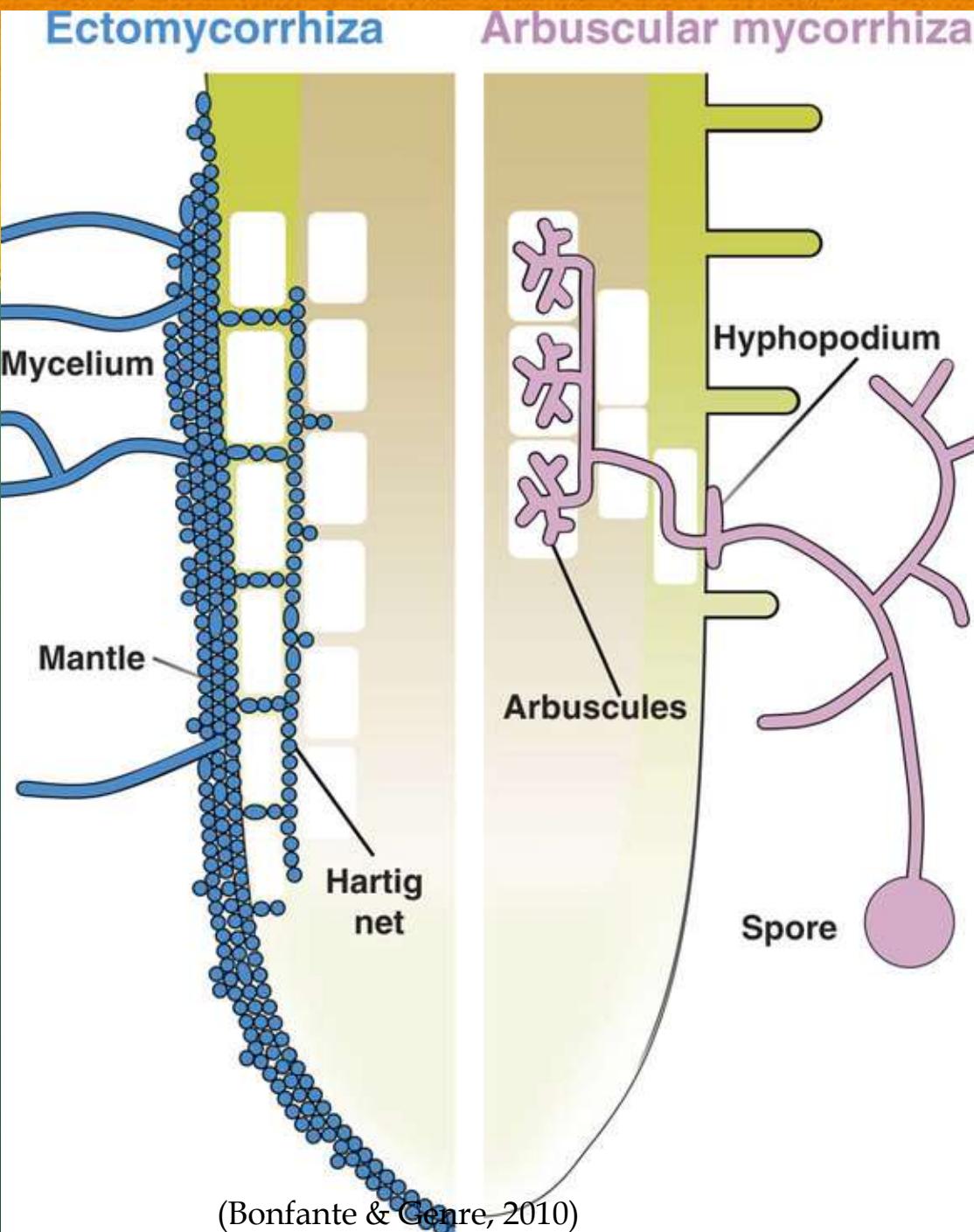
- Nutrient exchange
- Distribution
- Protection
- Immunity
- Communication



Nutrient Exchange



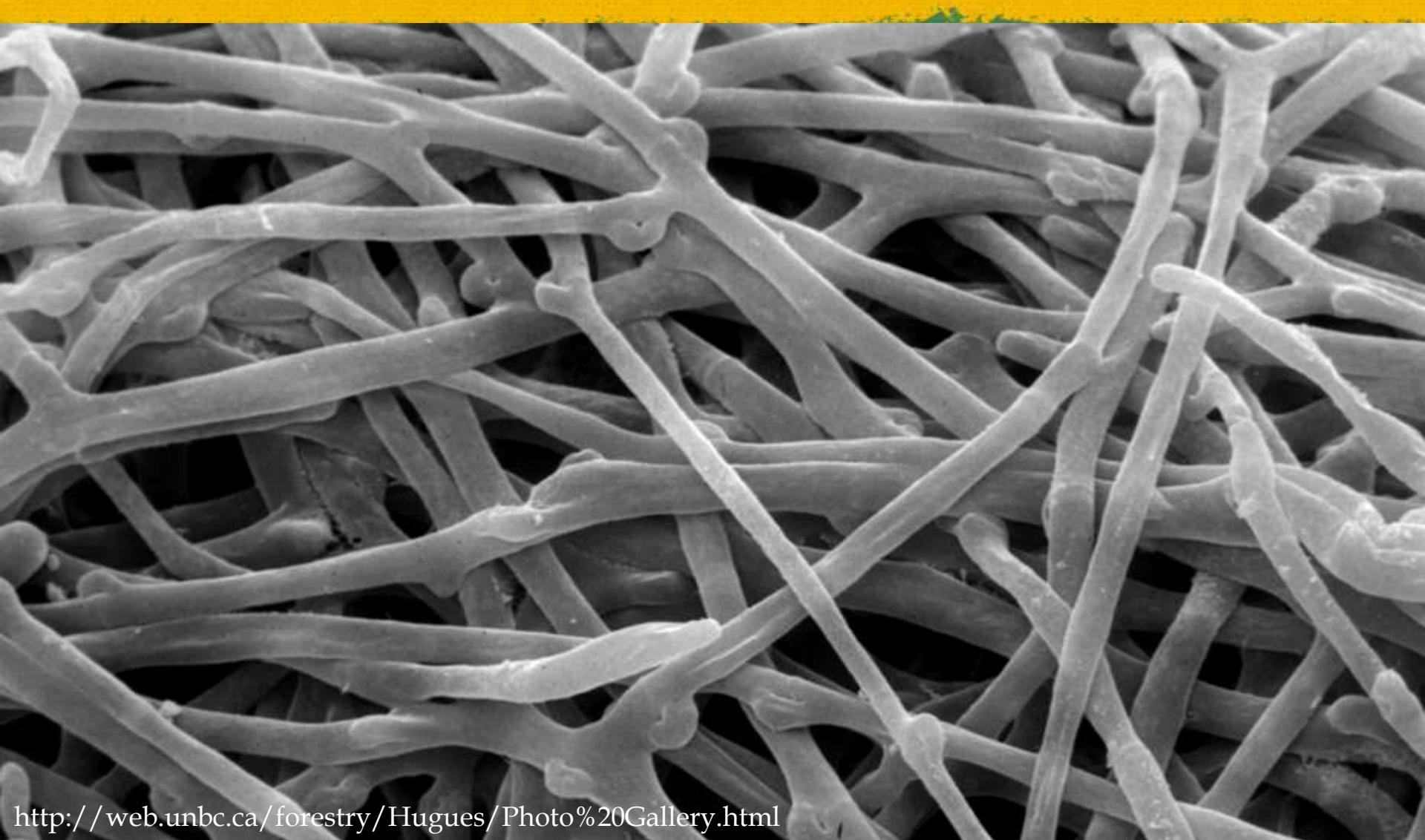
Types of root fungi



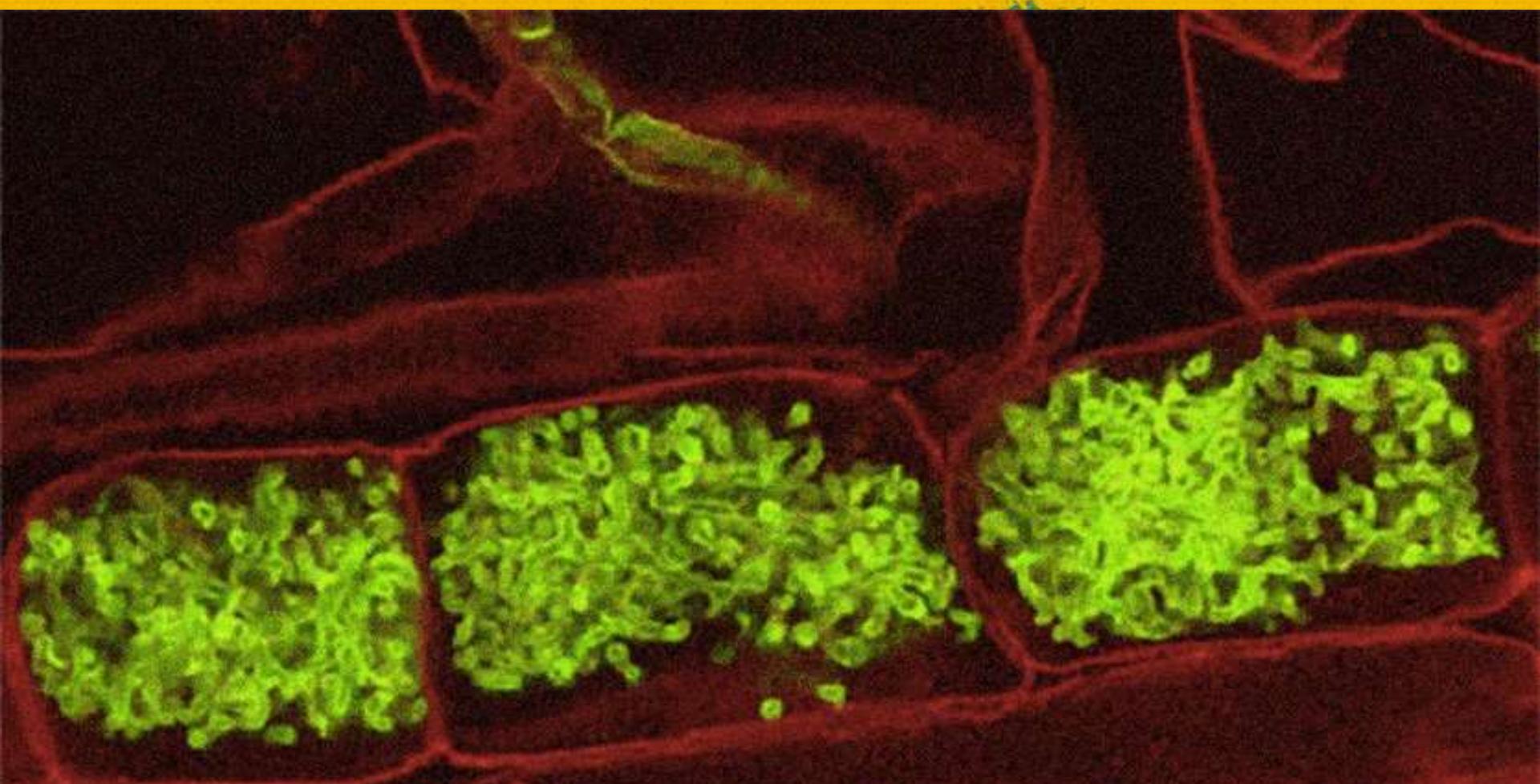
Mycelium = My silly arm



Enlarged Mycelium

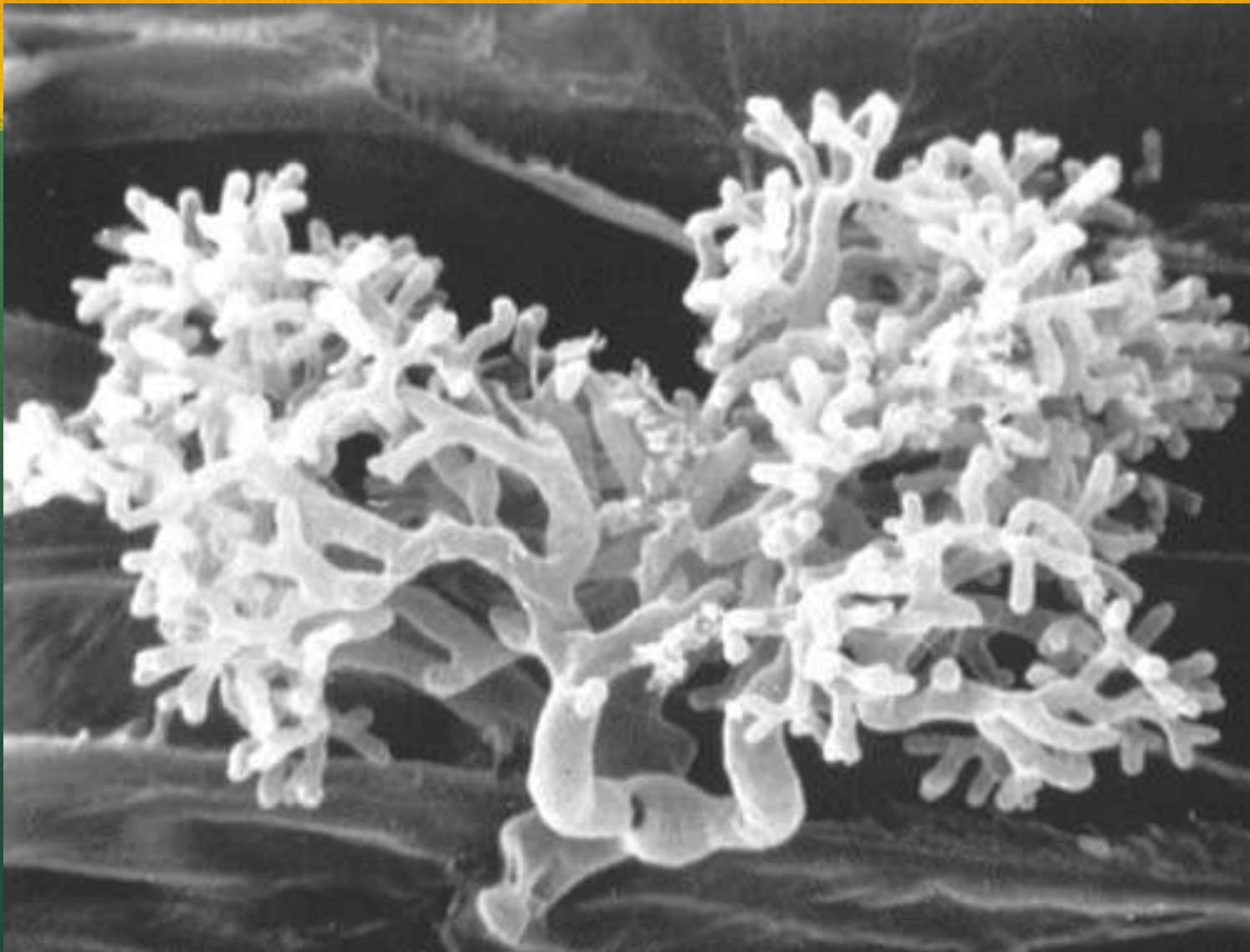


Arbuscular – Little Trees



Arbuscules in root cells: Maria J Harrison, BTI
<https://cosmosmagazine.com/biology/symbiotic-connections-of-plants-and-fungi>

Arbuscule - Little Tree



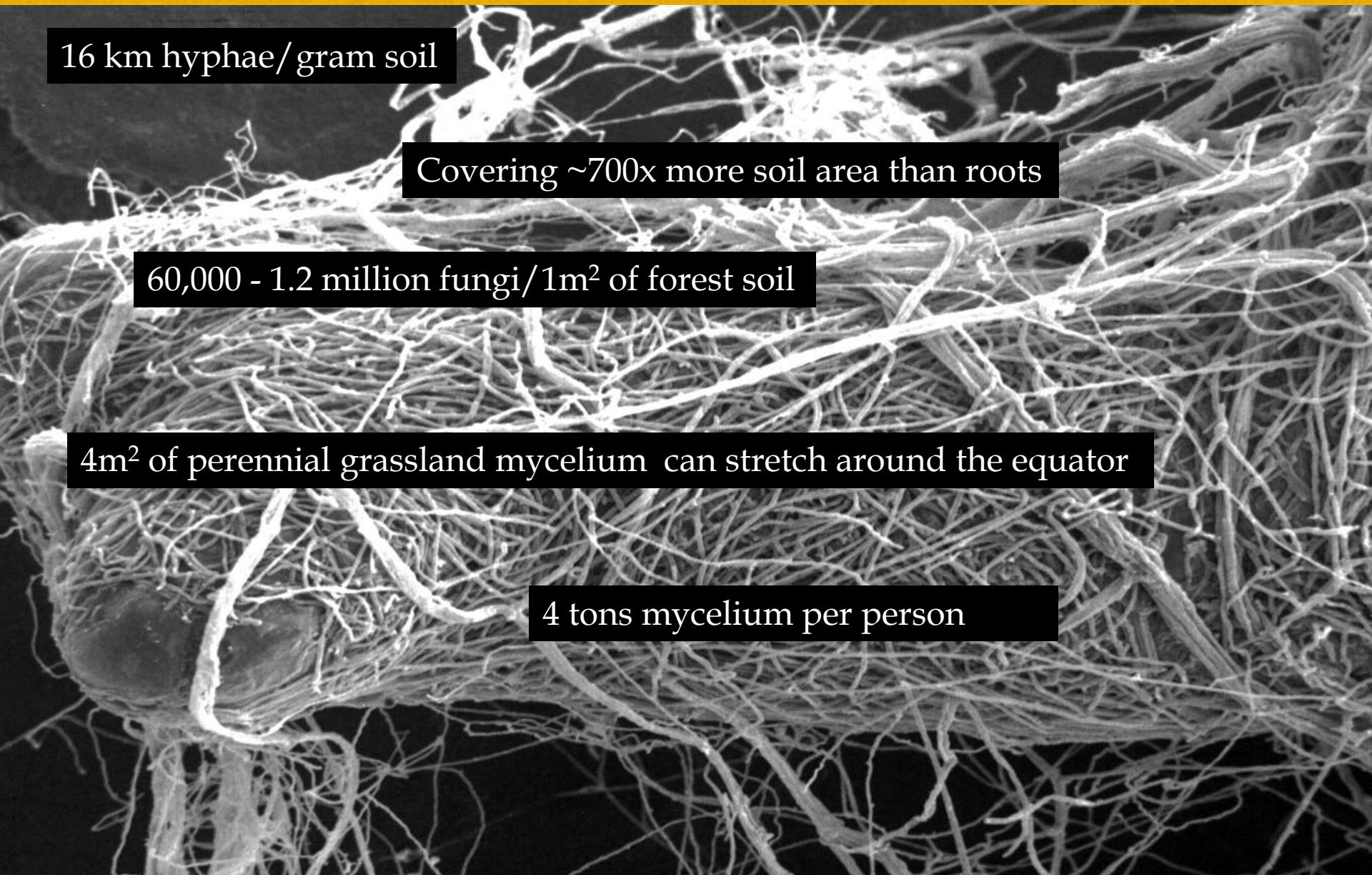
Mature arbuscules with finely branched hyphae © Mycotown Greentech AG
<https://www.bioökonomie-bw.de/en/articles/news/mykotown-greentech-ag-uses-mycorrhiza-to-keep-plants-going/>

The Wood Wide Web



Cooperative and equal distribution of resources within the community

Mycorrhizal fungi facts

A scanning electron micrograph (SEM) showing a dense, intricate network of white, branching mycorrhizal fungi hyphae against a dark background. The hyphae are thin and delicate, creating a complex web-like structure.

16 km hyphae/ gram soil

Covering ~700x more soil area than roots

60,000 - 1.2 million fungi/1m² of forest soil

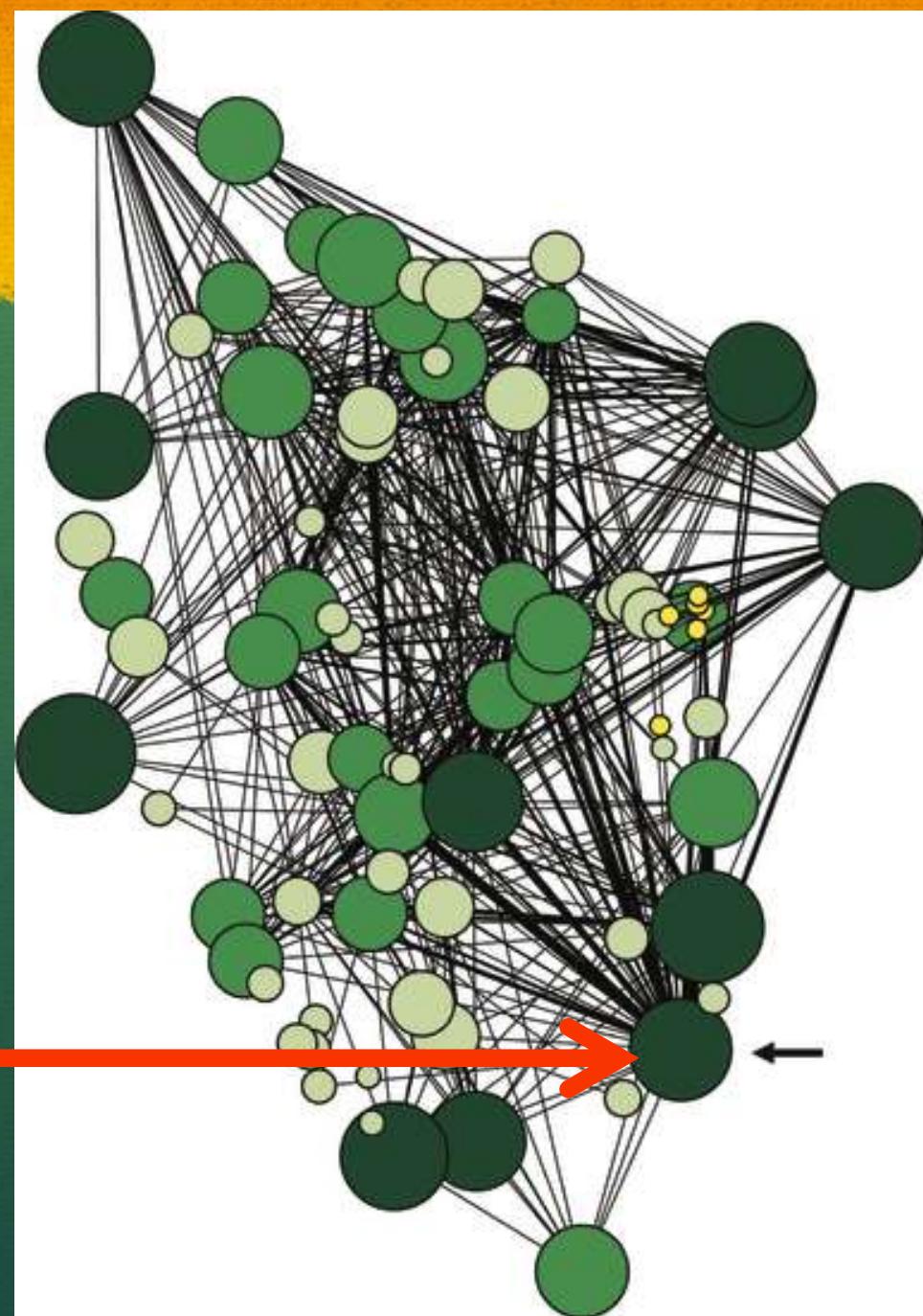
4m² of perennial grassland mycelium can stretch around the equator

4 tons mycelium per person

Wood Wide Web

FOREST SUPERORGANISM

- One tree connected to 47 other trees (Beiler et al., 2010)





Birch



Douglass-fir

Sharing is
Caring

Coping with Climate Change

(Song et al., 2014)

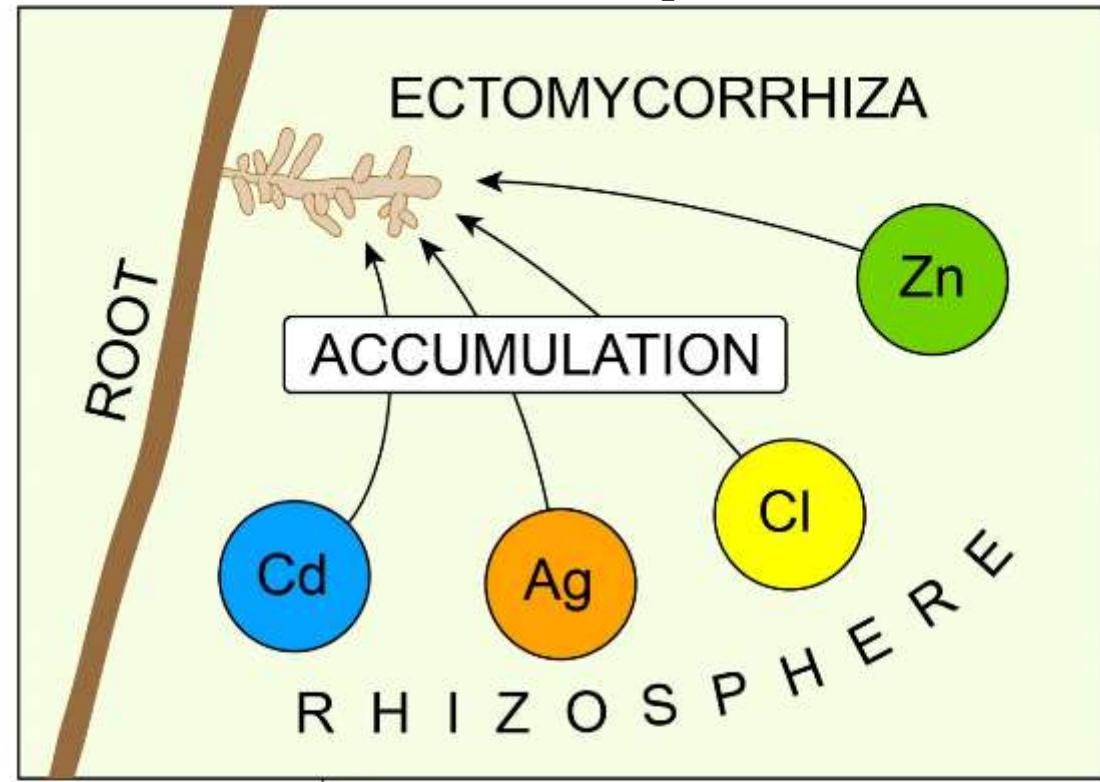
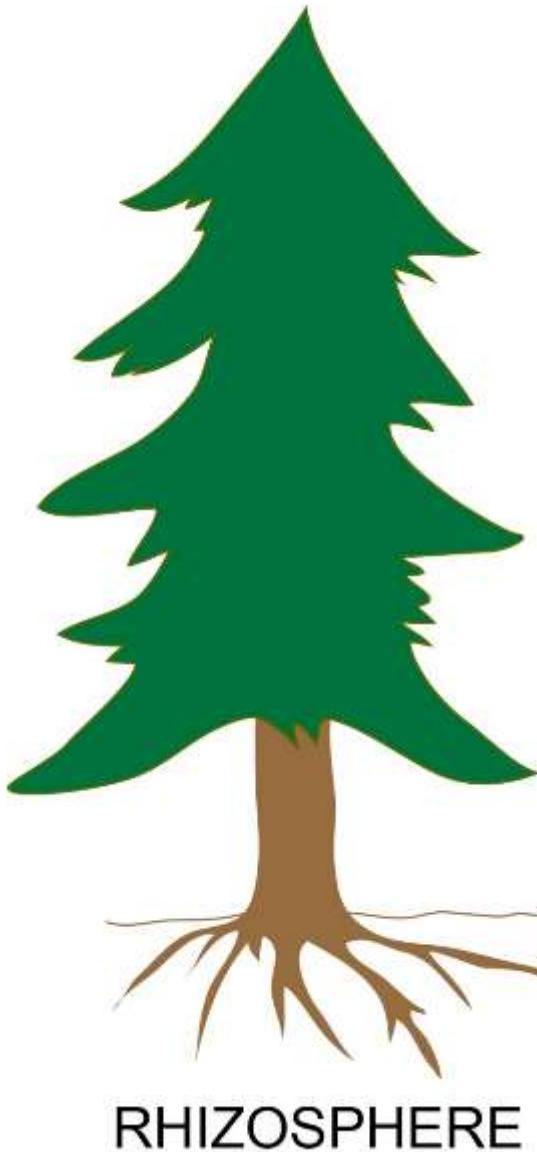


Douglas-Fir is being replaced with Ponderosa pine



Mycelium protects its host

Environmental Pollution, Impact Factor: 4.839



ECTOMYCORRHIZA
5% (w/w) FUNGUS
95% (w/w) PLANT

Myco-Remediation



Bioaccumulation



File:Paxillus involutus qt13.jpg

Radioactive Waste

Fukushima



Bioaccumulation

Gomphidius glutinosus



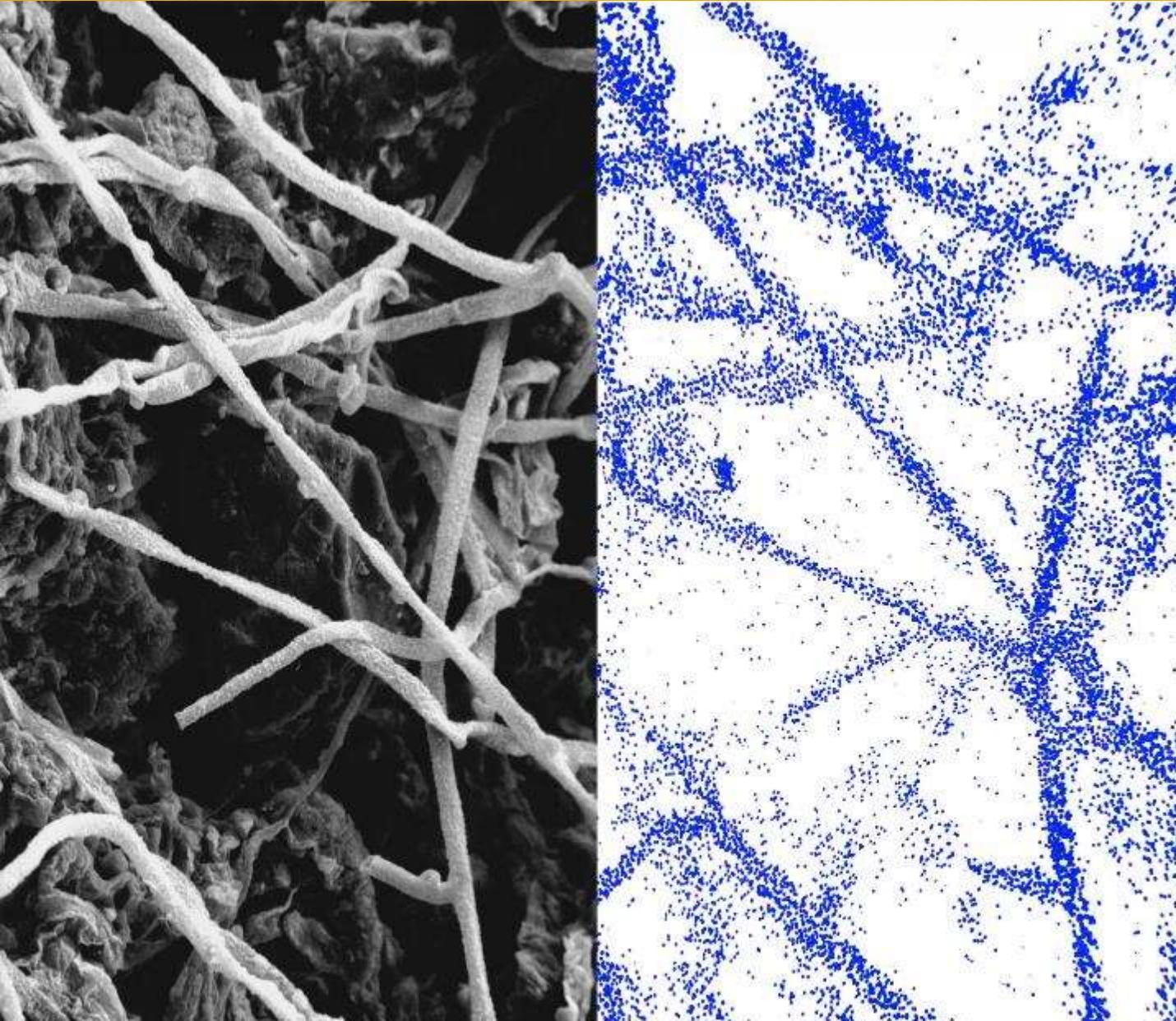
Accumulates caesium 137 - 10 000 x above background radiation

Agriculture





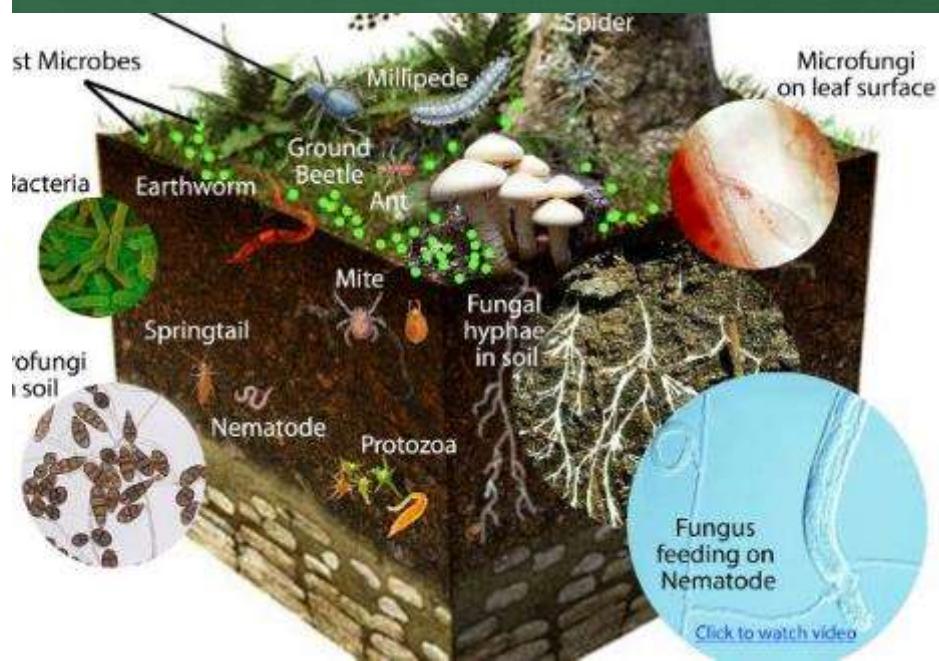
CO_2 Sequestration



Soil Aggregation



- AM 28m/cm³ soil
= 54-900 kg SOC/ha
- Fire absence > 1m humus
 - 6.2kg C/m² - 585 yrs
 - 22.5kg C/m² - 3250 yrs

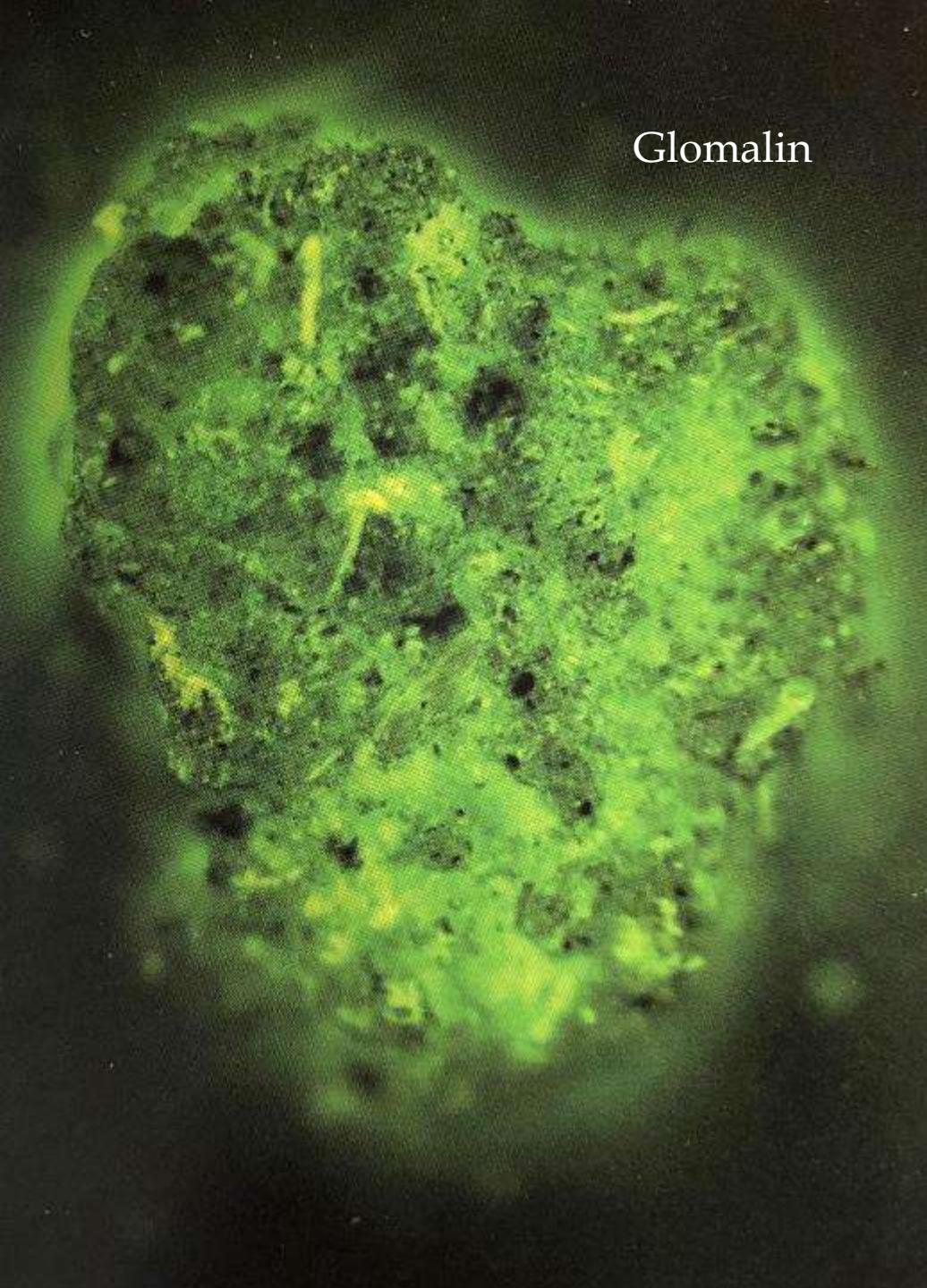


[Click to watch video](#)

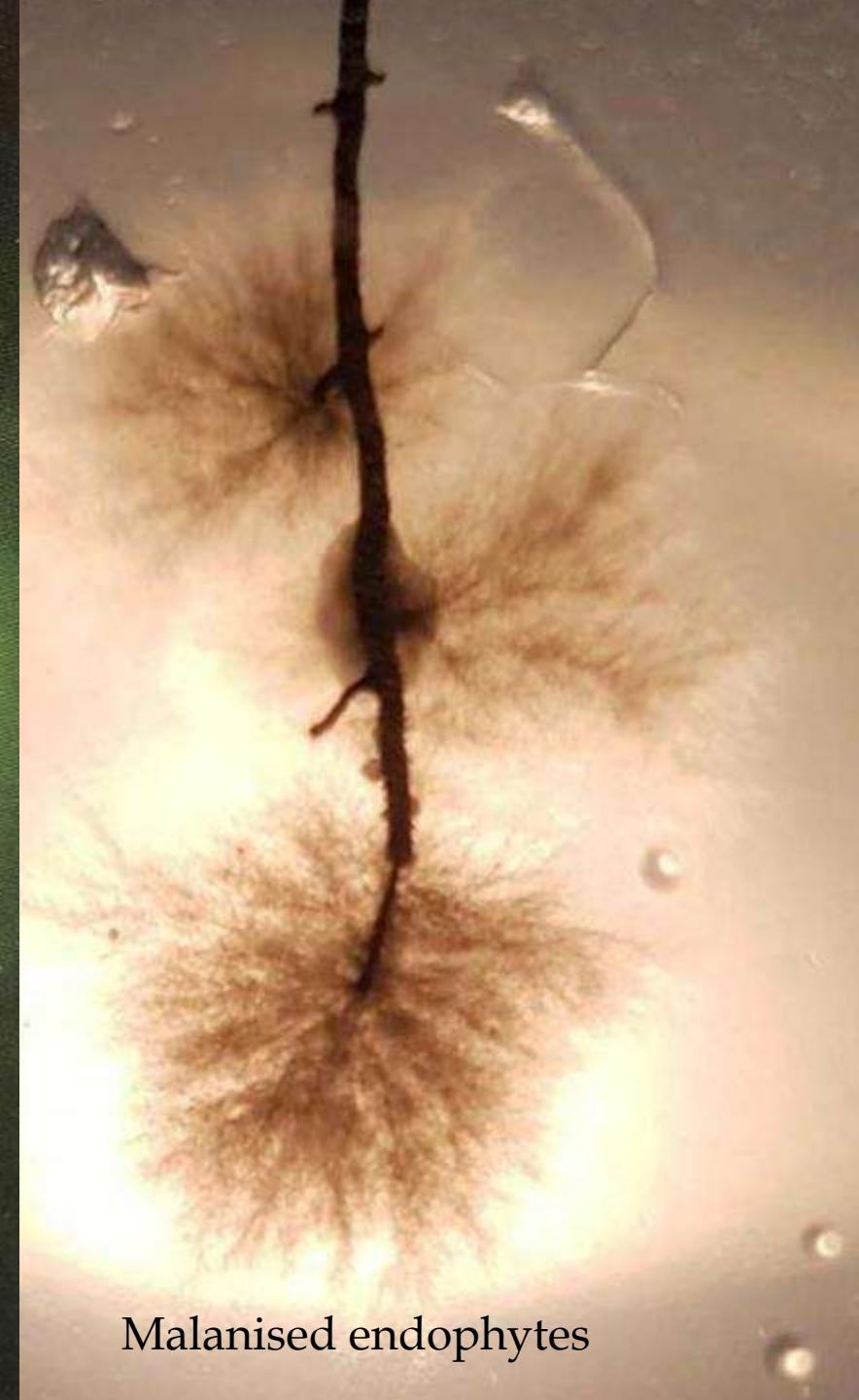
Aggregation



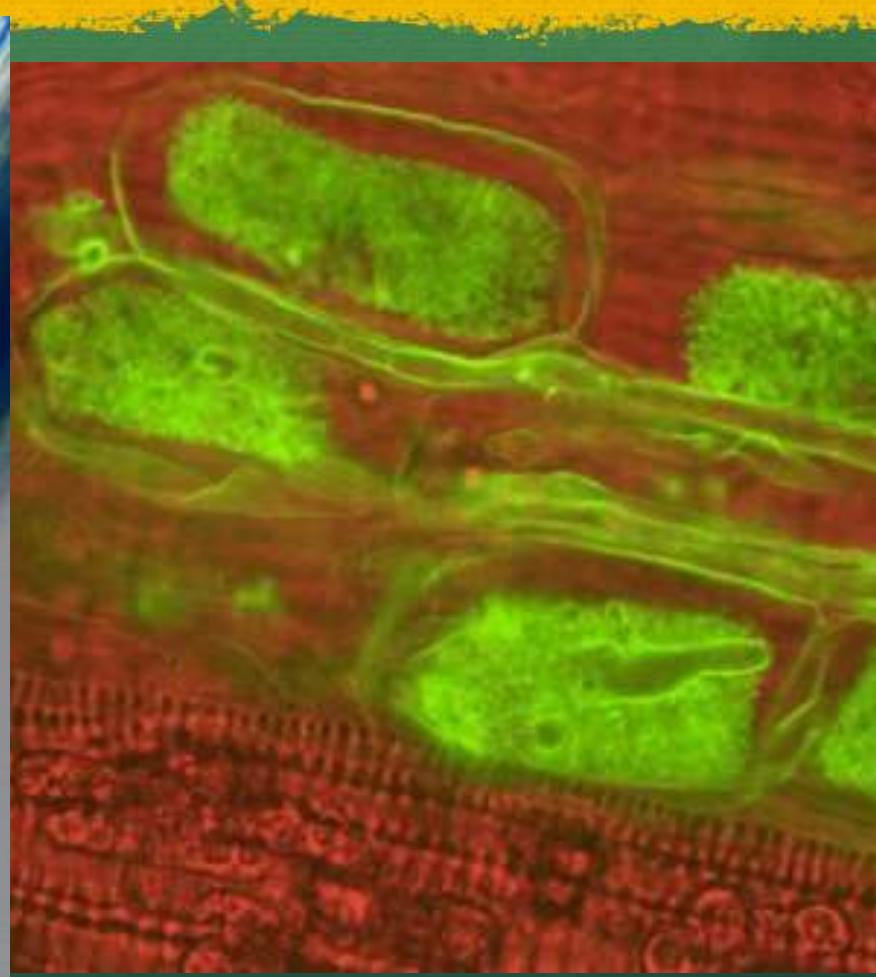
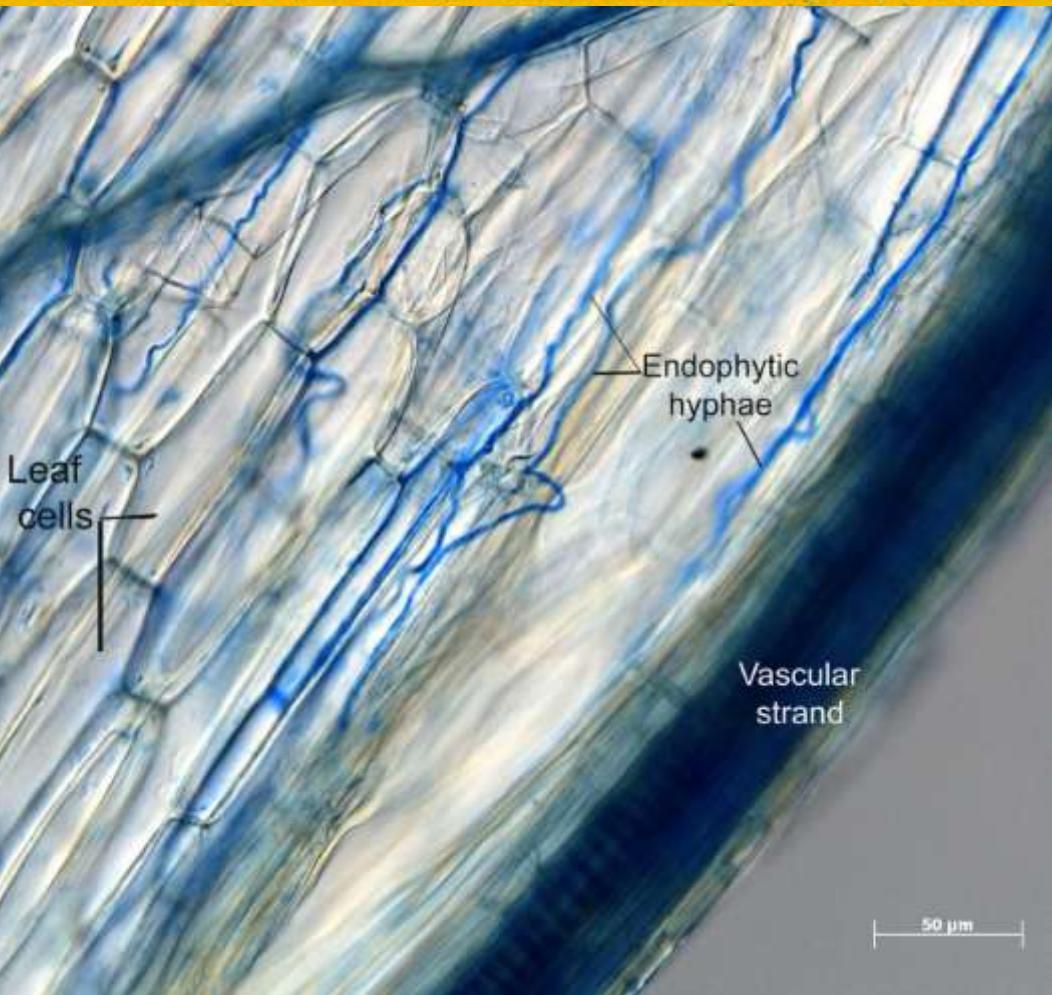
Glomalin



Malanised endophytes



Endophytes - Within Plant



Provide plant superpowers

Endophyte - Decomposer

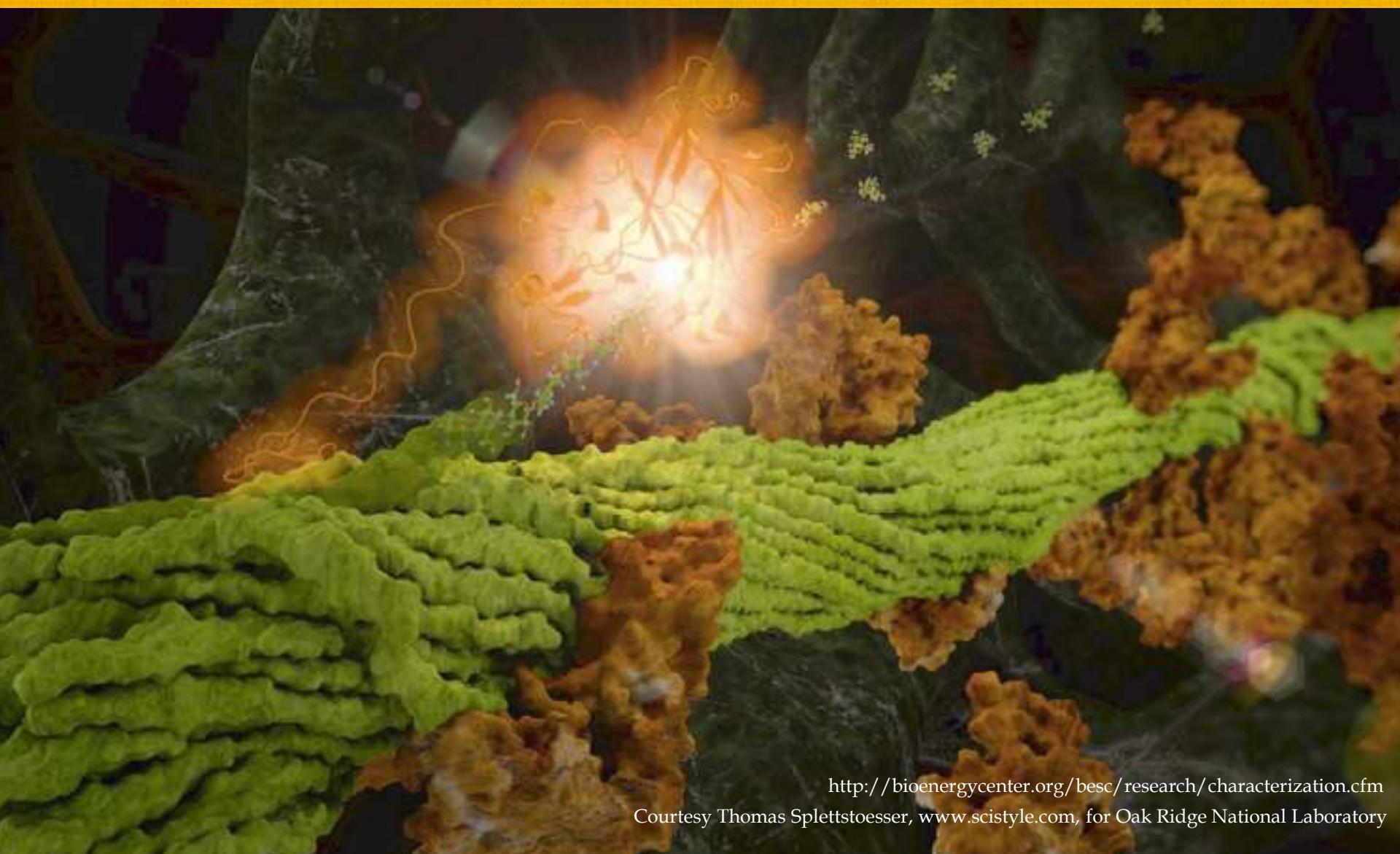


Phillipsia subpurpurea – Steve Axforf



Steve Axford

Wood Digestion by Enzymes



<http://bioenergycenter.org/besc/research/characterization.cfm>

Courtesy Thomas Splettstoesser, www.scistyle.com, for Oak Ridge National Laboratory

Cellulose

Degradation



Brown Rot



White Rot



Degradation



Lignin

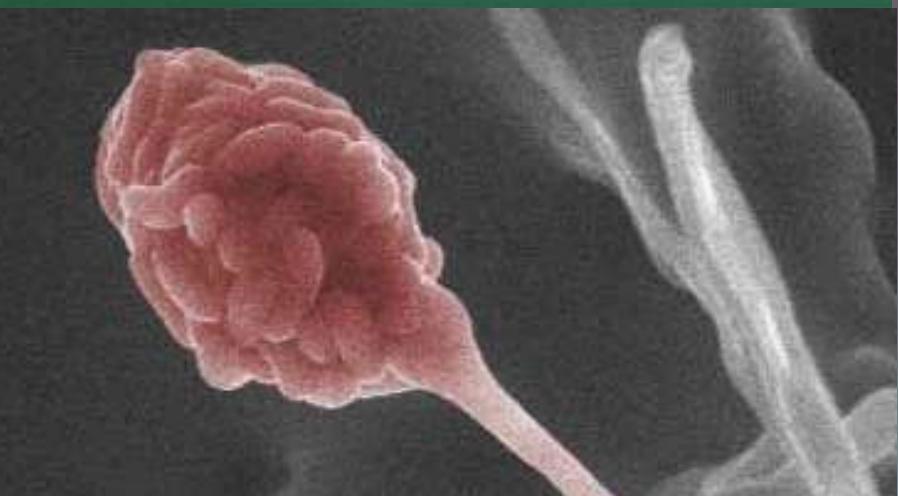
“Fossil” fuels =
Forest Fungi fuels



Myco-Diesel

(Strobel et al., 2008)

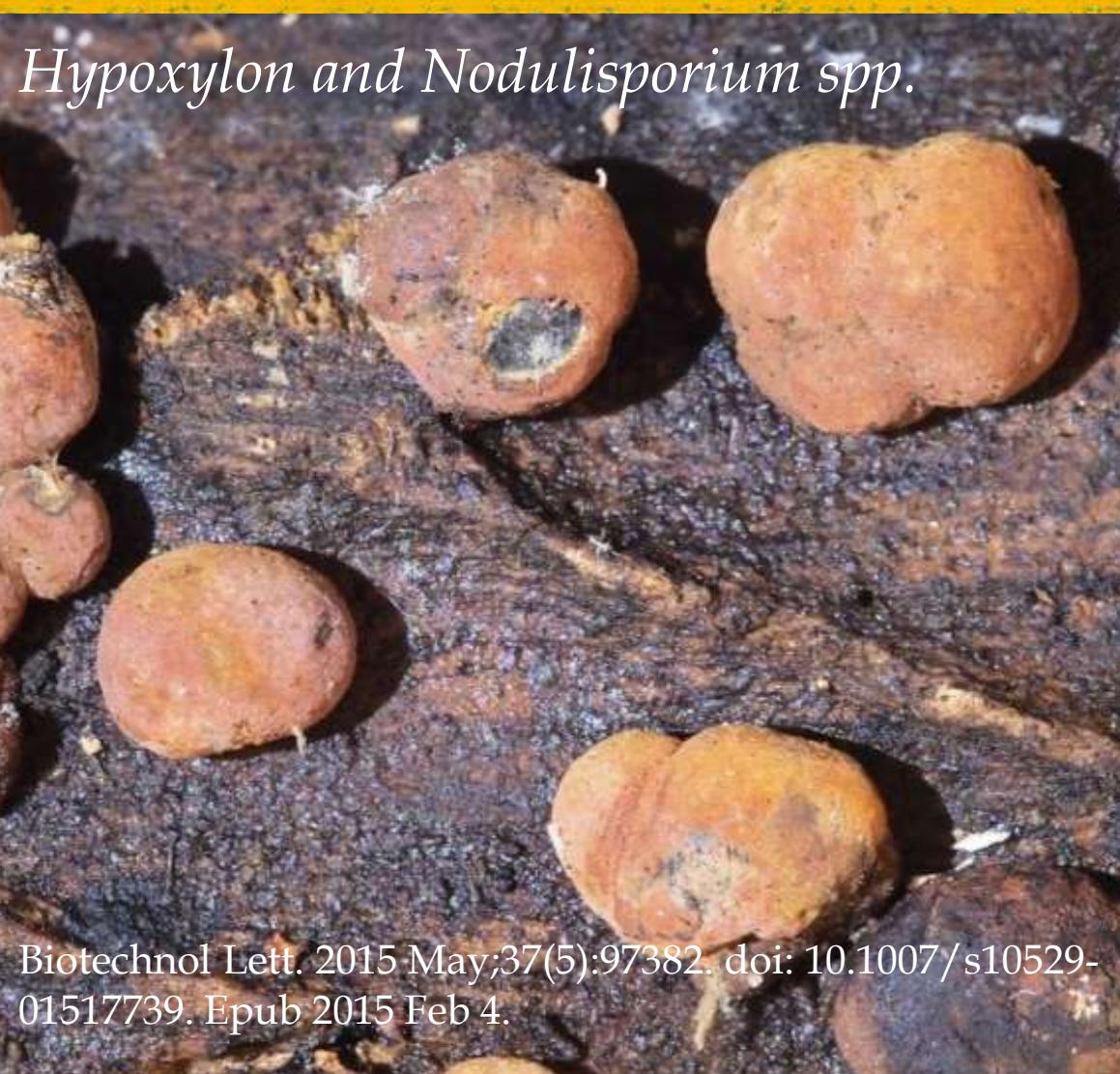
- *Gliocladium roseum* - Patagonian rainforest
- Diesel-like hydrocarbons
- Sustainable, cheaper, non-corrosive



Petroleum Cyclohexenes

(Strobel, 2015)

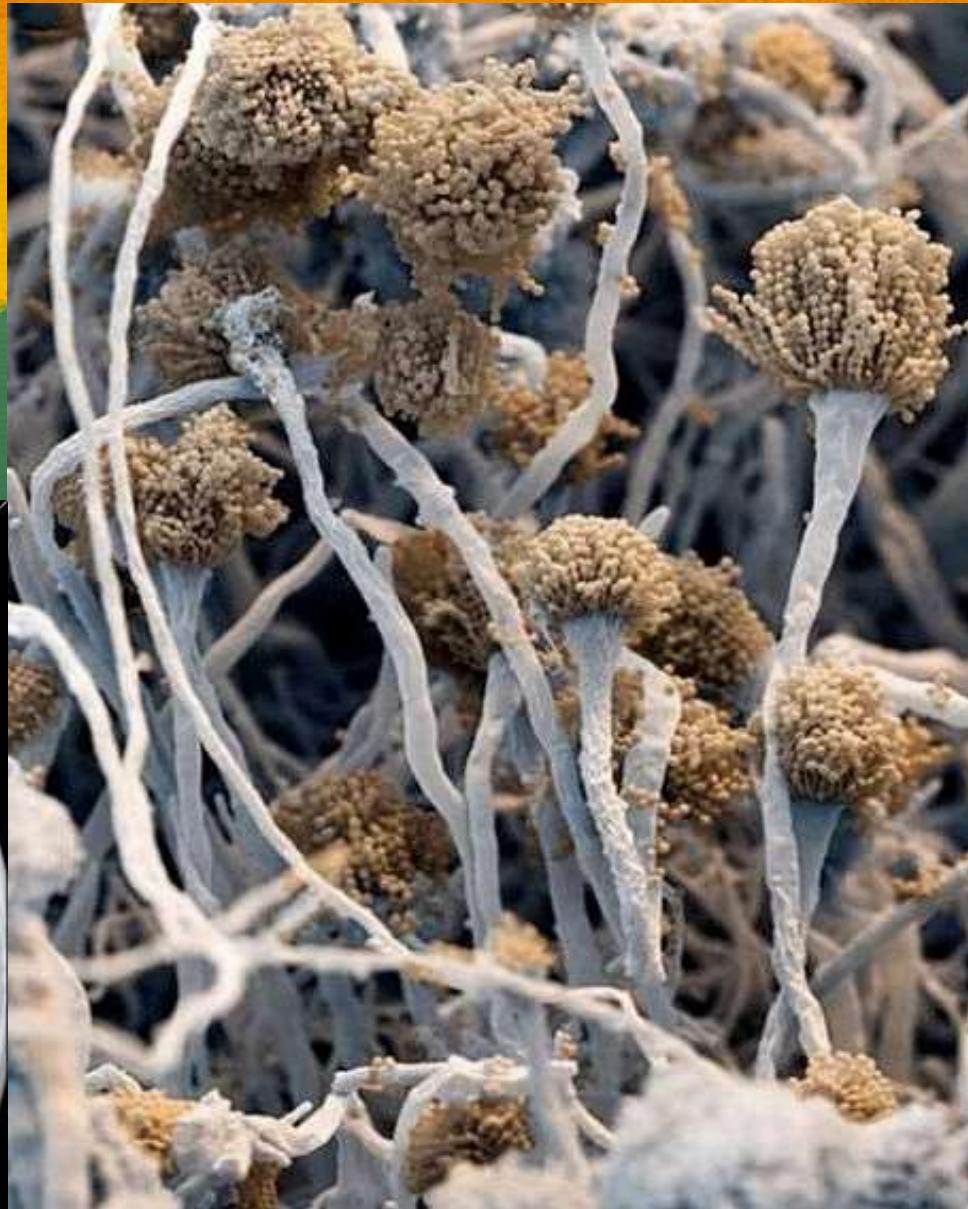
Hypoxyylon and *Nodulisporium* spp.



- Cineole = Eucalyptus oil terpine
- 8 cineole : 1 gasoline = octane 95
- > energy than ethanol
- Fermentation
- Jet fuel

Amazon fungi make biofuels

- *Aspergillus fumigatus*
thermoacidophile

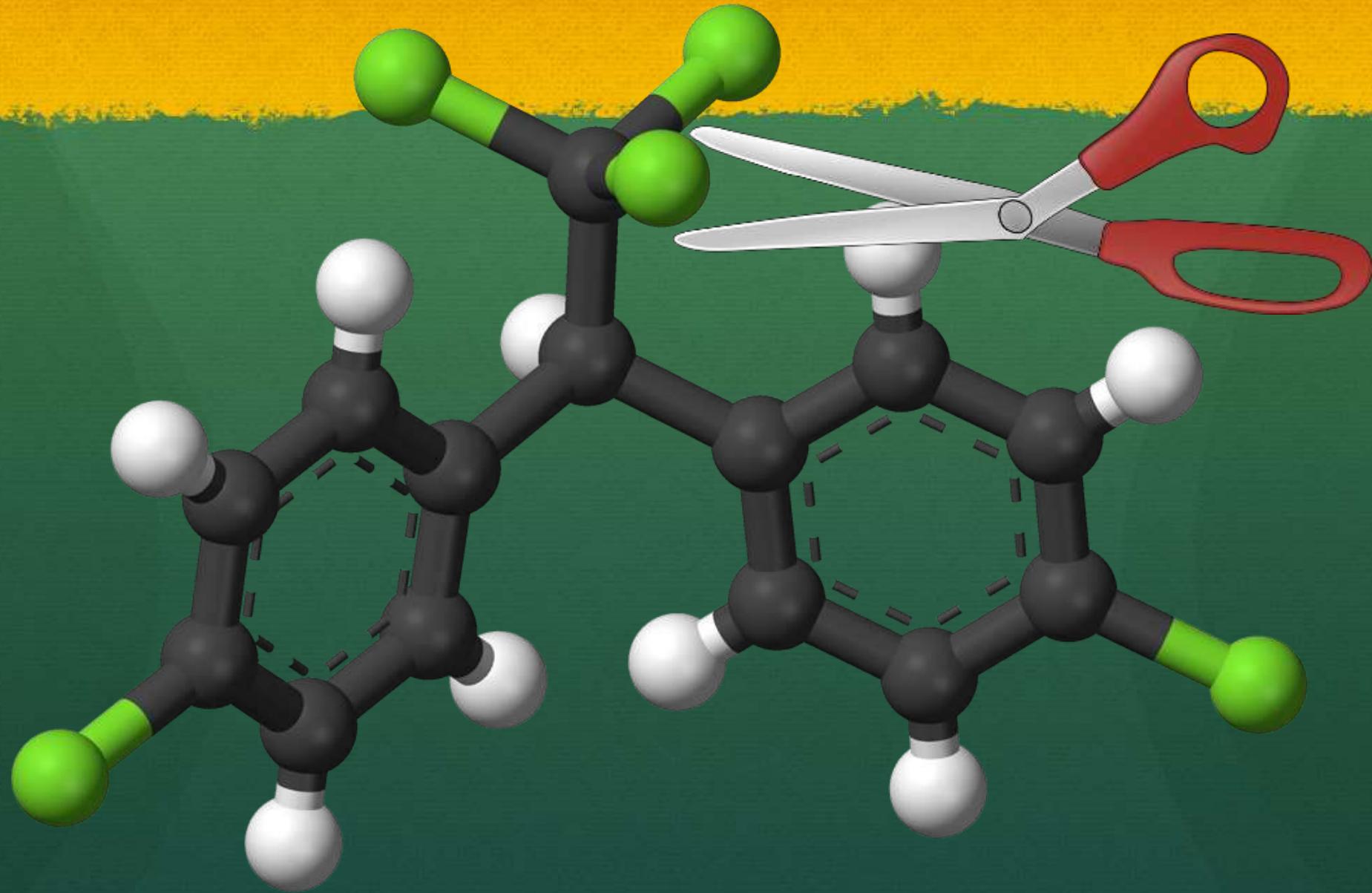


Ethanol production

Things made of fungi fuel



Fungal enzymes can digest pollutants



Endophyte Eats Plastic

(Russel et al., 2011, Prof. Strobel's lab, Yale)



Amazon - Ecuador

- *Pestalotiopsis microspora* use Polyester Polyurethane
- Aerobically anaerobically



Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Microscopic view of Pestalotiopsis microspora

conidia showing transverse septations

5390074

Can fungi eat...

- 300 million tons plastic pa



Maybe we can help?

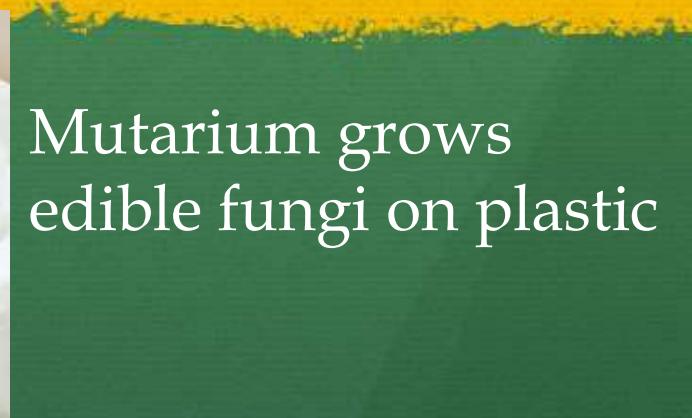


https://en.wikipedia.org/wiki/Schizophyllum_commune

Edible plastic eating fungi

Katharina Unger & Julia Kaisinger (LIVIN Studio)

Prof Han Wösten & Kasia Łukasiewicz (Utrecht University)



<http://www.livinstudio.com/fungi-mutarium/>



The Process

UV - activation cylinder



FU - agar capsule + starch + sugar



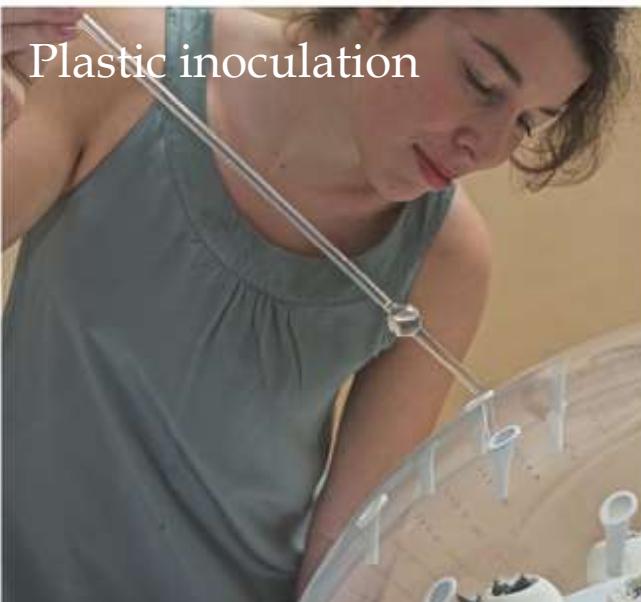
FU - fed with sterile plastic



Liquid fungal nursery



Plastic inoculation



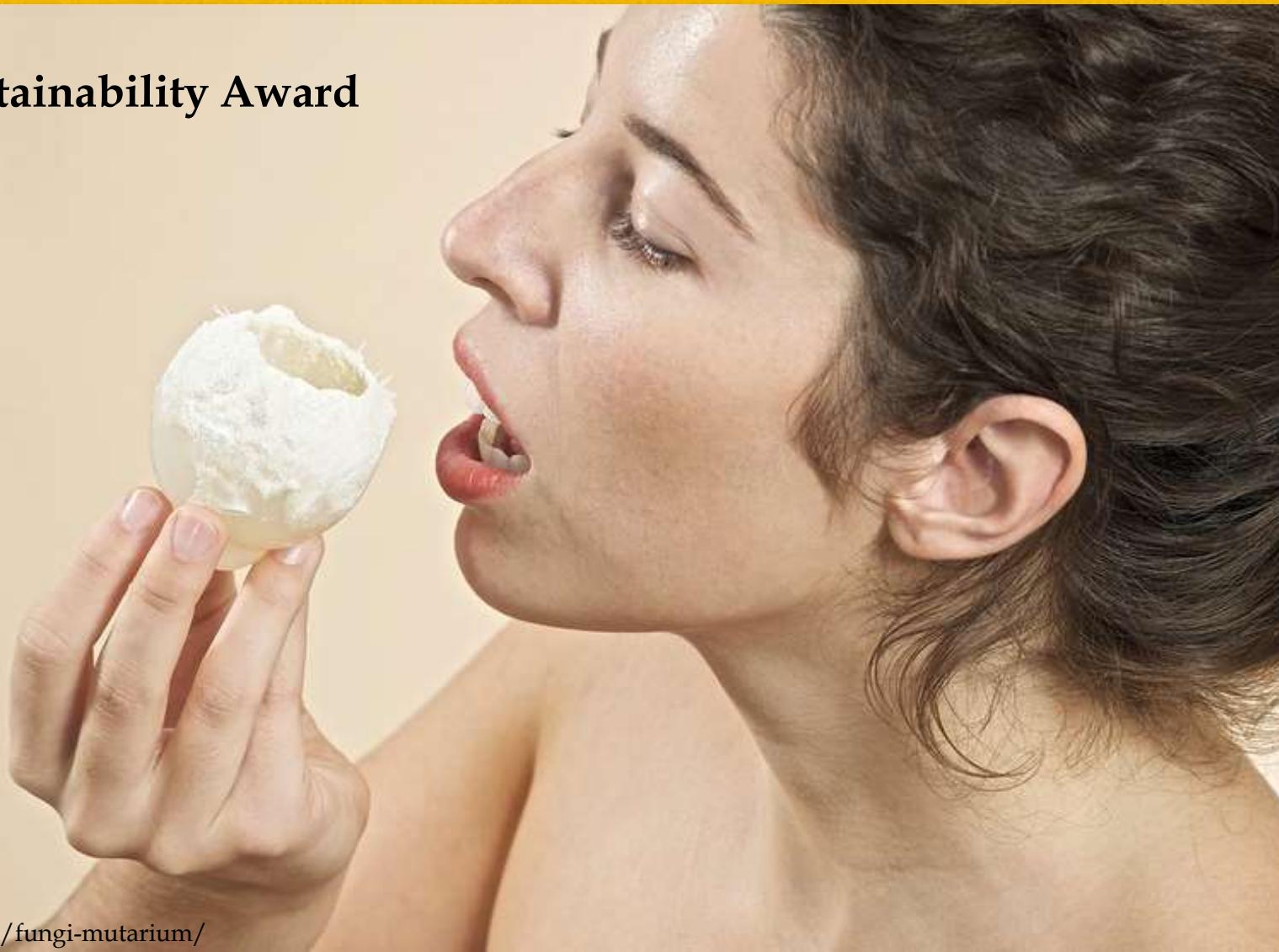
Edible FU after 2 week incubation





Bon Appetite Katarina!

**BraunPrize Sustainability Award
(2015)**

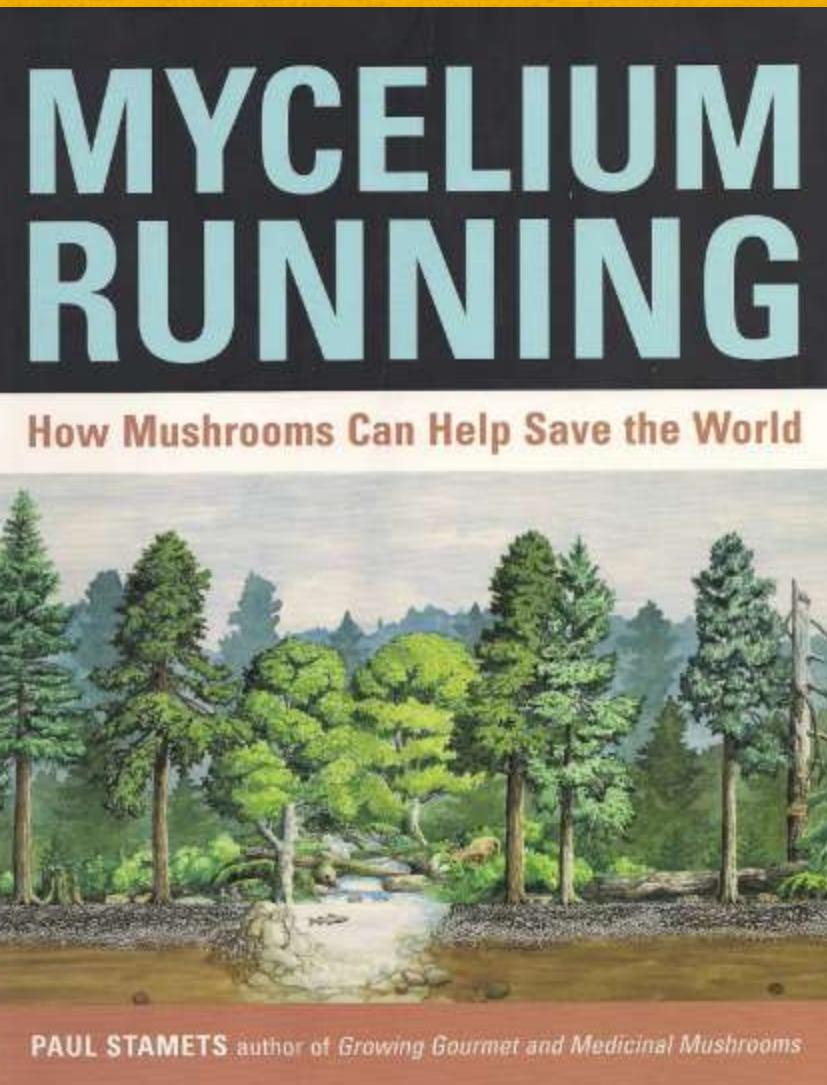


Fungi also eat



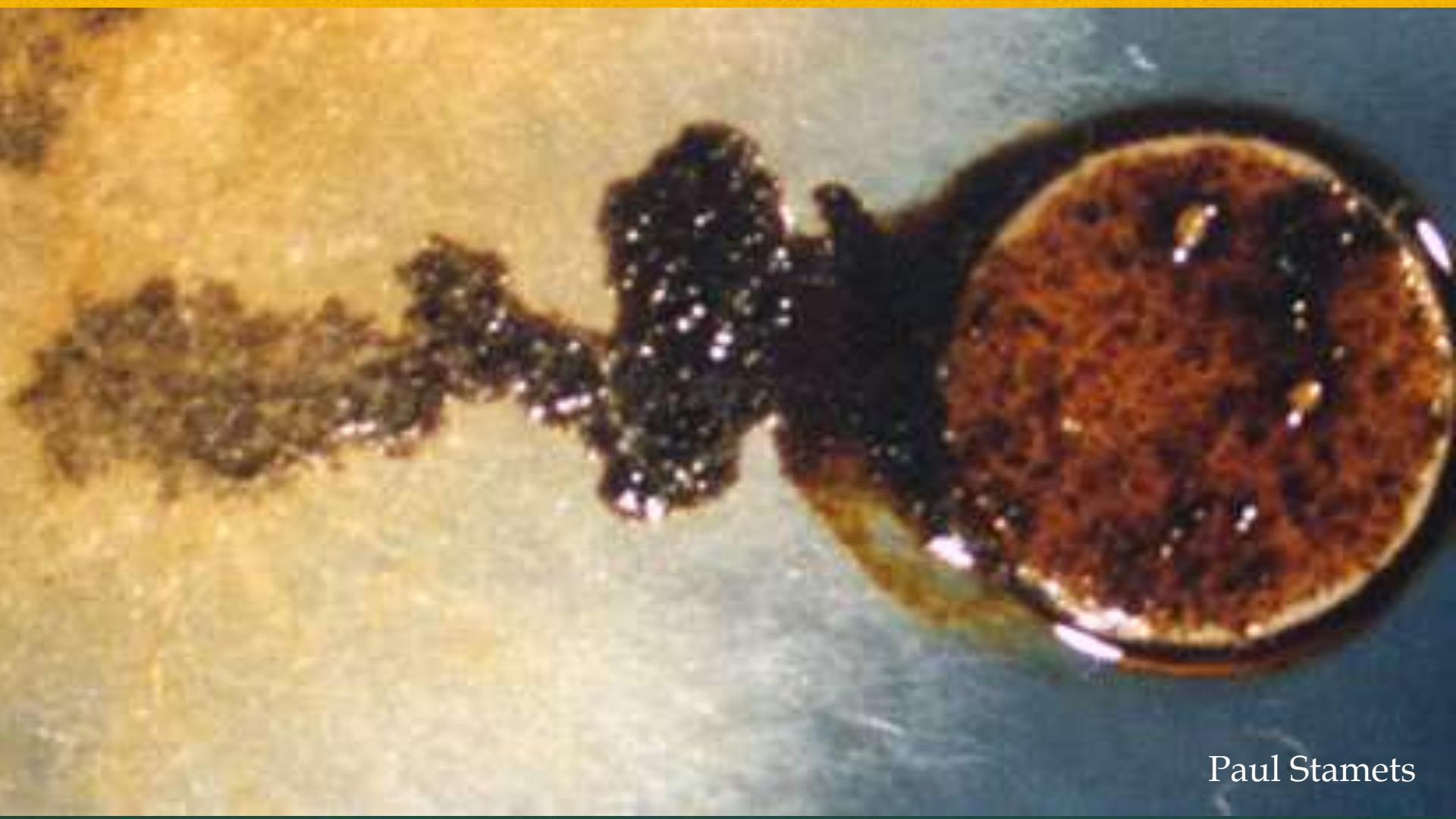
- Petroleum
- Pesticides
- Dioxins
- PCB, PCP
- Pathogens
- Nerve Gasses
- Explosives

Paul Stamets



PAUL STAMETS author of *Growing Gourmet and Medicinal Mushrooms*

Oyster Mushrooms eat petrochemicals



Paul Stamets



Fungi eat diesel



- Diesel soil + sawdust spawn + wood chip
- 97% PAHs converted into mushrooms in 8 weeks

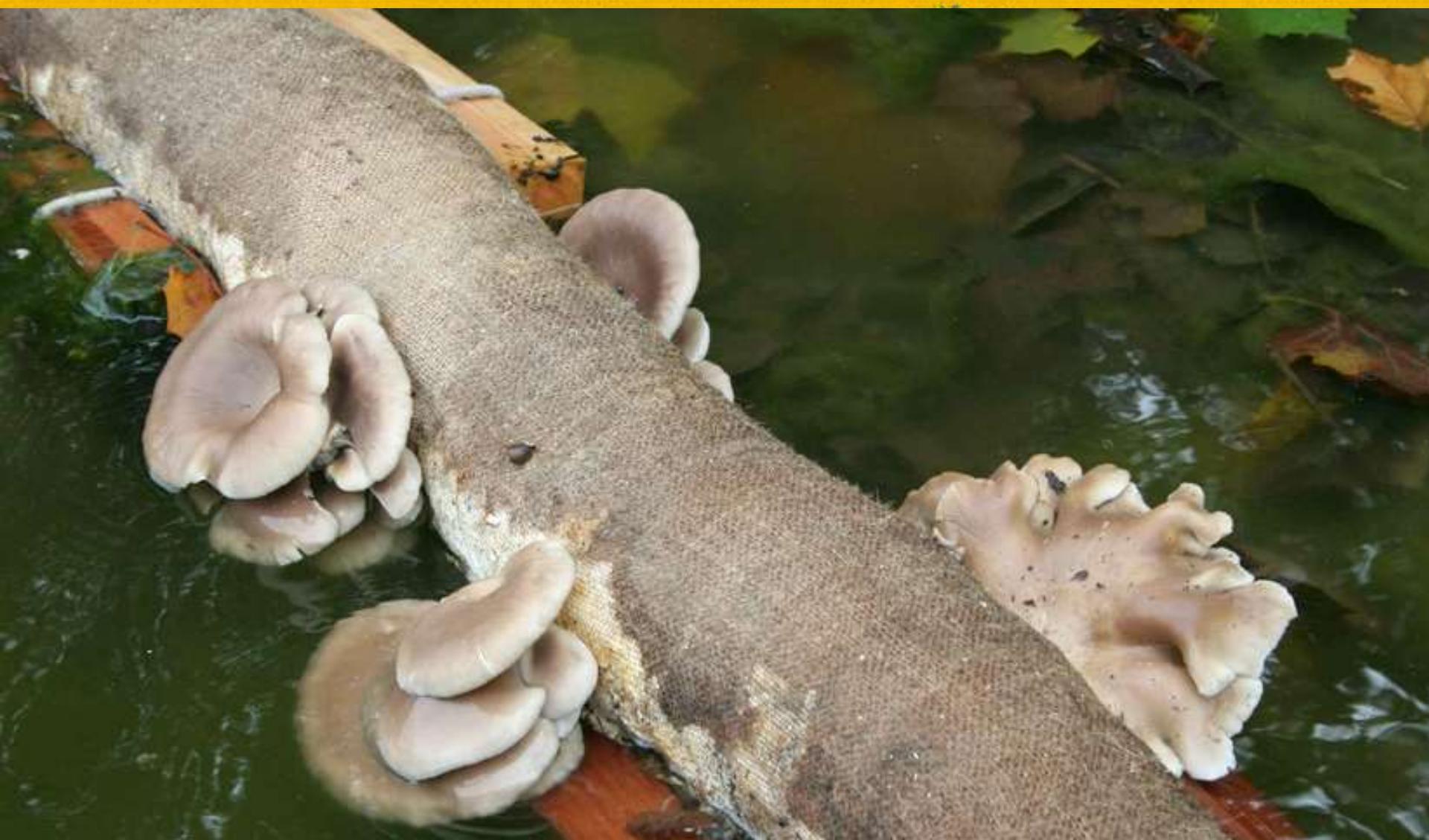
Myco-Booms™



Paul Stamets

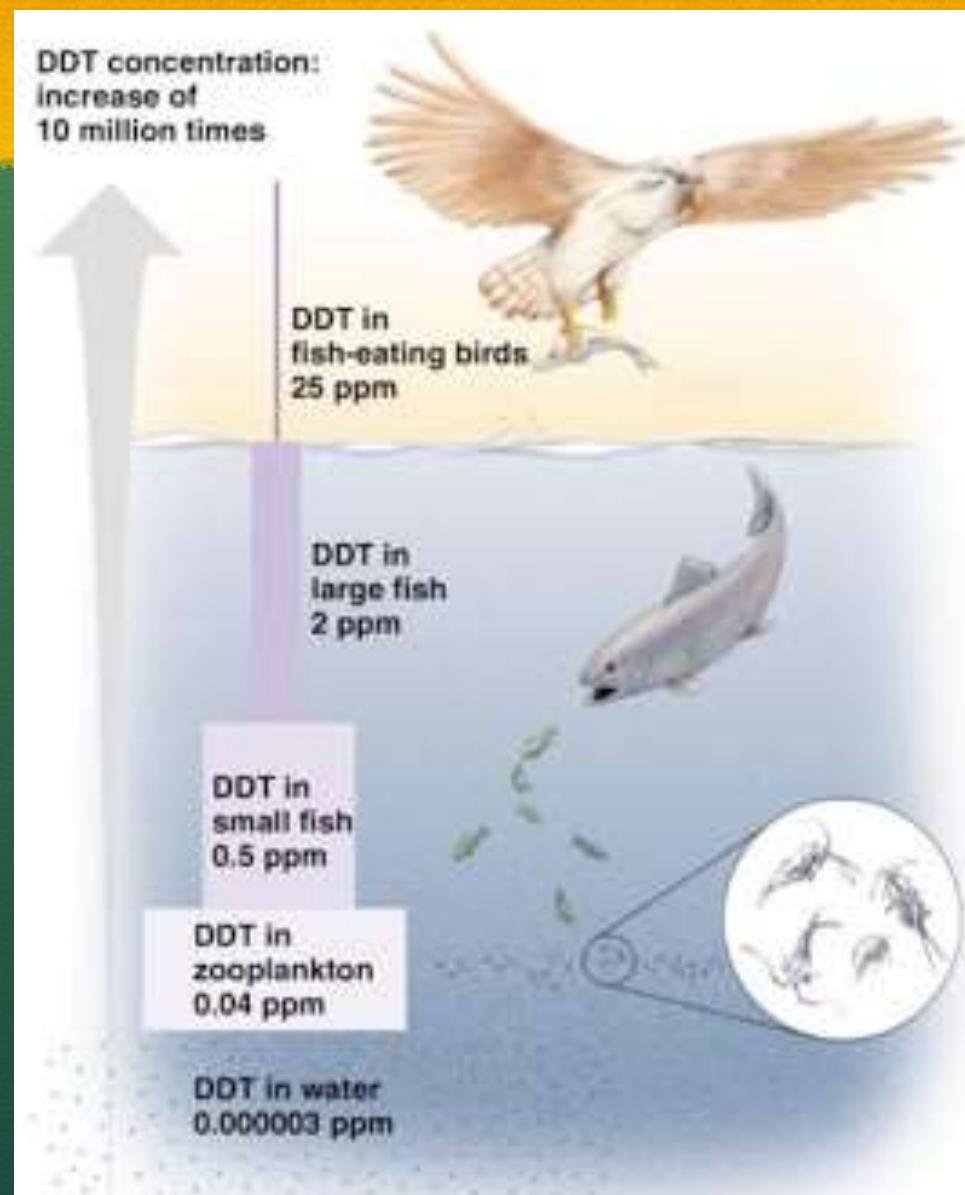
Straw colonised with oyster mushroom encased in hemp-tubes
<http://www.fungi.com/blog/items/the-petroleum-problem.html#sthash.Sy4geITu.dpuf>

Myco-Filters eat pathogens and toxins

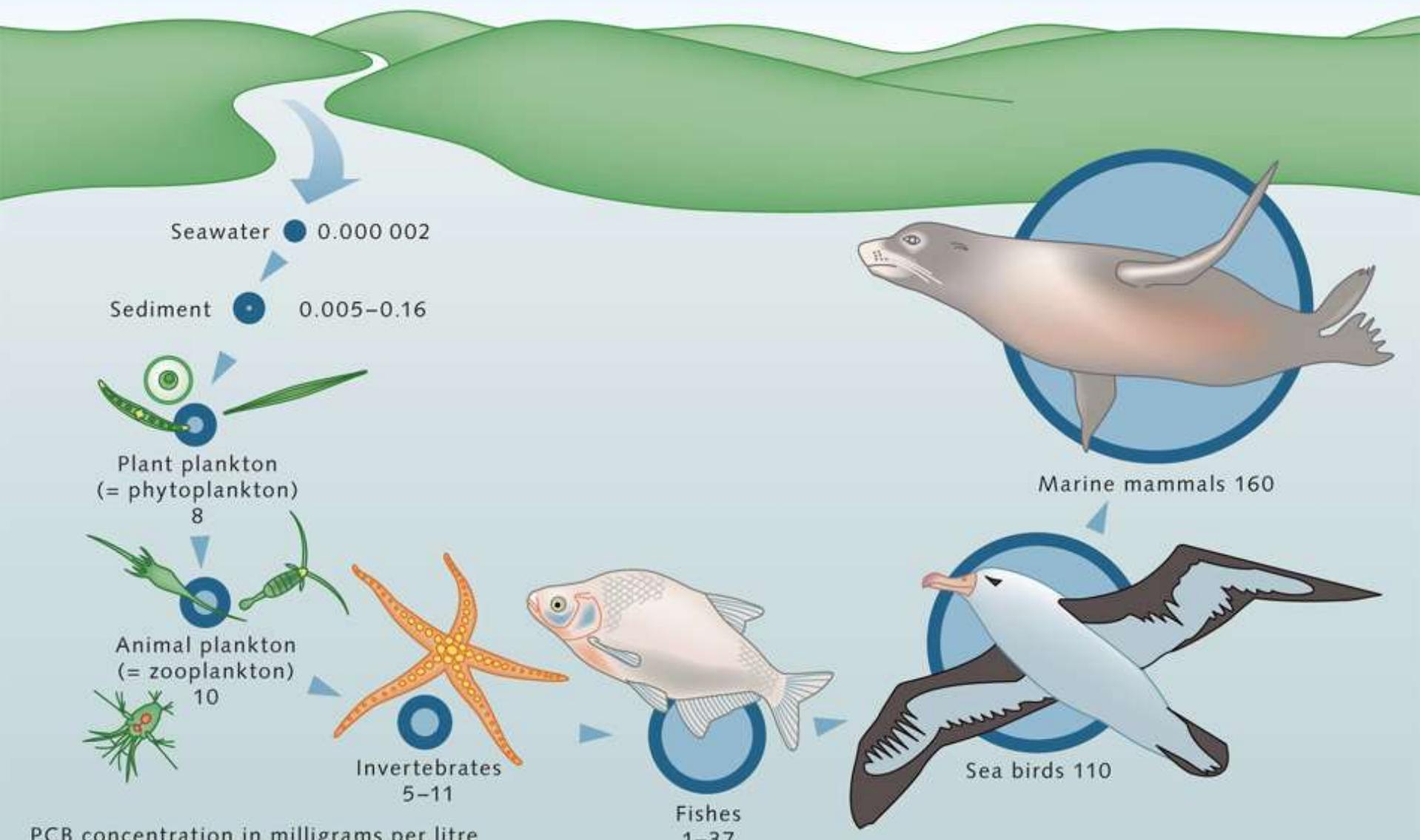


Pollutants bioaccumulate

- Pesticides
- Petrochemicals
- PCB, PCP

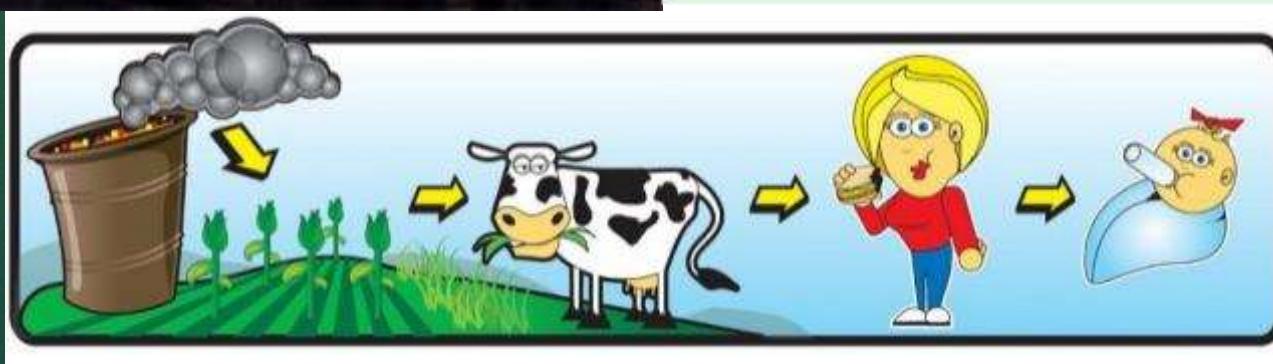


Biomagnification



Biomagnification

- Diabetes
- Neurological disorders
- Cancers
- Infertility
- Birth defects



Pollutants harm people



Pollutants harm animals



Fungi eat poisonous pollutants



Trametes versicolor eating PAH and Dioxin contaminated soil (Aalto University)



96% PAHs and 64% dioxin eaten in 3 months

<http://ecowatch.com/2014/05/23/mushrooms-fungi-bioremediation-contaminated-soil/>

Our bodies accumulates toxins

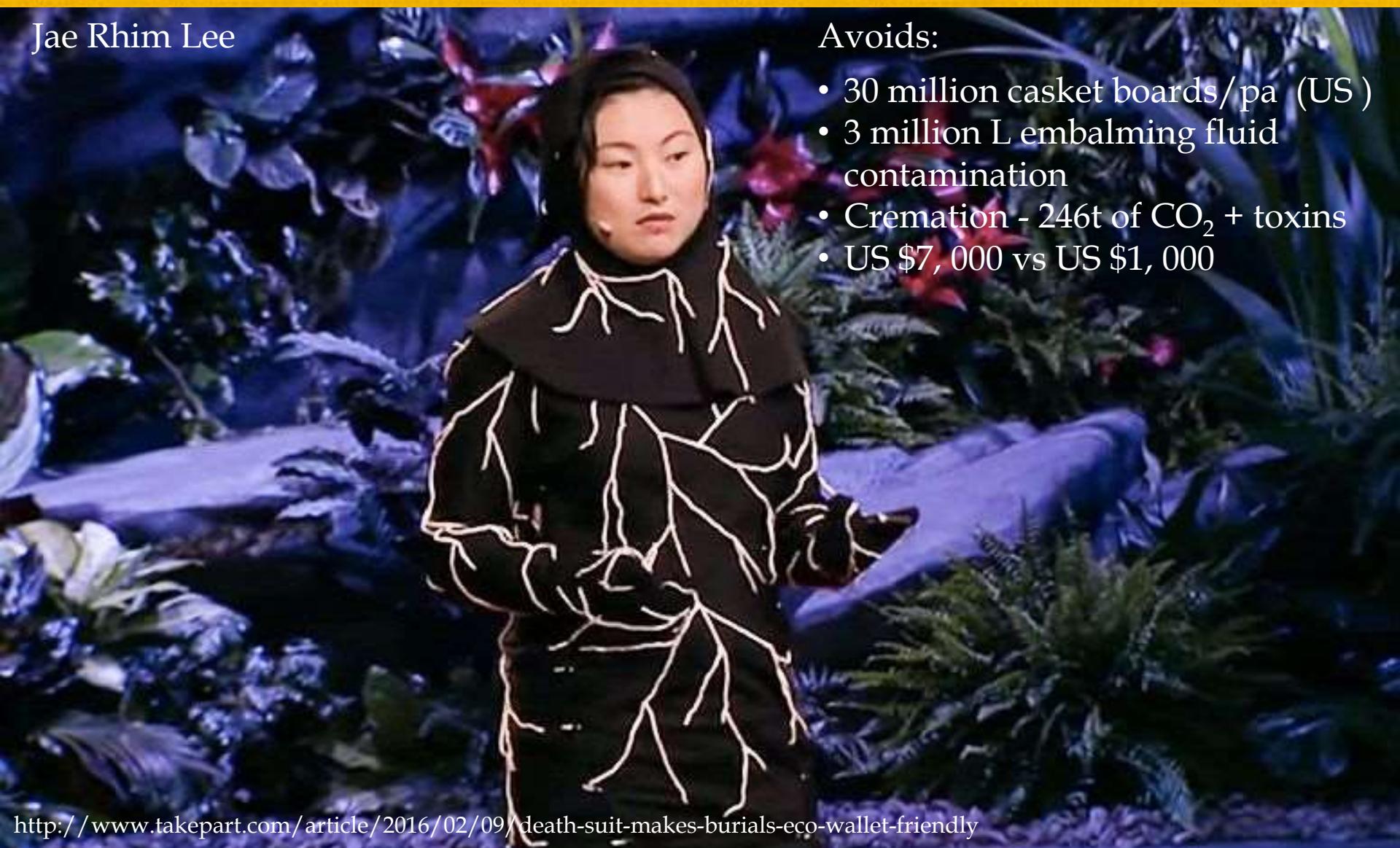


The Myco-Death-Suit

Jae Rhim Lee

Avoids:

- 30 million casket boards/pa (US)
- 3 million L embalming fluid contamination
- Cremation - 246t of CO₂ + toxins
- US \$7,000 vs US \$1,000



We can use fungi to clean up...

- The Great Barrier Reef
- Mining sites
- Landfills
- Nuclear waste
- Petrochemical and other industrial spills



© Stephen Axford/HotSpot Media

Myco-design and technology



Maurizio Montalti

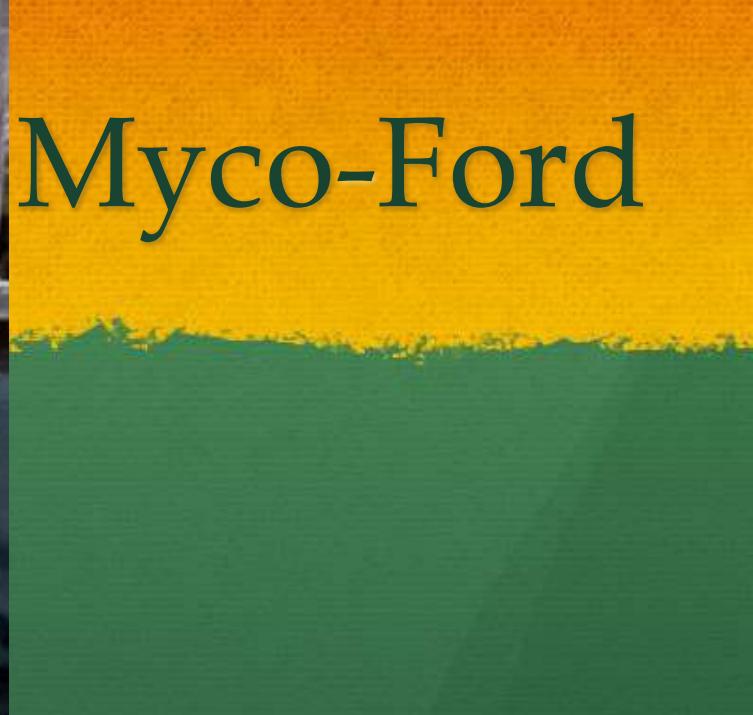
Myco- Design

Jonas Edvard



Myco Foam





Packaging



<http://ecowatch.com/2016/03/04/ikea-mushroom-packaging/>

Myco-Form (TERRAFORM)



<http://terreform.blogspot.com.au/2015/06/mycoform-surface-multi-curved-mycelium.html>

Myco-Chair

(Eric Klarenbeek)



<http://www.dezeen.com/2013/10/20/mycelium-chair-by-eric-klarenbeek-is-3d-printed-with-living-fungus/>

Myco-Board



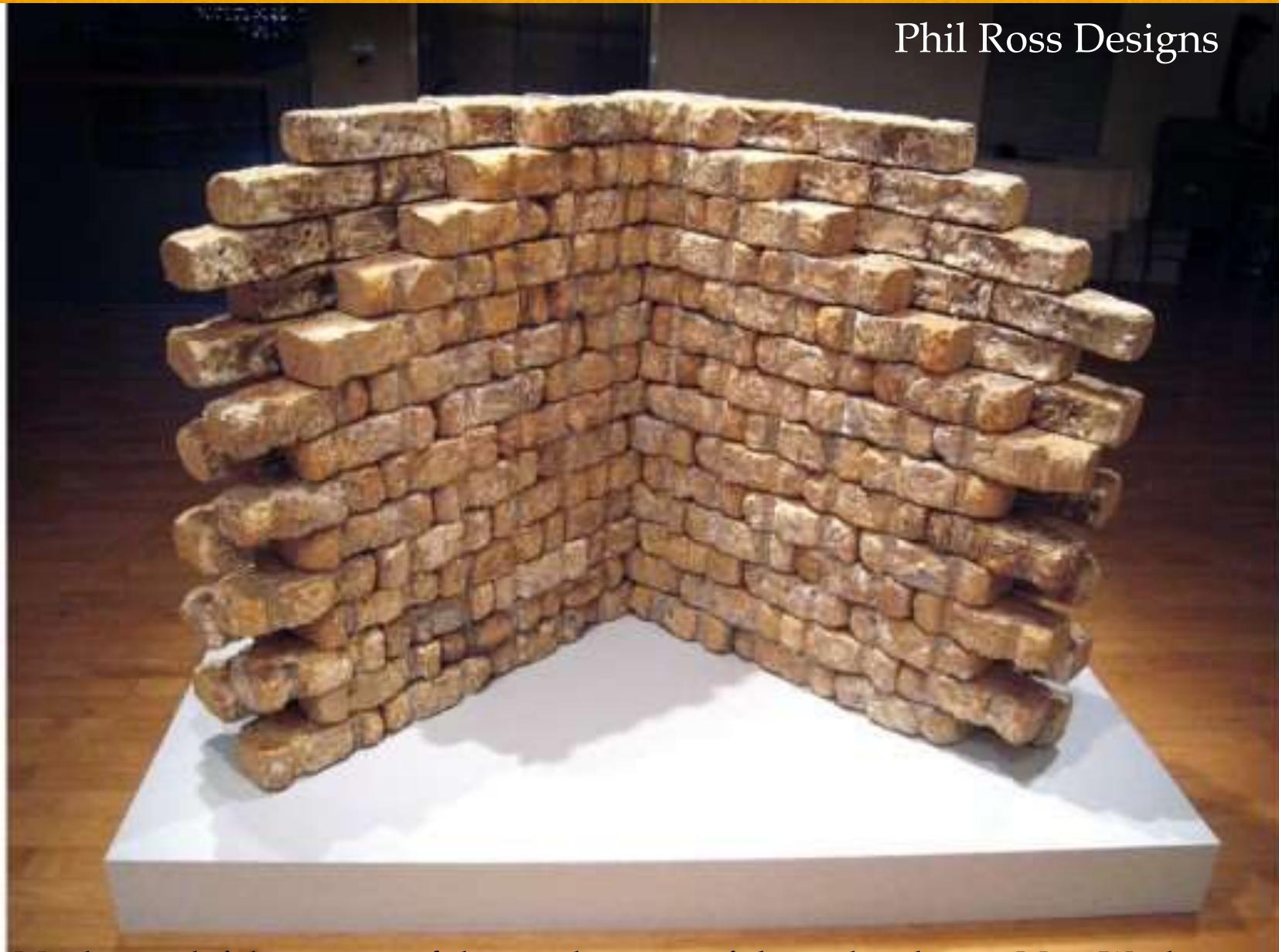
Myco - Insulation (Antoni Gandia)

<http://www.mediamatic.net/385489/en/mycelium-insulation-panels>

*Wheat husks and Reishi mycelium, grown for
three weeks at 25°C and 85% humidity*

Myco-Construction

Phil Ross Designs



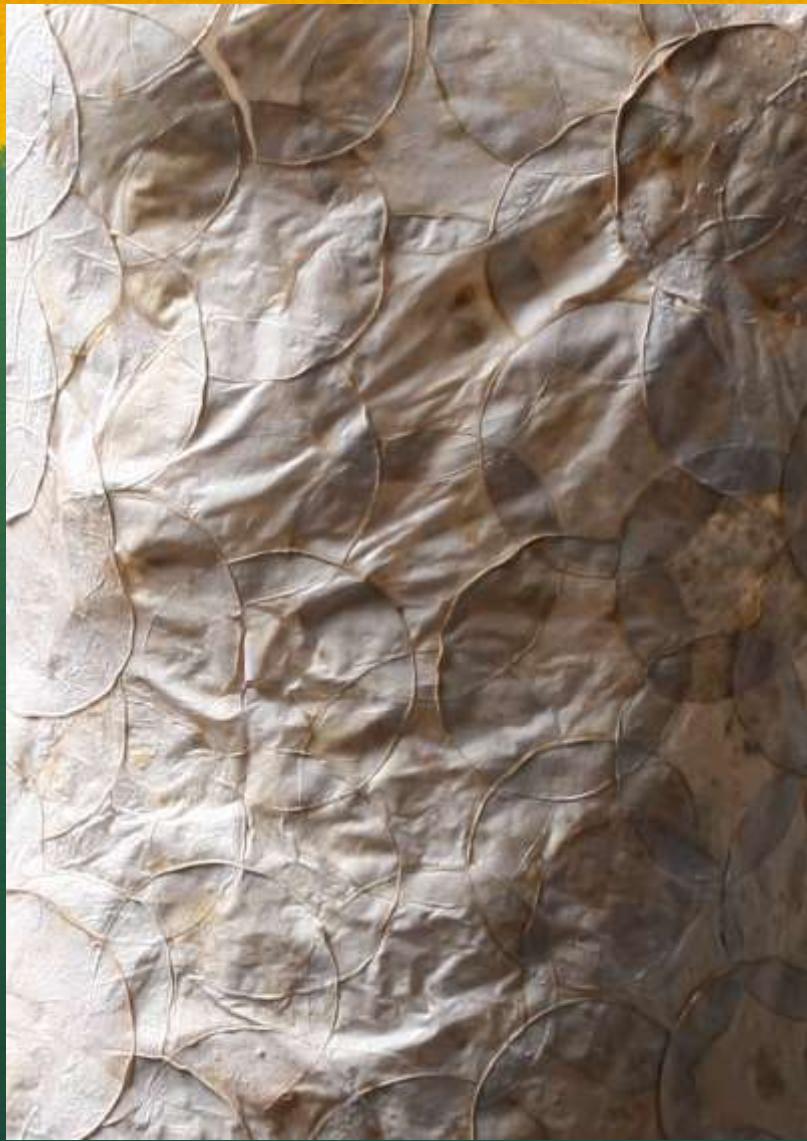
Mushroom bricks are one of the toughest materials on the planet - MycoWorks

Myco-Architecture



Myco-Dress

Aniela Hoitink



Myco-Design

Kristel Cojak

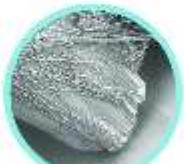


Muskin - Leather



Mushroom® Surfboards

by Ecovative



Mycelium, the root-like structure of mushrooms, acts as a natural self-assembling glue.



Mycelium gets its strength from chitin, the same stuff that makes a crab's exoskeleton durable and tough.

The board grows from formable particles (left) to a rigid structure (right) in 4 days.

Ecovative grows custom molded shapes.



Surfboards



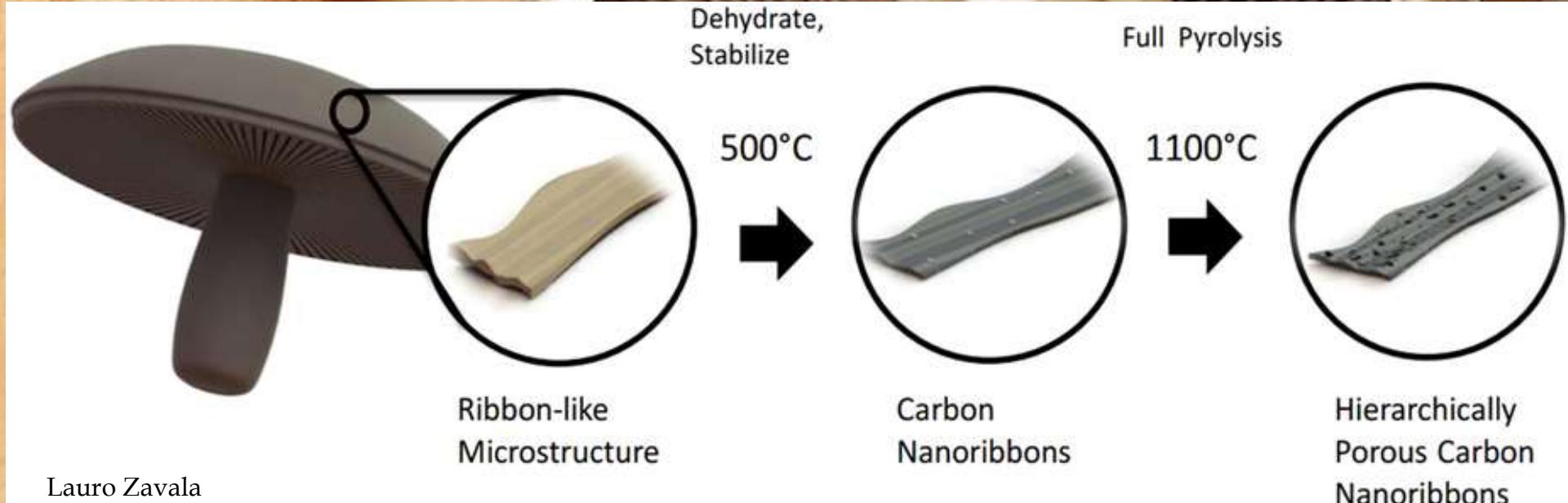
Lowe-White

Mushroom Batteries



Portobello Mushroom Batteries

(Campbell et al., 2015)



Lauro Zavala

Replaces synthetic graphite positive anodes to lower cost and pollution

Woodfordia's Fungi Future

The Mycology Research Project – citizen science

- University course
- Isolation, identification and application
- Design and architecture
- Plastic decomposition...

A close-up photograph of a large, brown mushroom cap with a prominent, intricate white gill network. The mushroom is resting on a bed of green grass. The lighting highlights the texture of the mushroom's skin and the delicate veins of its gills.

Thank You

sandra@woodfordia.com
[www.myco-mania.facebook.com](https://www.facebook.com/myco-mania)