



Fungi – The Superheroes of Our Future

Sandra Tuszyńska (PhD)

Fungi

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





2.4 b.y.a Prototaxites

450 mya algae + fungi = plants

Dissolve rock

Decomposed organic matter

Made first soils

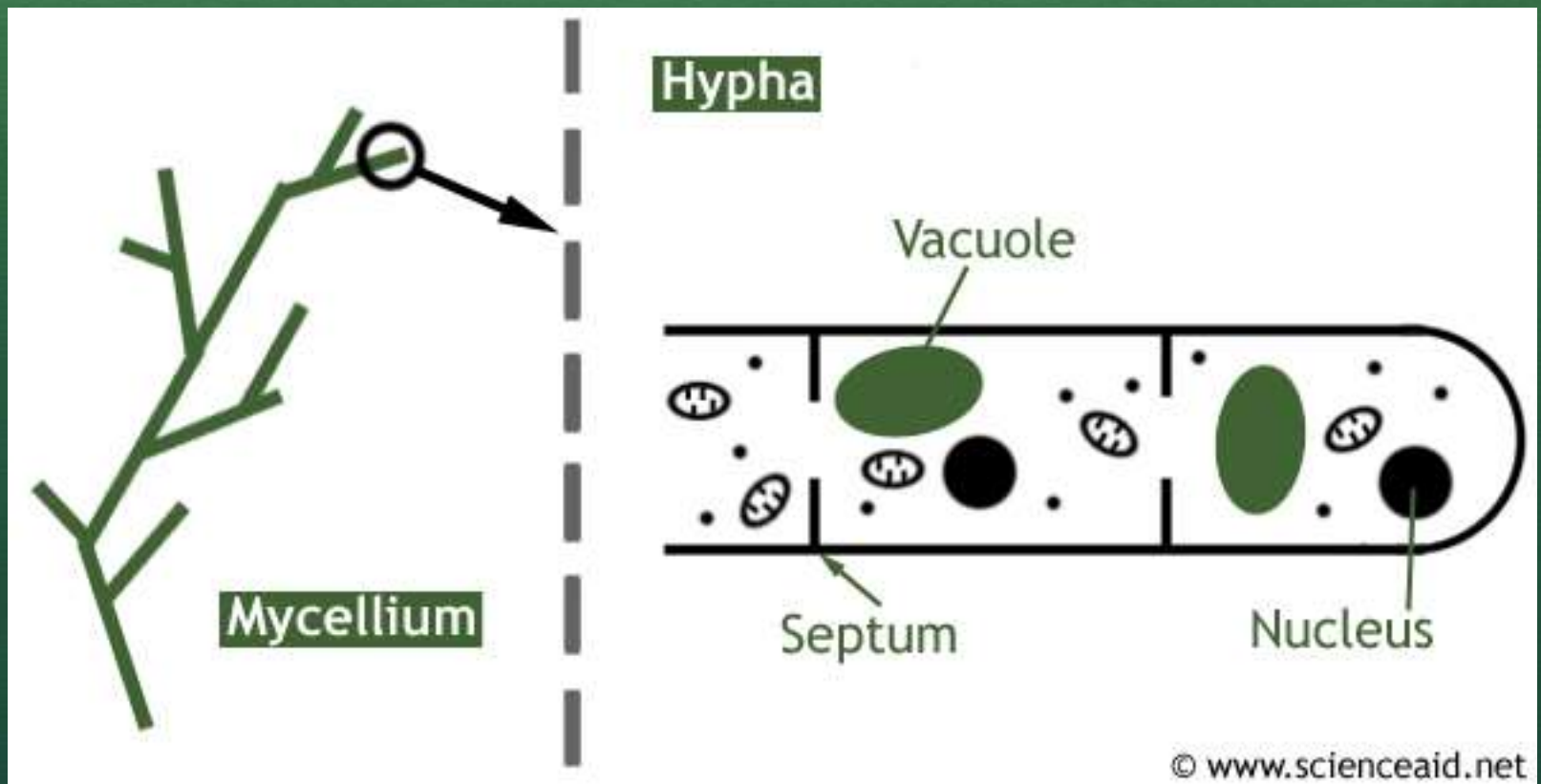
Forgotten heroes

Mushrooms = Flowers



Fungi kingdom 1969

Animal or plant?



The superpowers of the fractal web



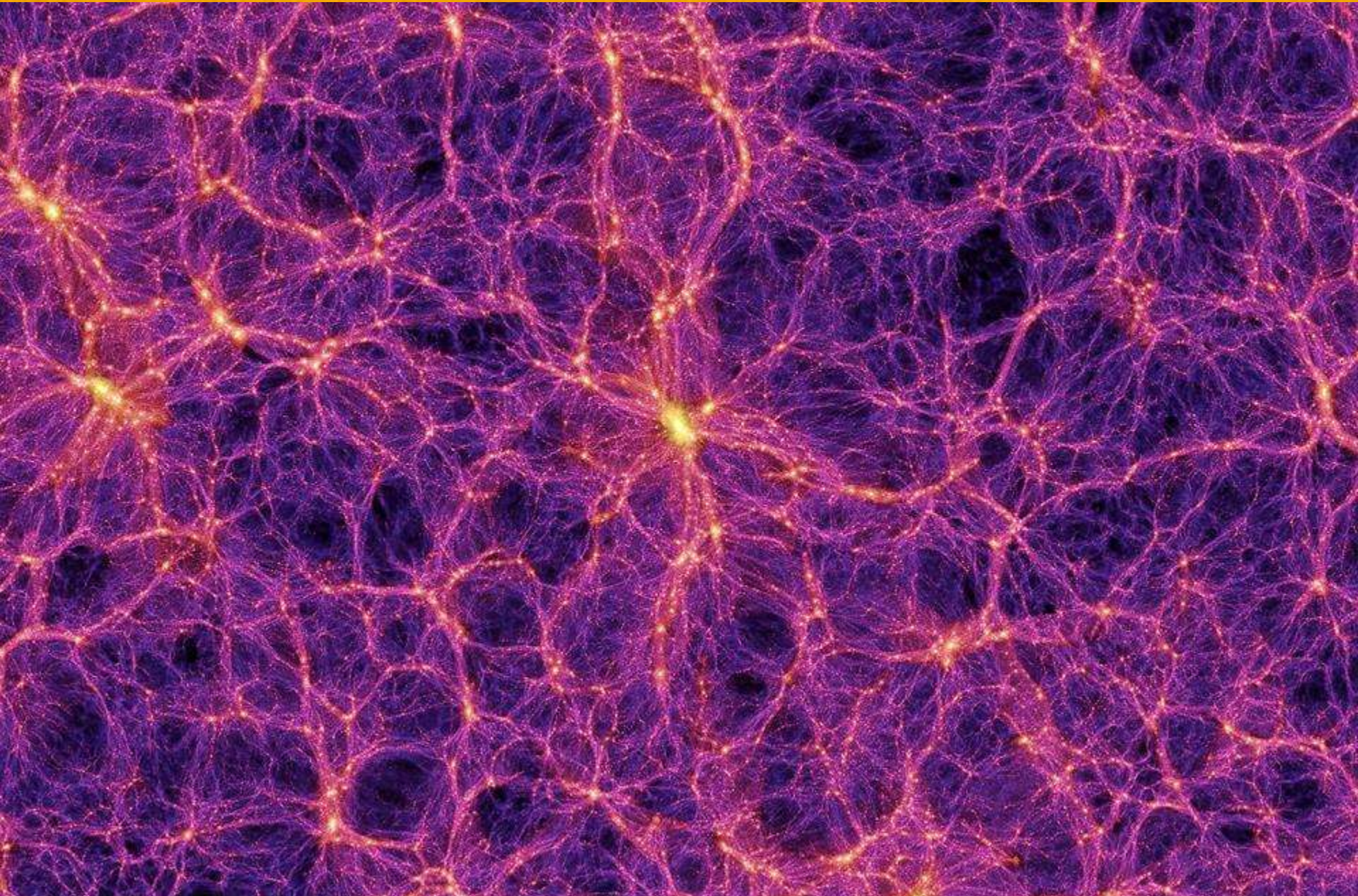
The Neuron Web



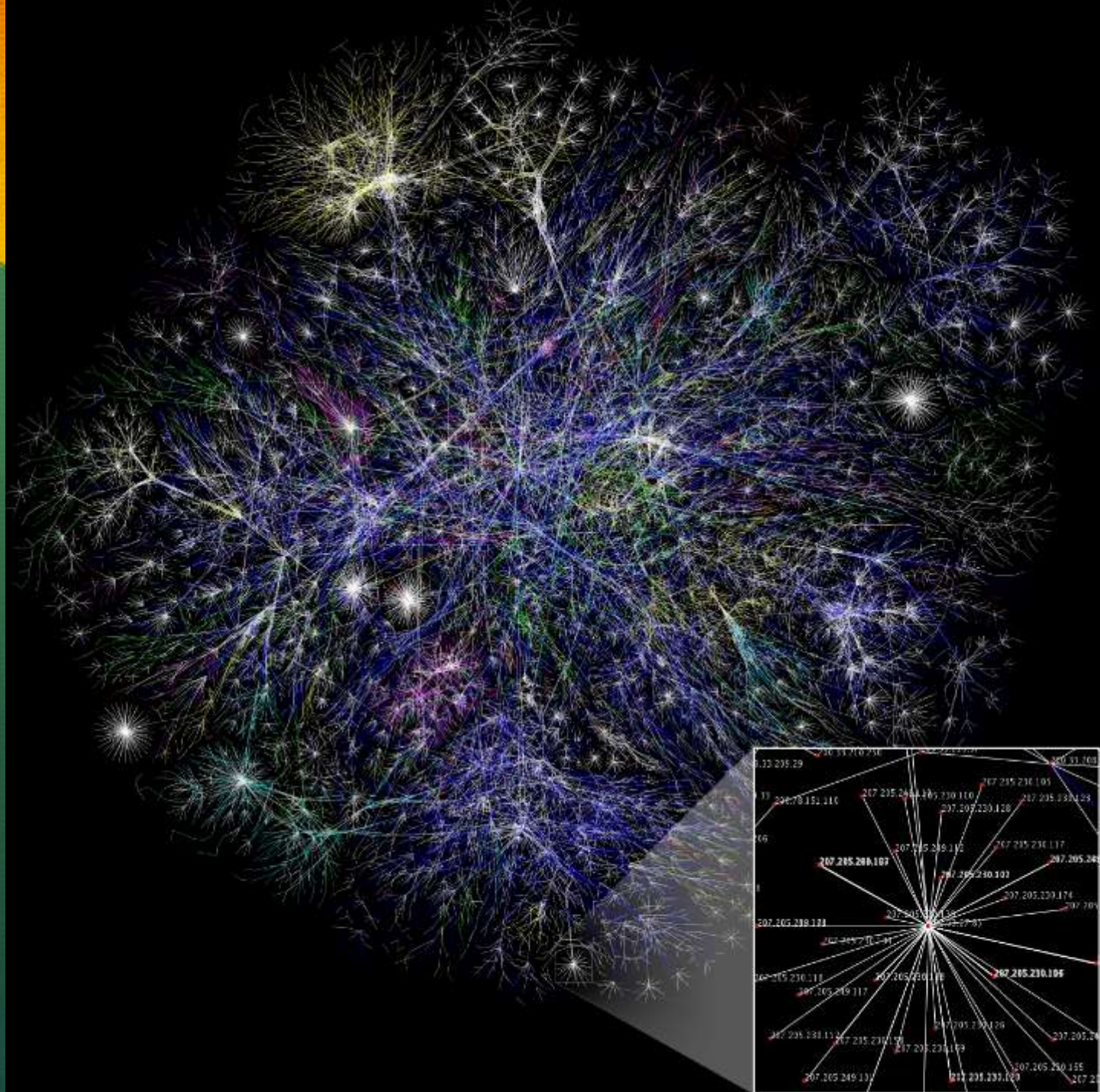
Tree Web



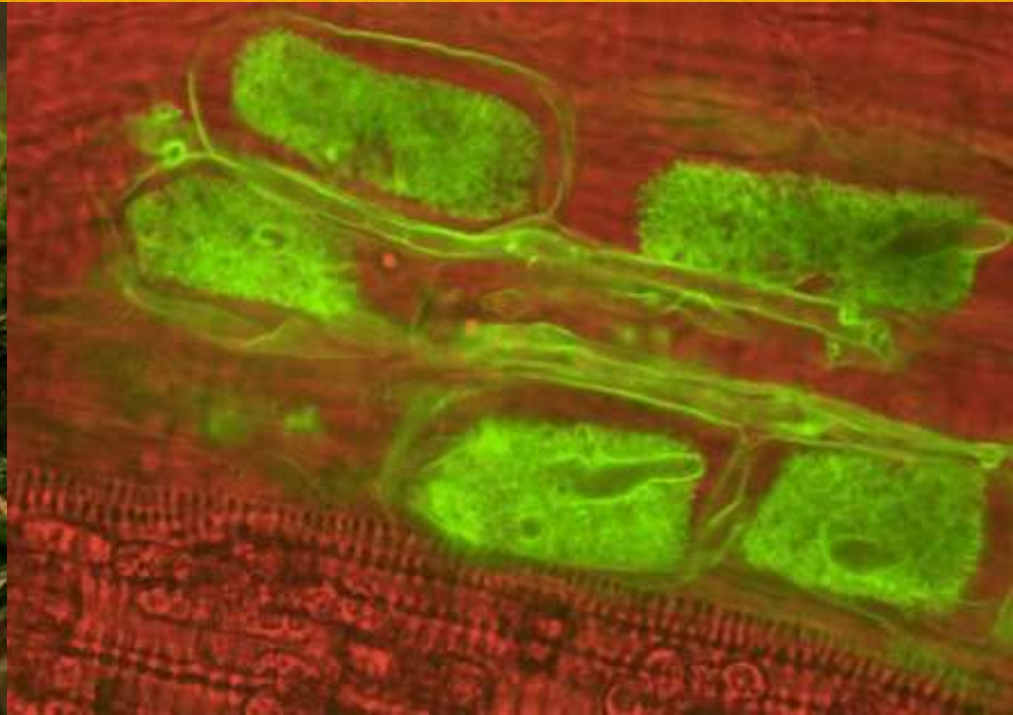
The Cosmic Web



W
W
W



Fungi Types



Root Fungi

Endophytes



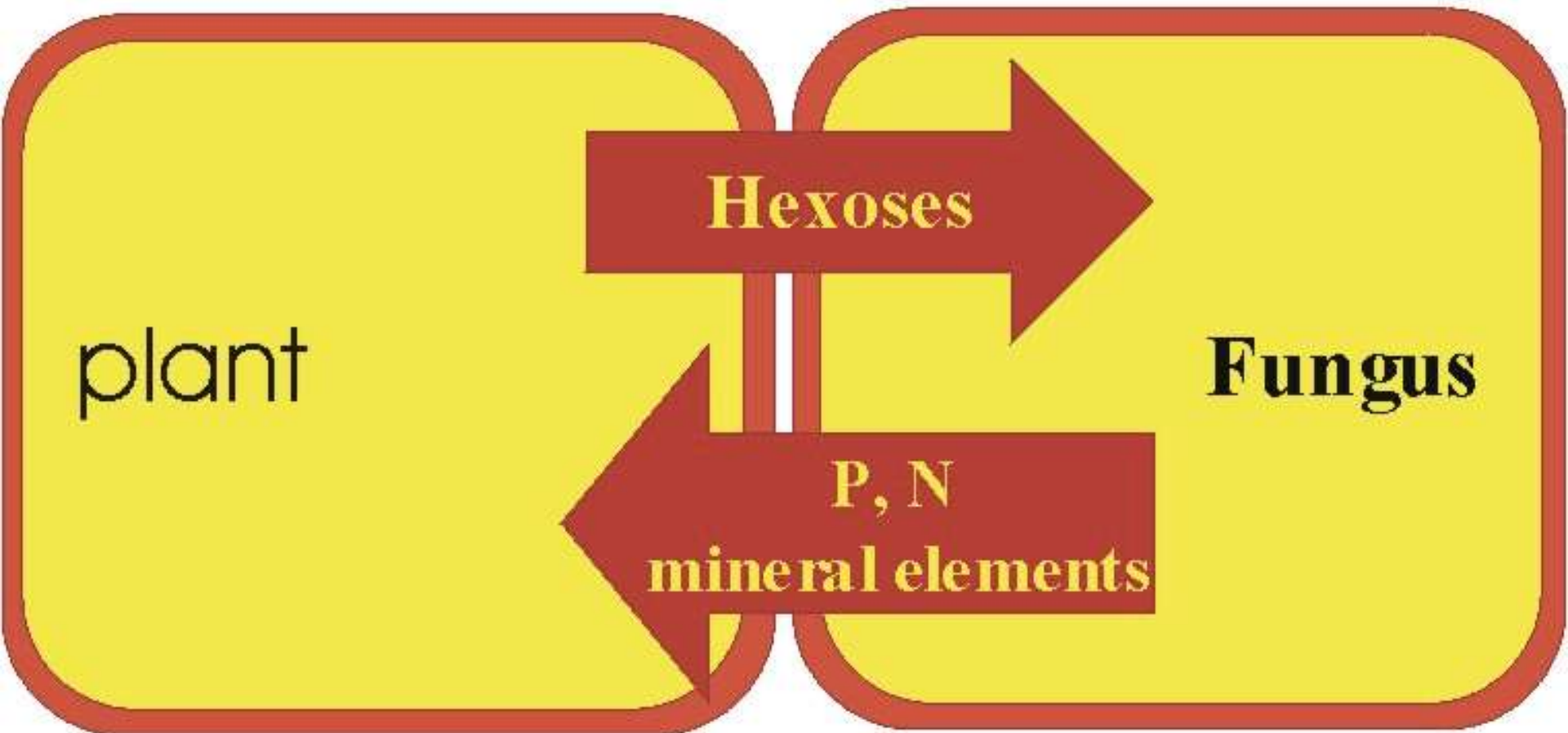
Decomposers

Root Fungi (Mycorrhizal)

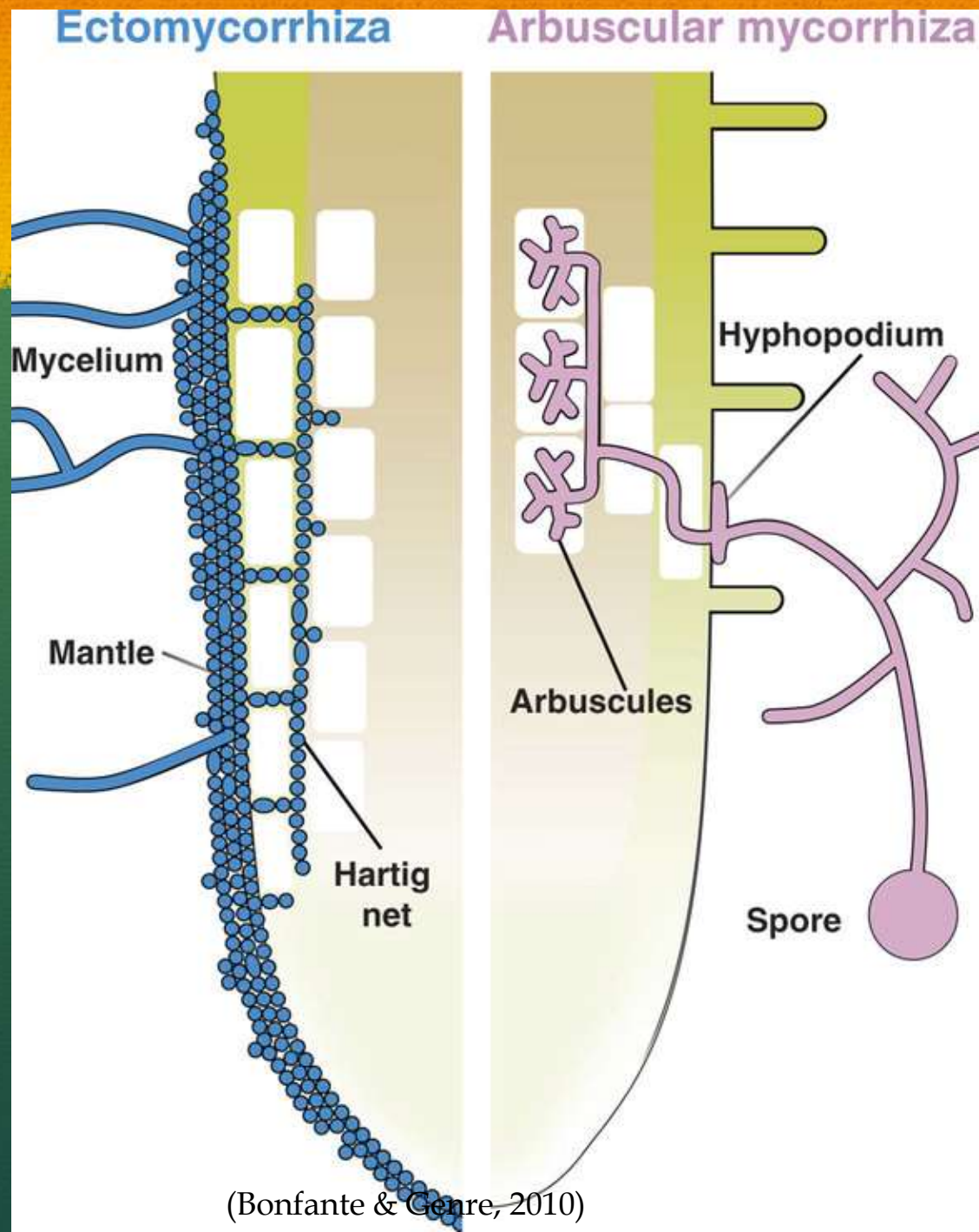
- Nutrient exchange
- Distribution
- Protection
- Immunity
- Communication



Nutrient Exchange



Types of root fungi



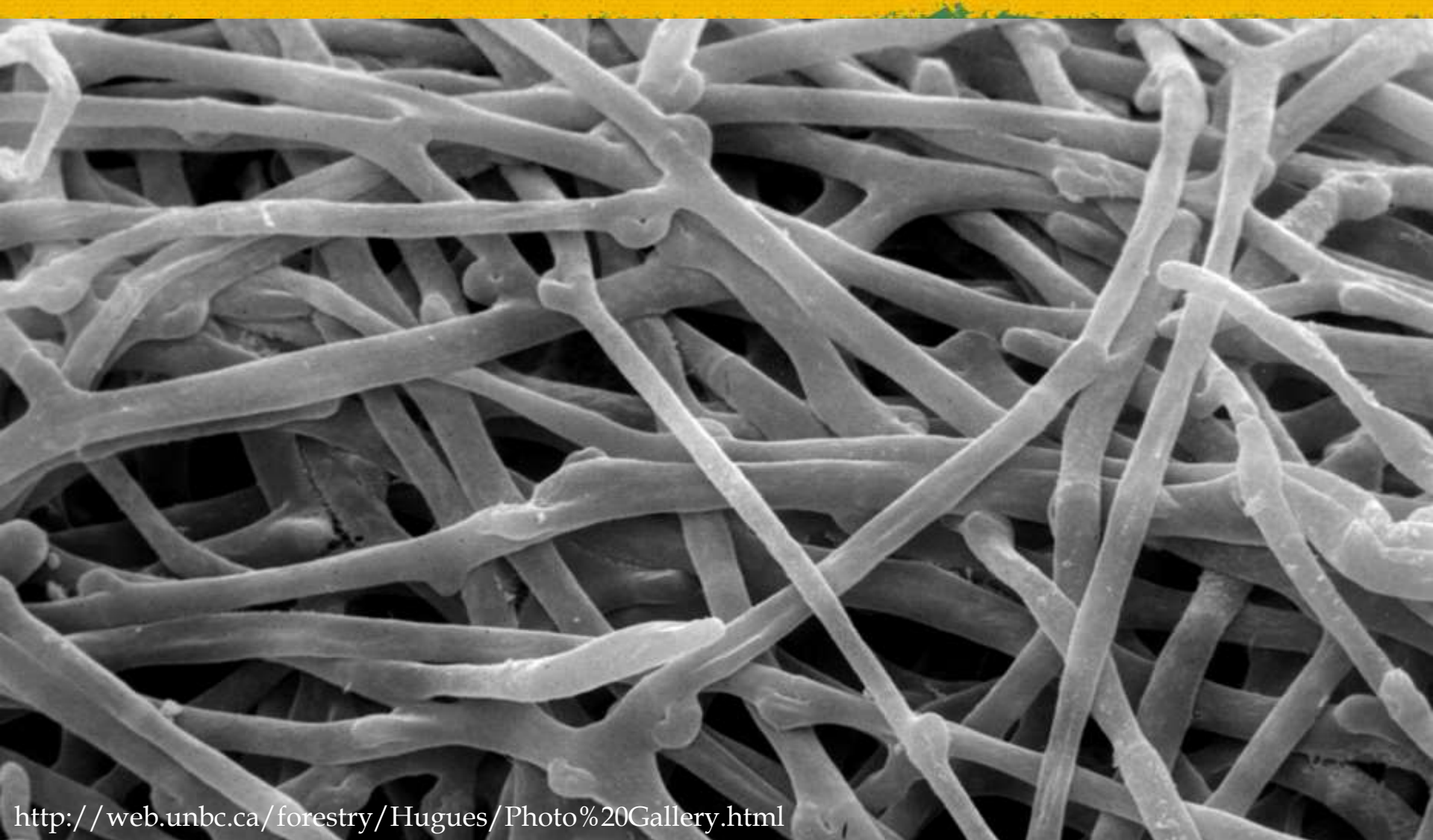
Mycelium = My silly arm



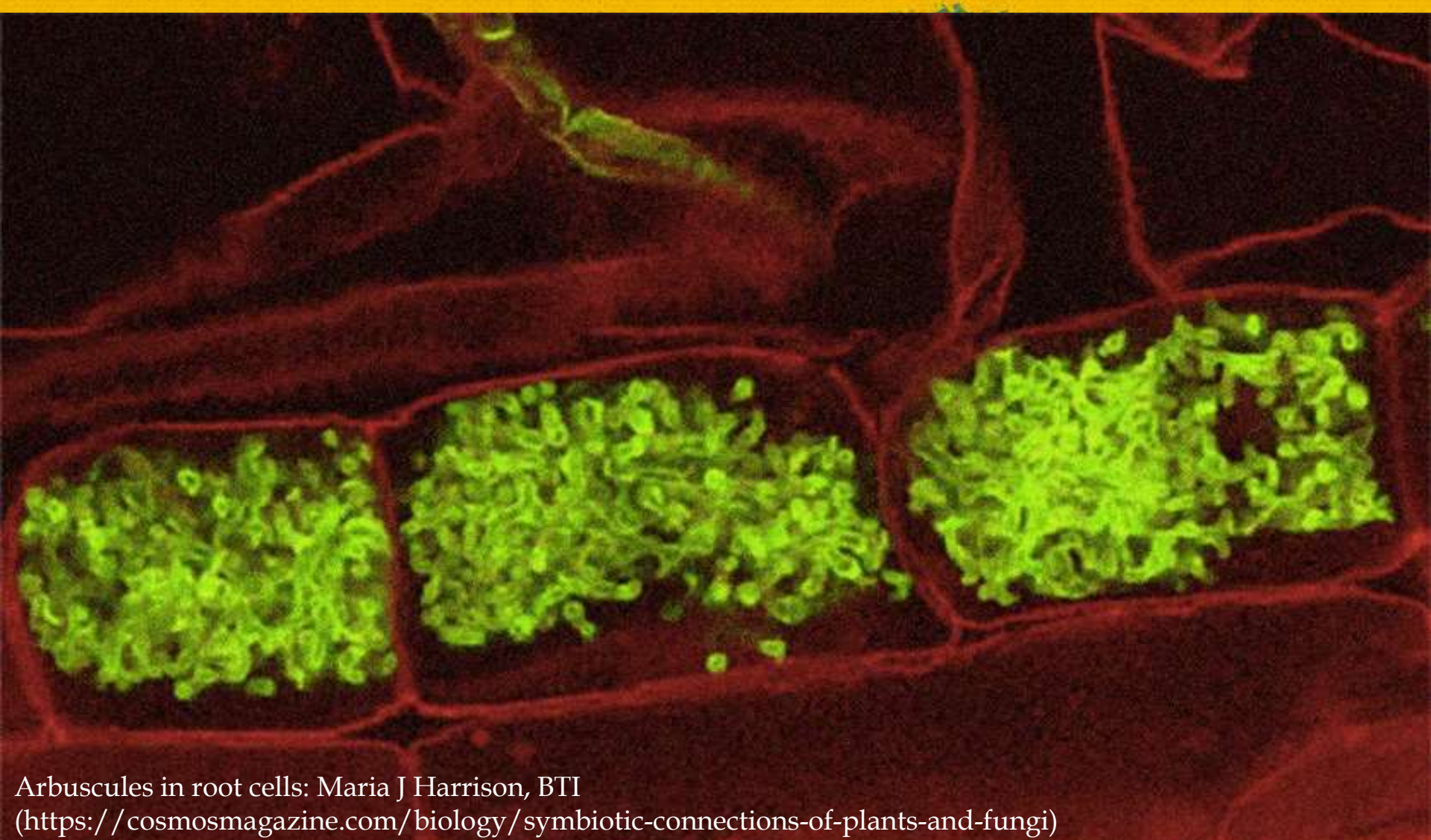
©ALEX HYDE

www.alexhydephotography.com

Enlarged Mycelium

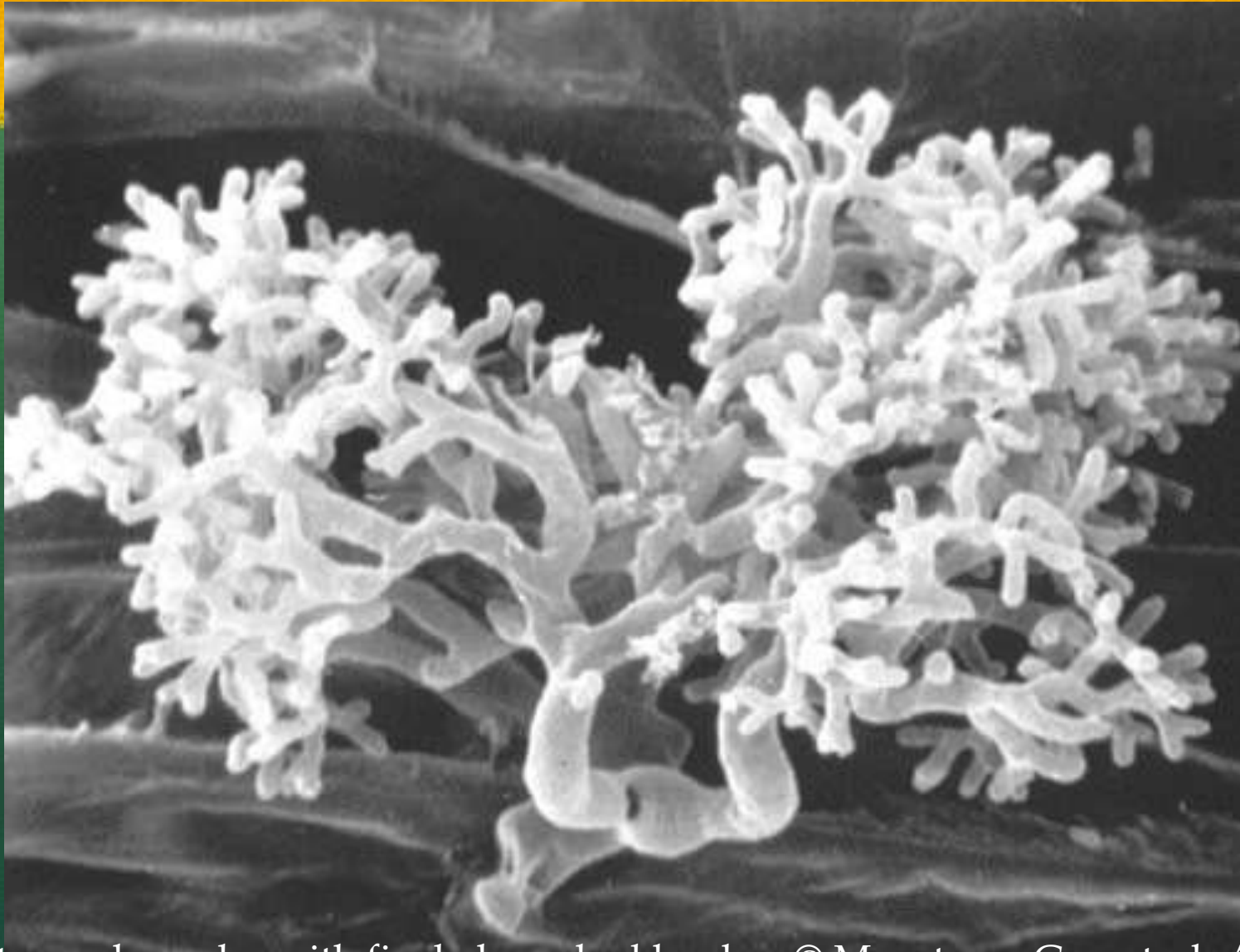


Arbascular – Little Trees



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.biooekonomie-bw.de/en/articles/news/mycotown-greentech-ag-uses-mycorrhiza-to-keep-plants-going/>

The Wood Wide Web



Cooperative and equal distribution of resources within the community

Mycorrhizal fungi facts



16 km hyphae/ gram soil

Covering $\sim 700\times$ more soil area than roots

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

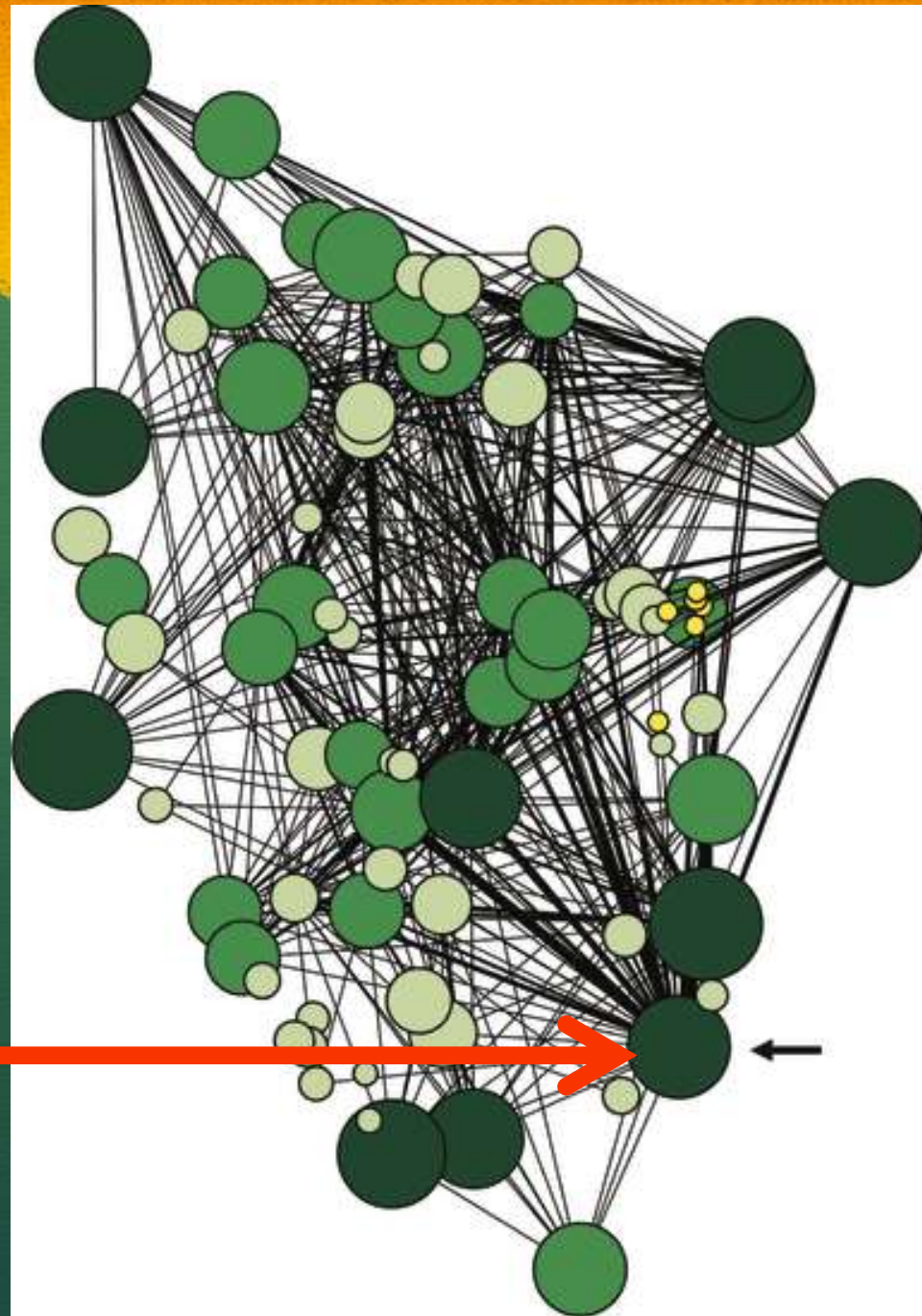
4m² of perennial grassland mycelium can stretch around the equator

4 tons mycelium per person

Wood Wide Web

FOREST SUPERORGANISM

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





Birch



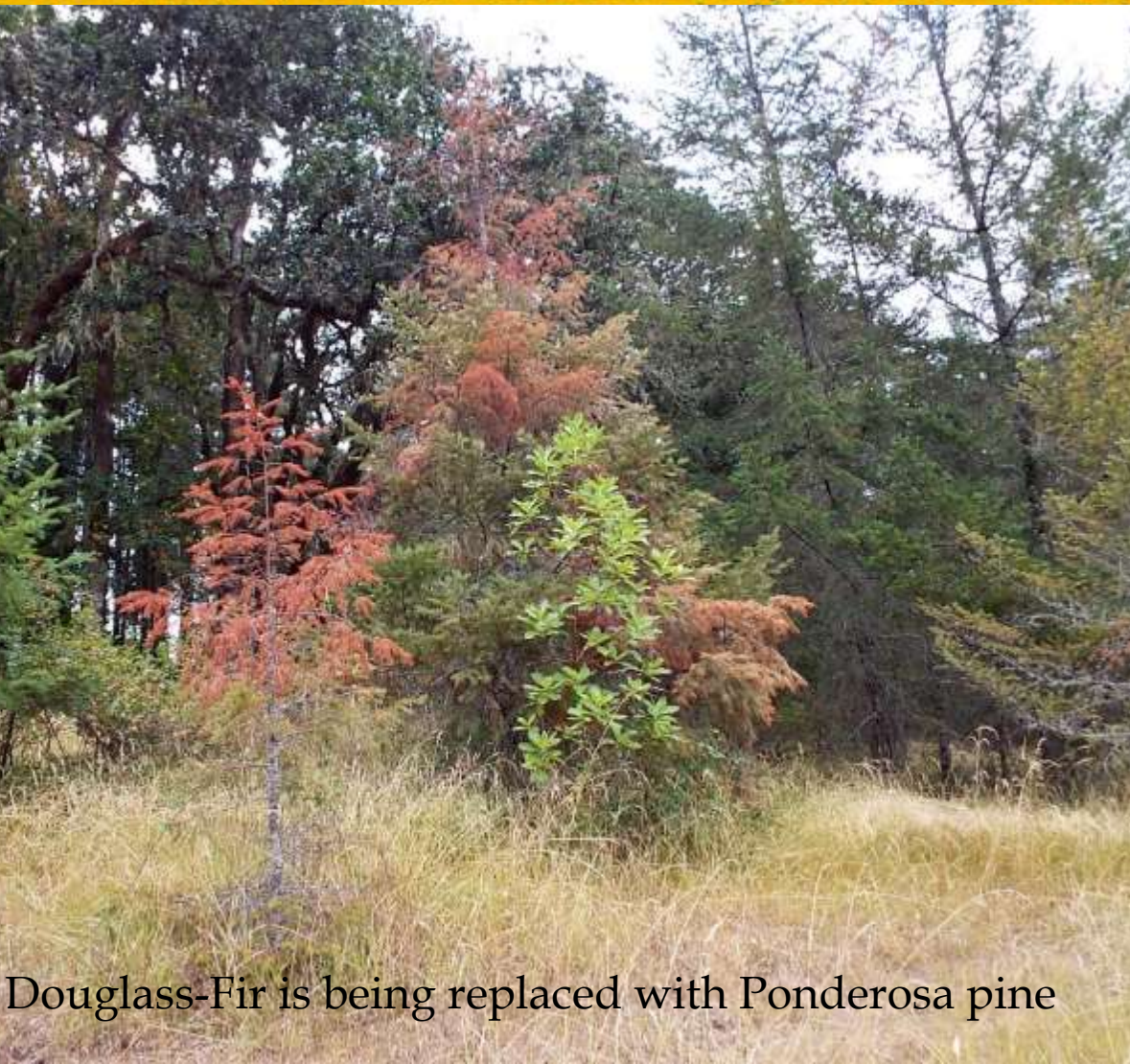
Douglass-fir



Sharing is
Caring

Coping with Climate Change

(Song et al., 2014)

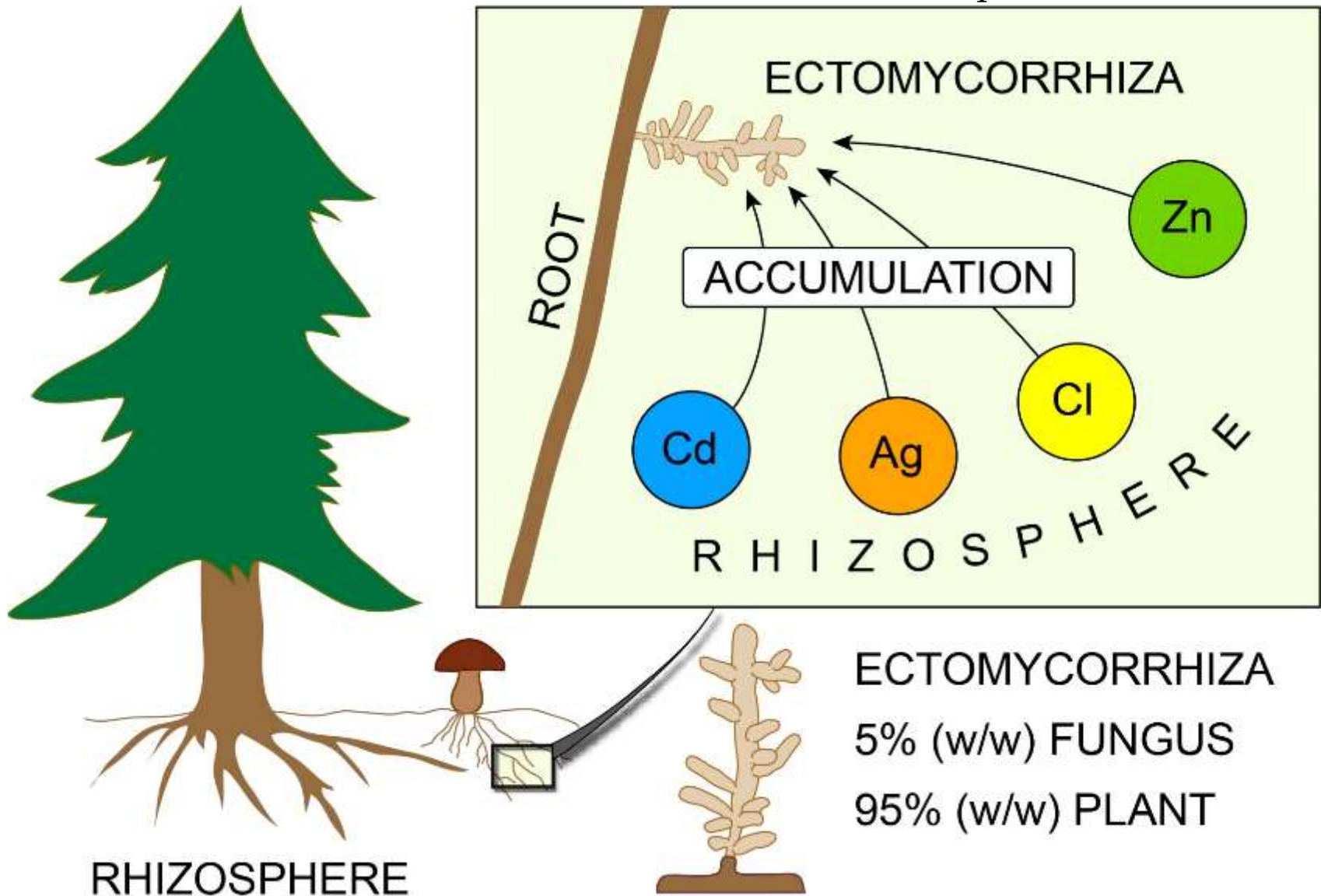


Douglass-Fir is being replaced with Ponderosa pine



Mycelium protects its host

Environmental Pollution, Impact Factor: 4.839



Myco-Remediation



Bioaccumulation



File:Paxillus involutus qtl3.jpg

Radioactive Waste

Fukushima



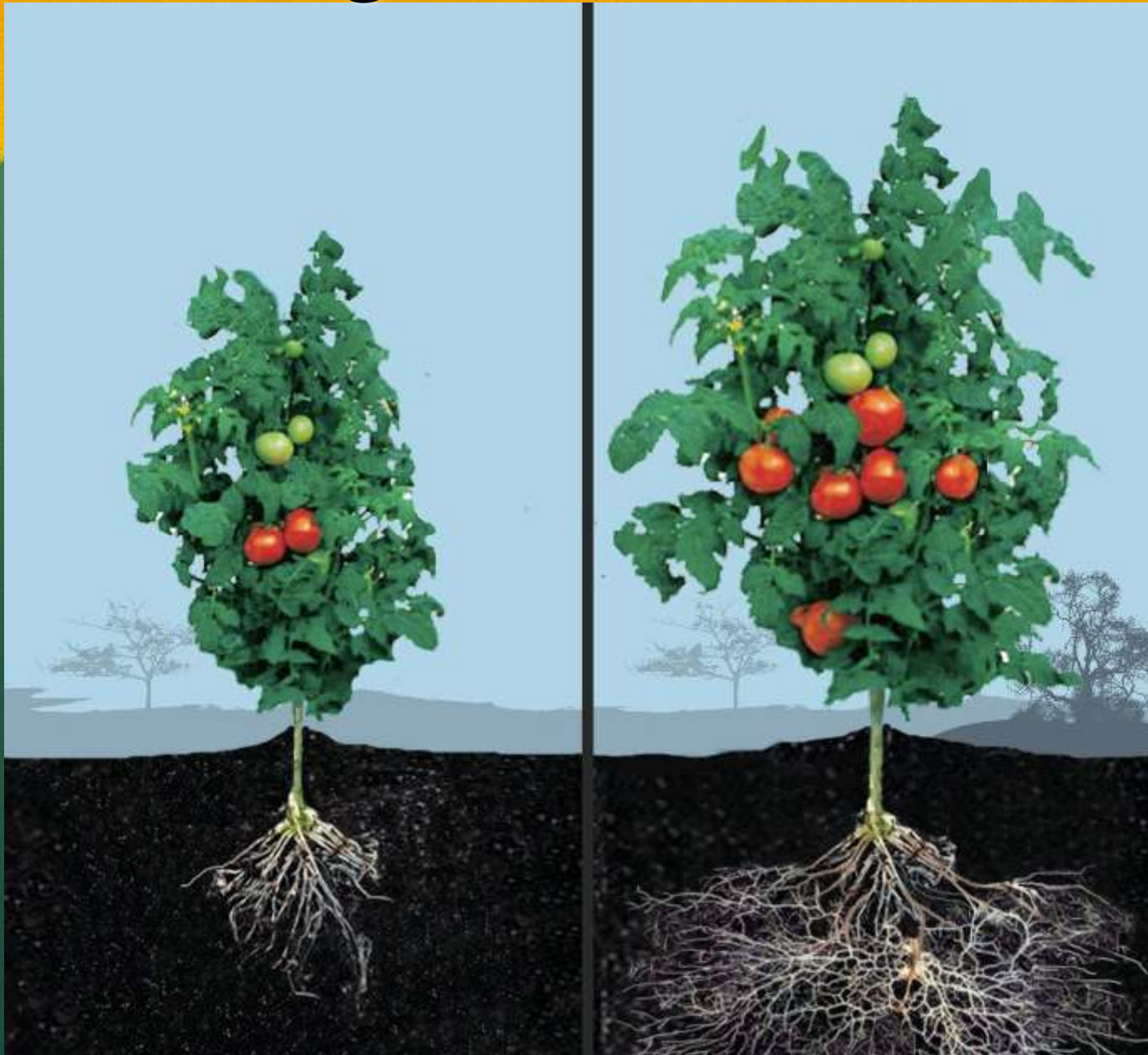
Bioaccumulation

Gomphidius glutinosus



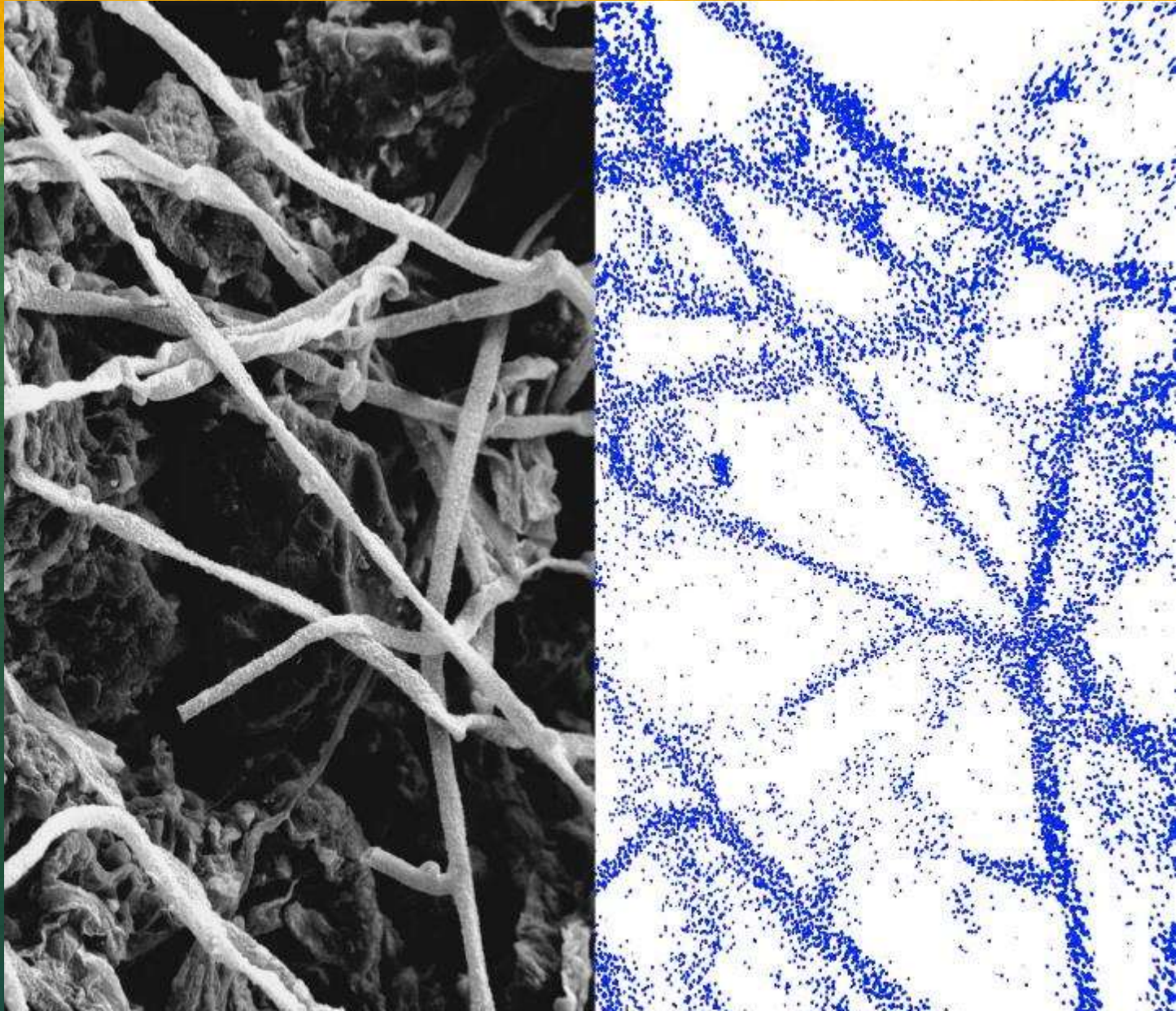
Accumulates caesium 137 - 10 000 x above background radiation

Agriculture



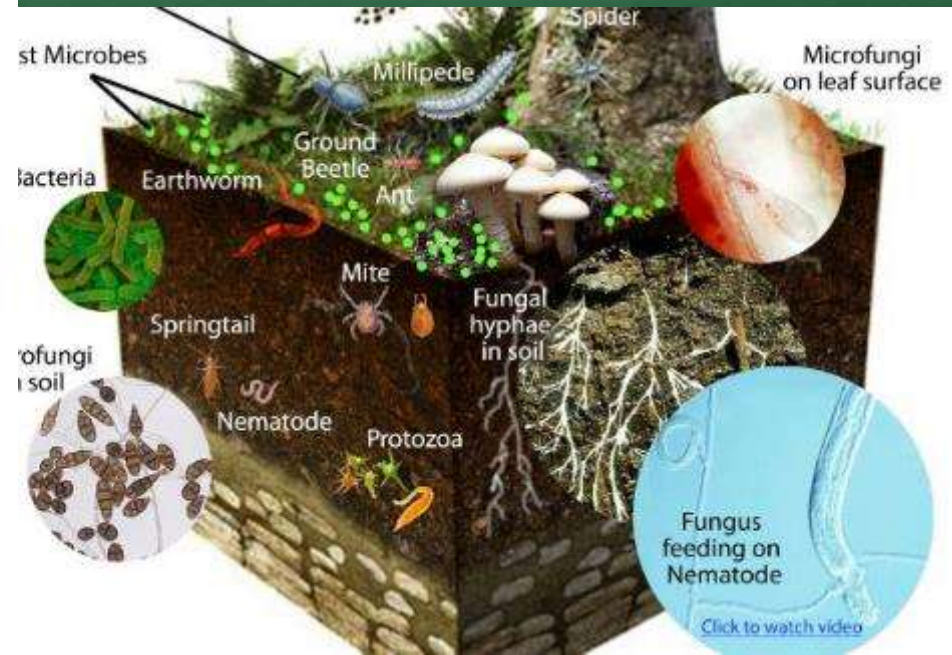


CO₂ Sequestration



Soil Aggregation

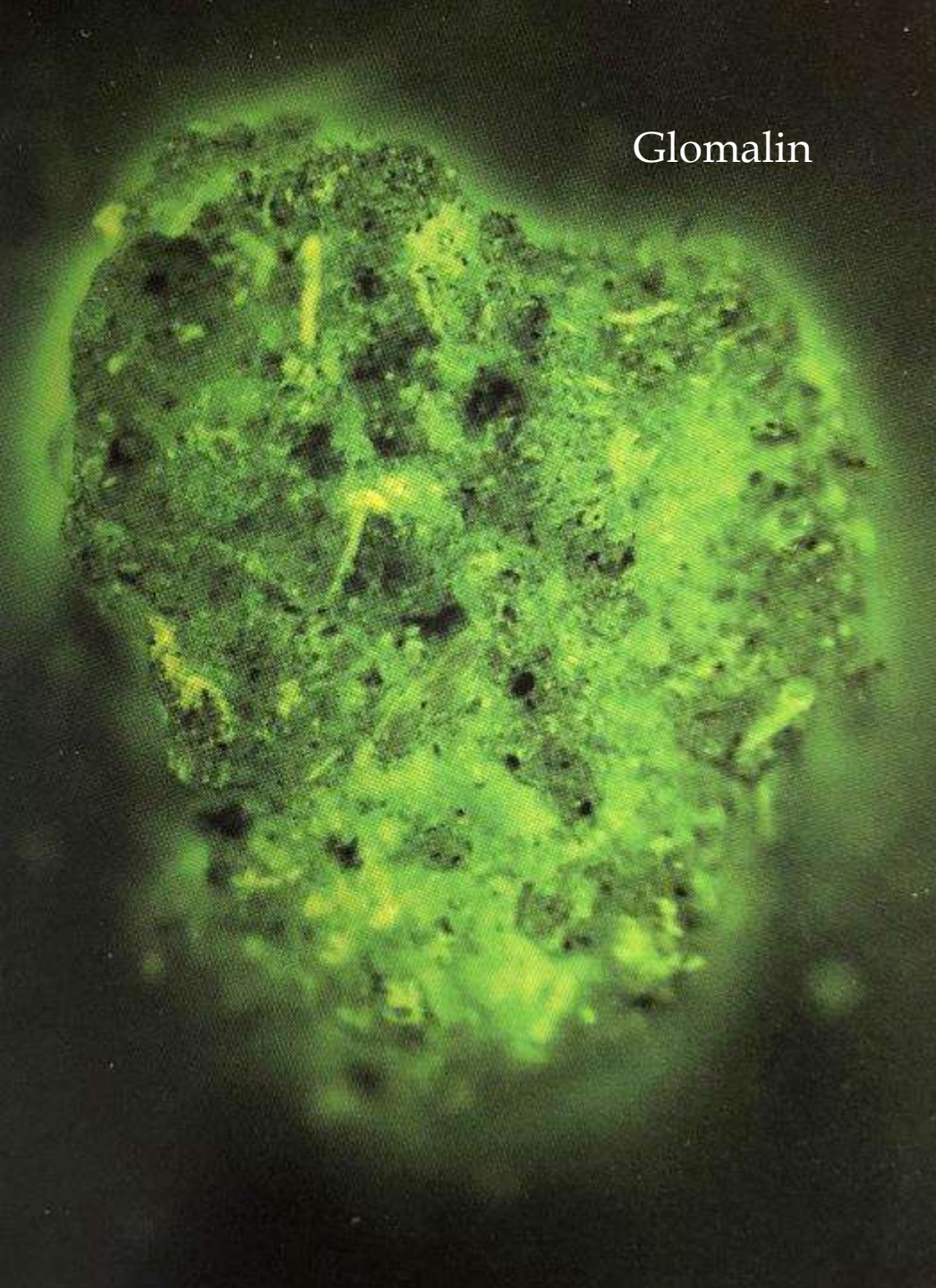
- AM 28m/cm³ soil
= 54-900 kg SOC/ha
- Fire absence > 1m humus
 - 6.2kg C/m² - 585 yrs
 - 22.5kg C/m² - 3250 yrs



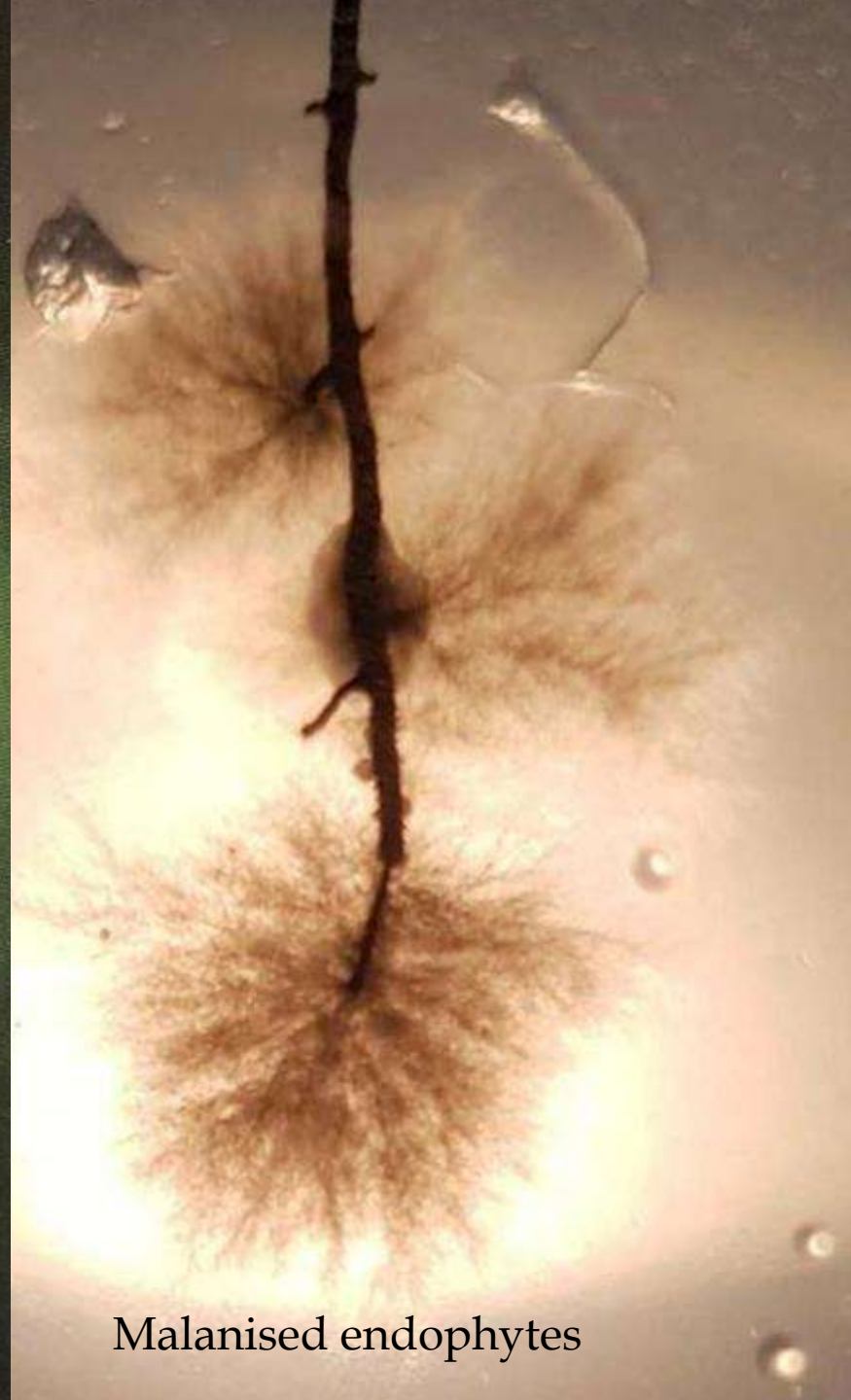
Aggregation



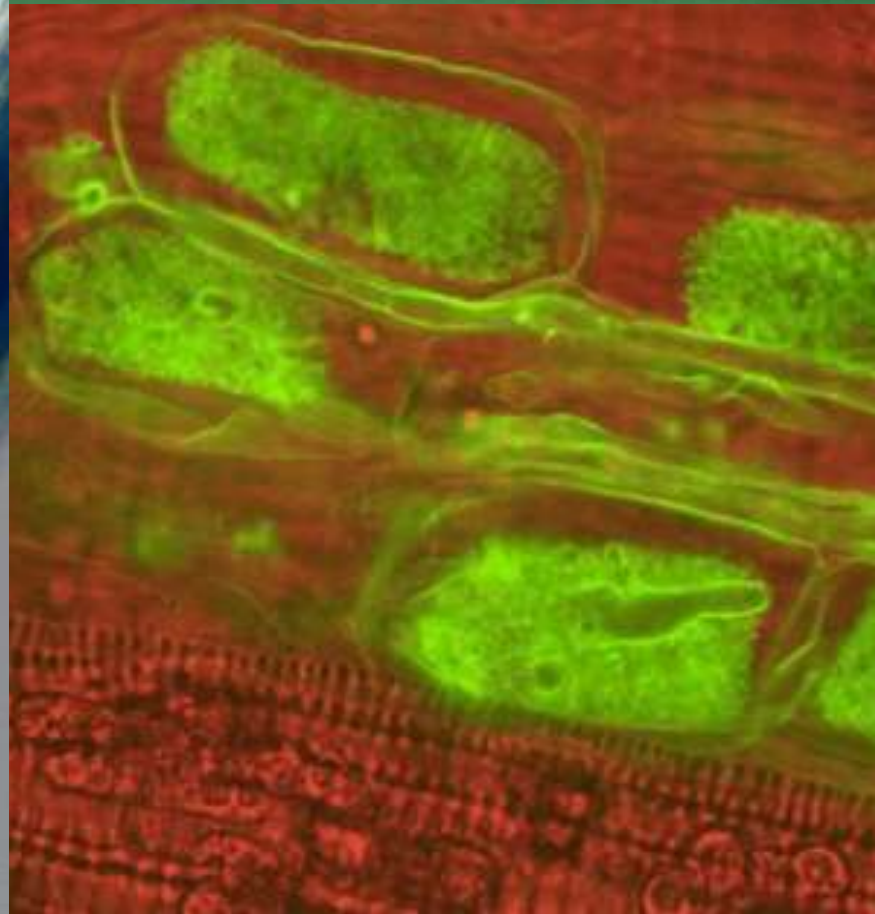
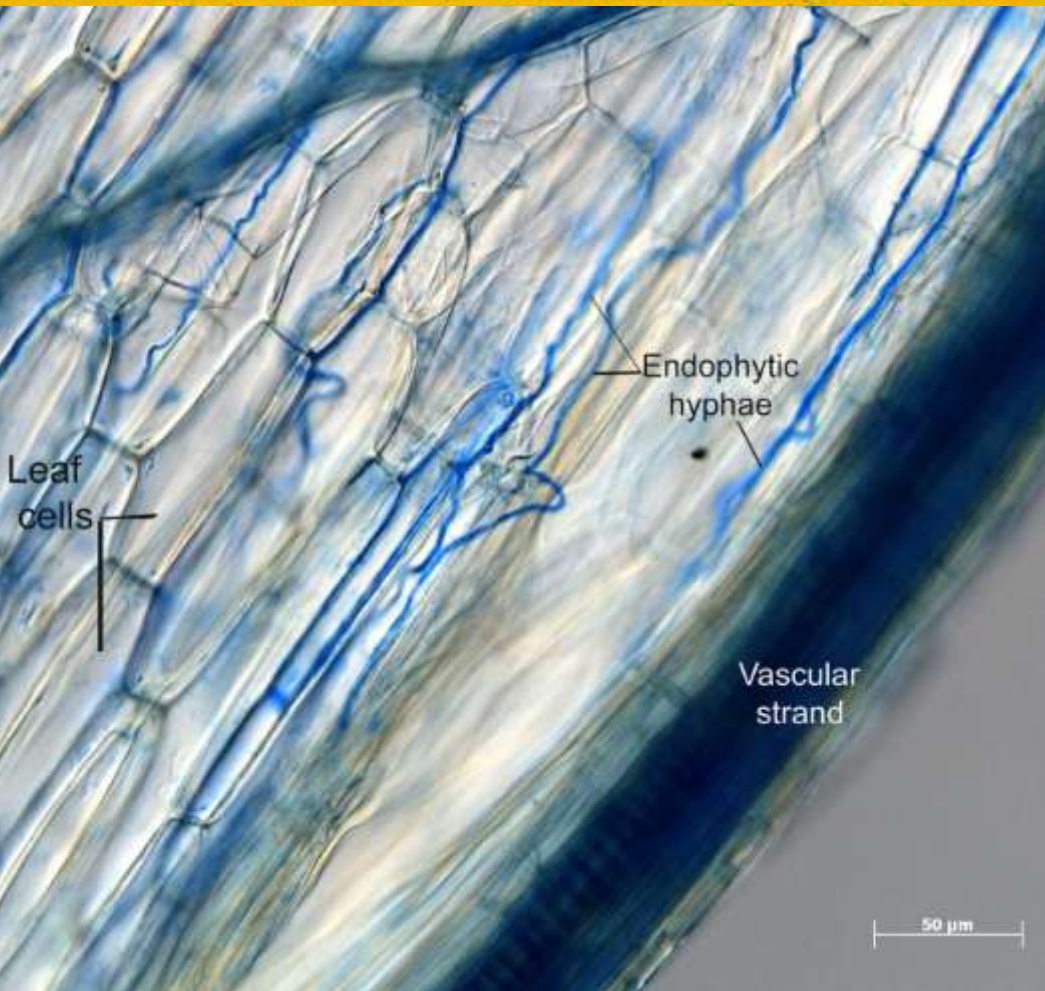
Glomalin



Malanised endophytes



Endophytes – Within Plant



Provide plant superpowers

Endophyte - Decomposer



Phillipsia subpurpurea – Steve Axforf



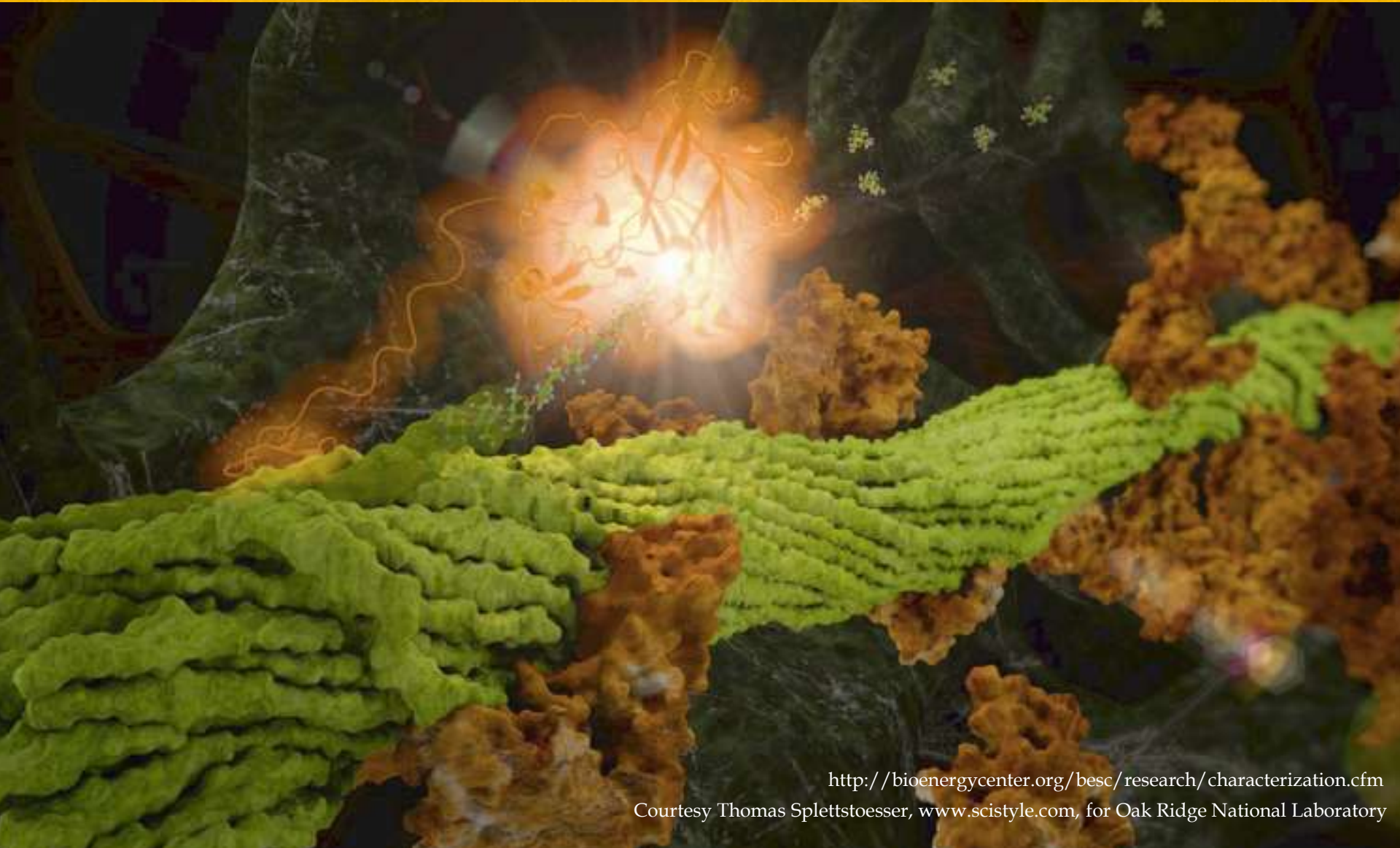
Recycling

Wood and other dead things



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

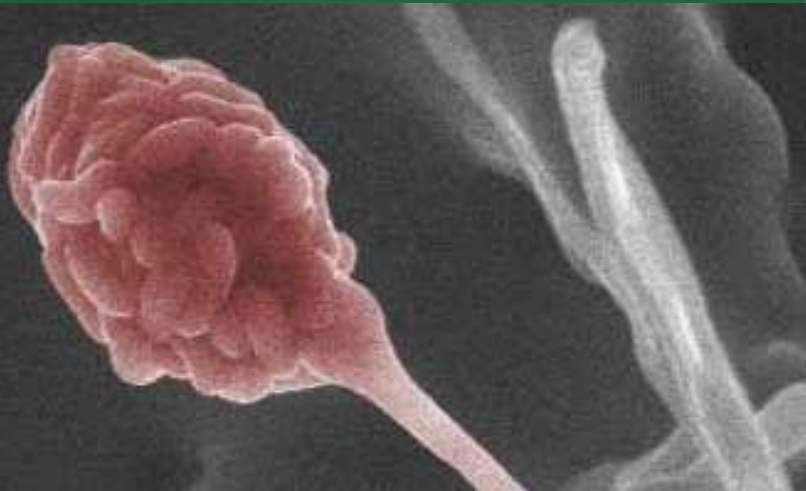
“Fossil” fuels = Forest Fungi fuels



Myco-Diesel

(Strobel et al., 2008)

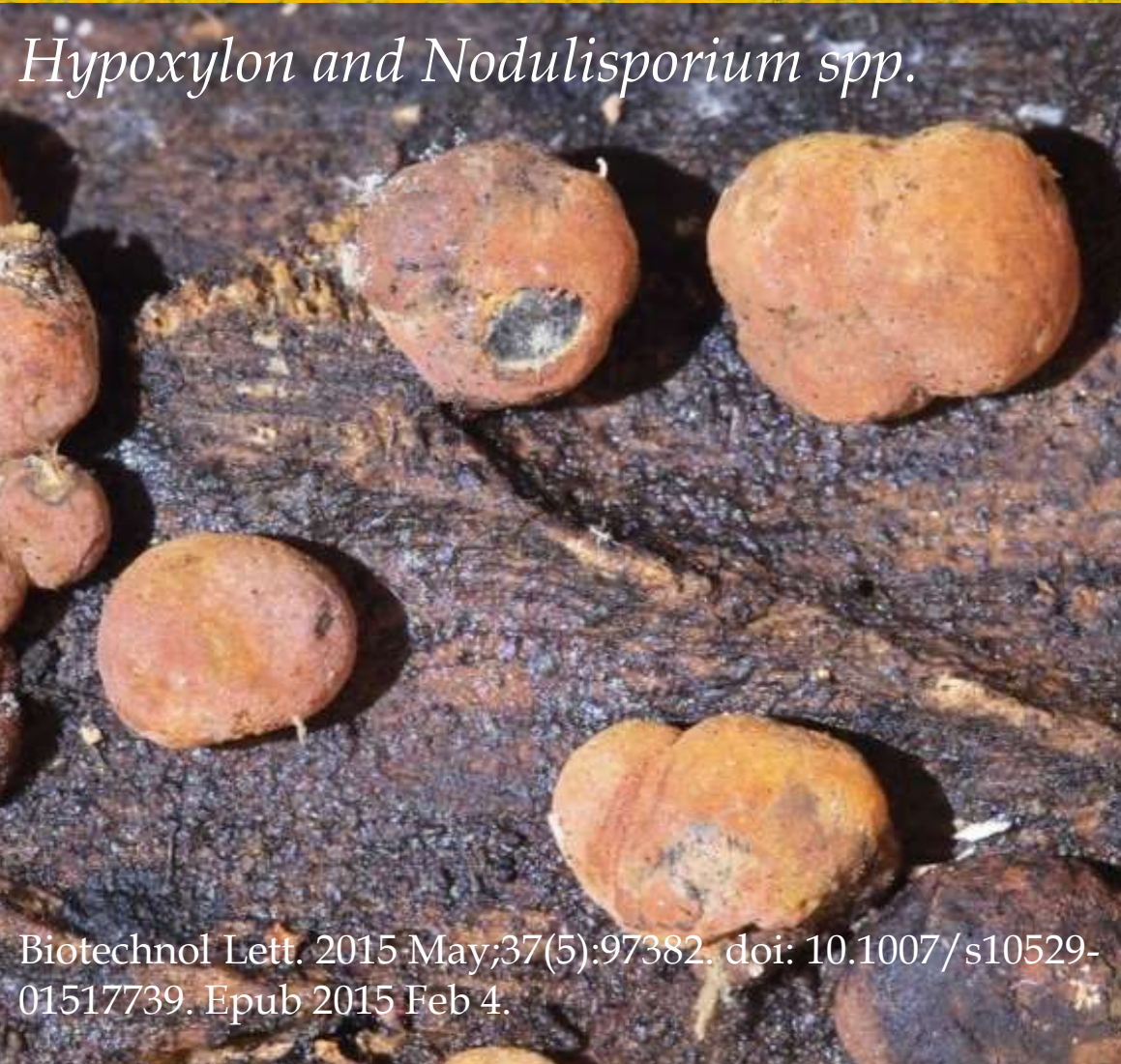
- *Gliocladium roseum* - Patagonian rainforest
- Diesel-like hydrocarbons
- Sustainable, cheaper, non-corrosive



Petroleum Cyclohexenes

(Strobel, 2015)

Hypoxylon and Nodulisporium spp.



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

Biotechnol Lett. 2015 May;37(5):97382. doi: 10.1007/s10529-01517739. Epub 2015 Feb 4.

Amazon fungi make biofuels

- *Aspergillus fumigatus*
thermoacidophile

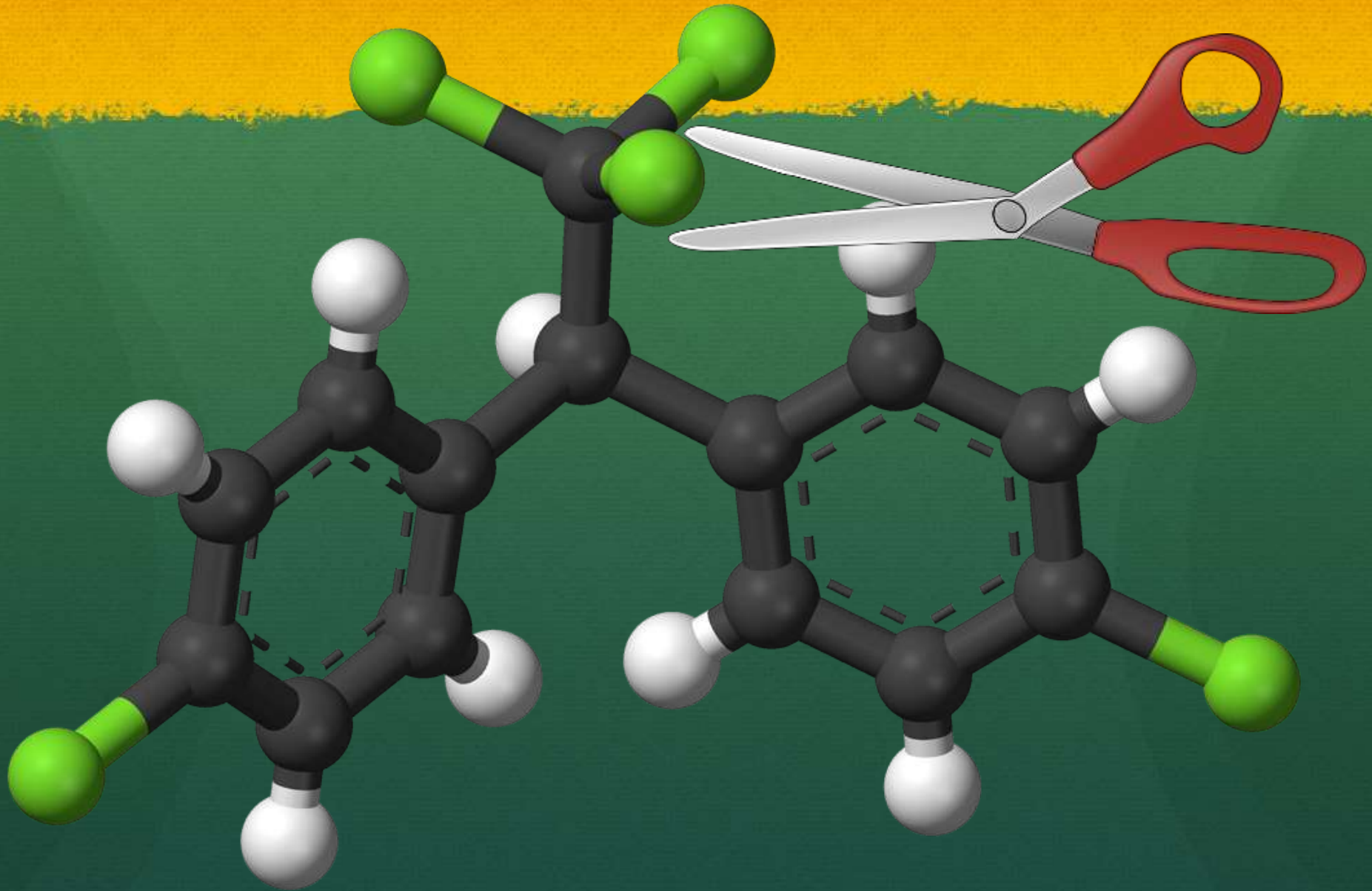


Ethanol production

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



[http://www.herbmuseum.c
a/content/pestalotiopsis-microspora](http://www.herbmuseum.ca/content/pestalotiopsis-microspora)

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)



Mutarium grows
edible fungi on plastic

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



The Process

UV - activation
cylinder



FU - agar capsule +
starch + sugar



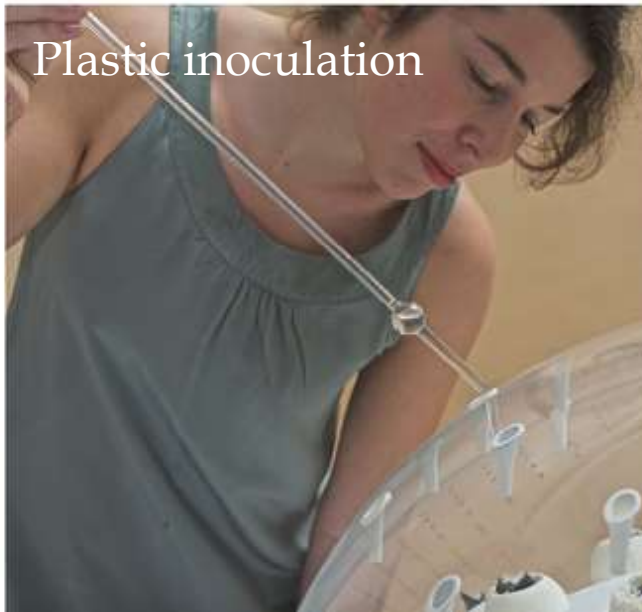
FU - fed with sterile
plastic



Liquid fungal nursery



Plastic inoculation



Edible FU after 2
week incubation





Bon Appetite Katarina!

**BraunPrize Sustainability Award
(2015)**

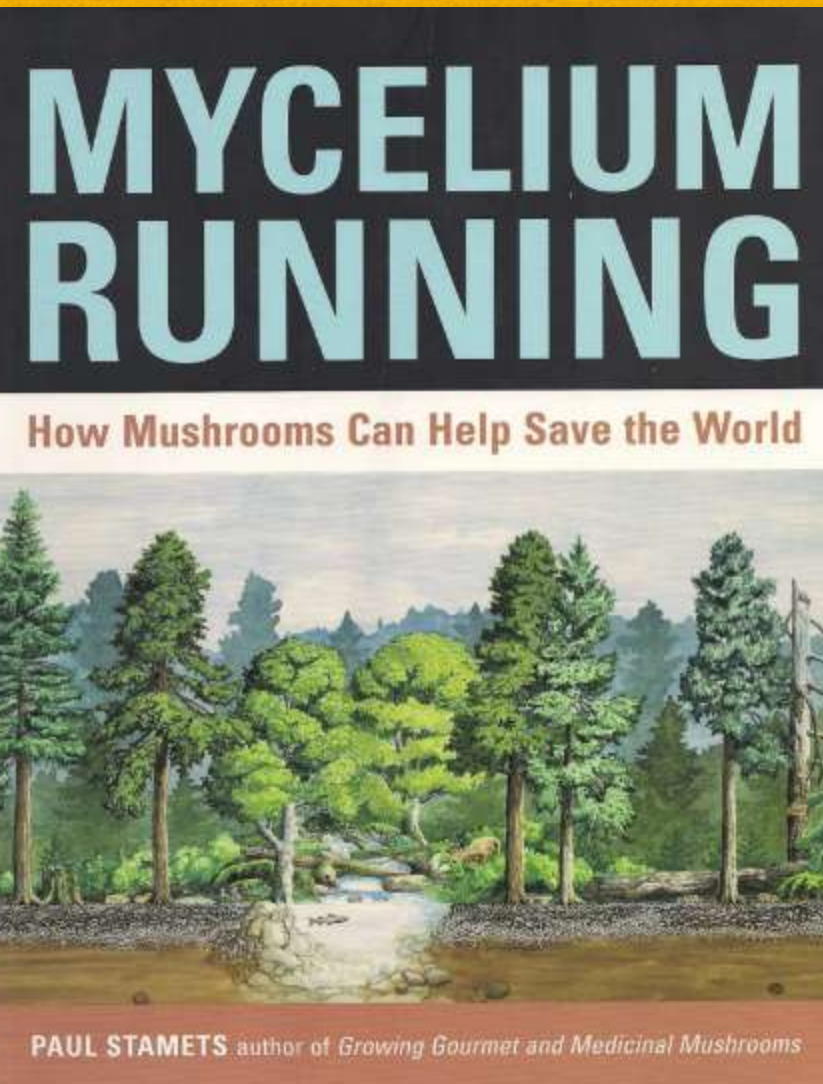


Fungi also eat

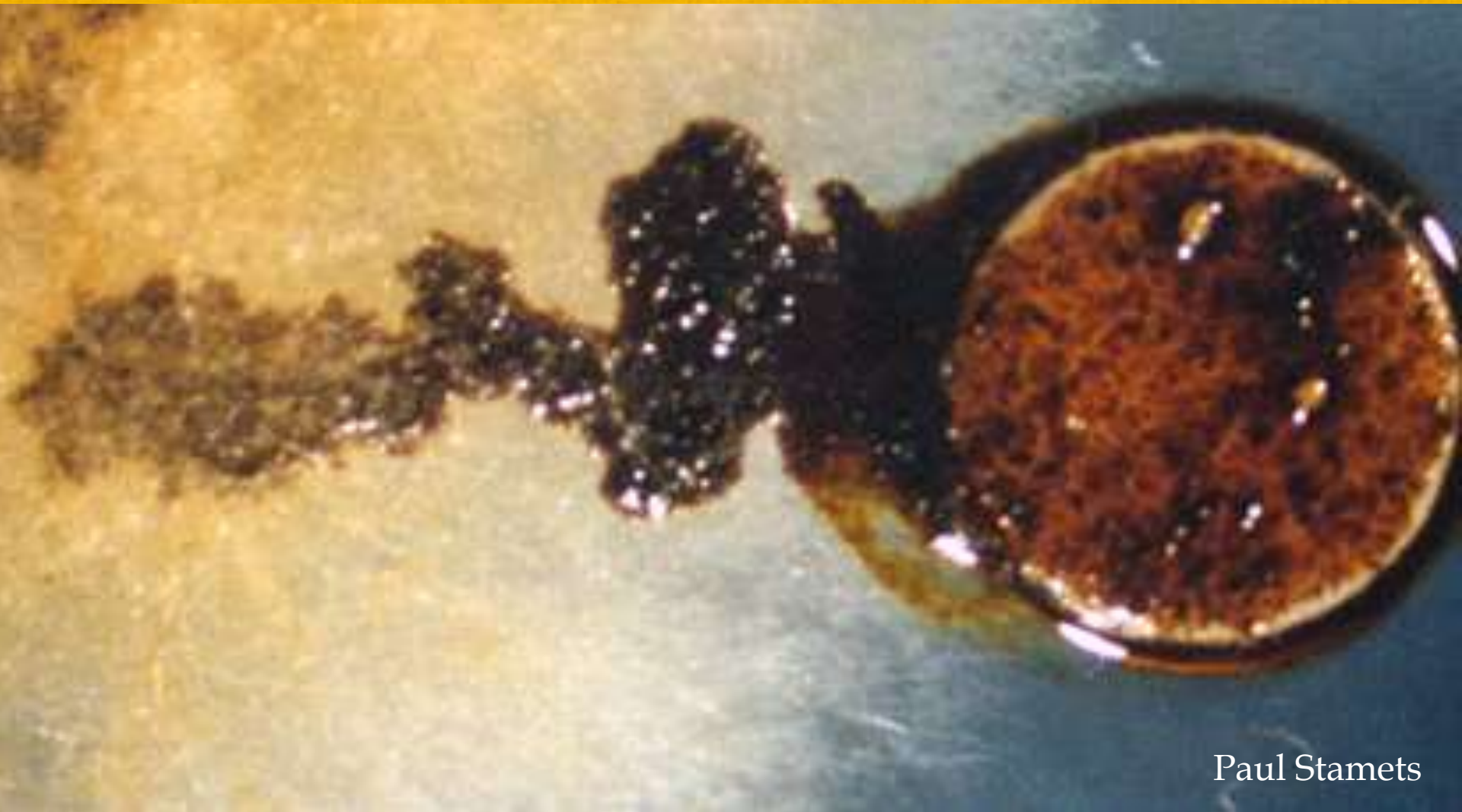


- Petroleum
- Pesticides
- Dioxins
- PCB, PCP
- Pathogens
- Nerve Gasses
- Explosives

Paul Stamets



Oyster Mushrooms eat petrochemicals



Paul Stamets

The Petroleum Problem - <http://www.fungi.com/blog/items/the-petroleum-problem.html#sthash.Sy4geITu.dpuf>

Fungi eat diesel



Susan Thomas



- 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

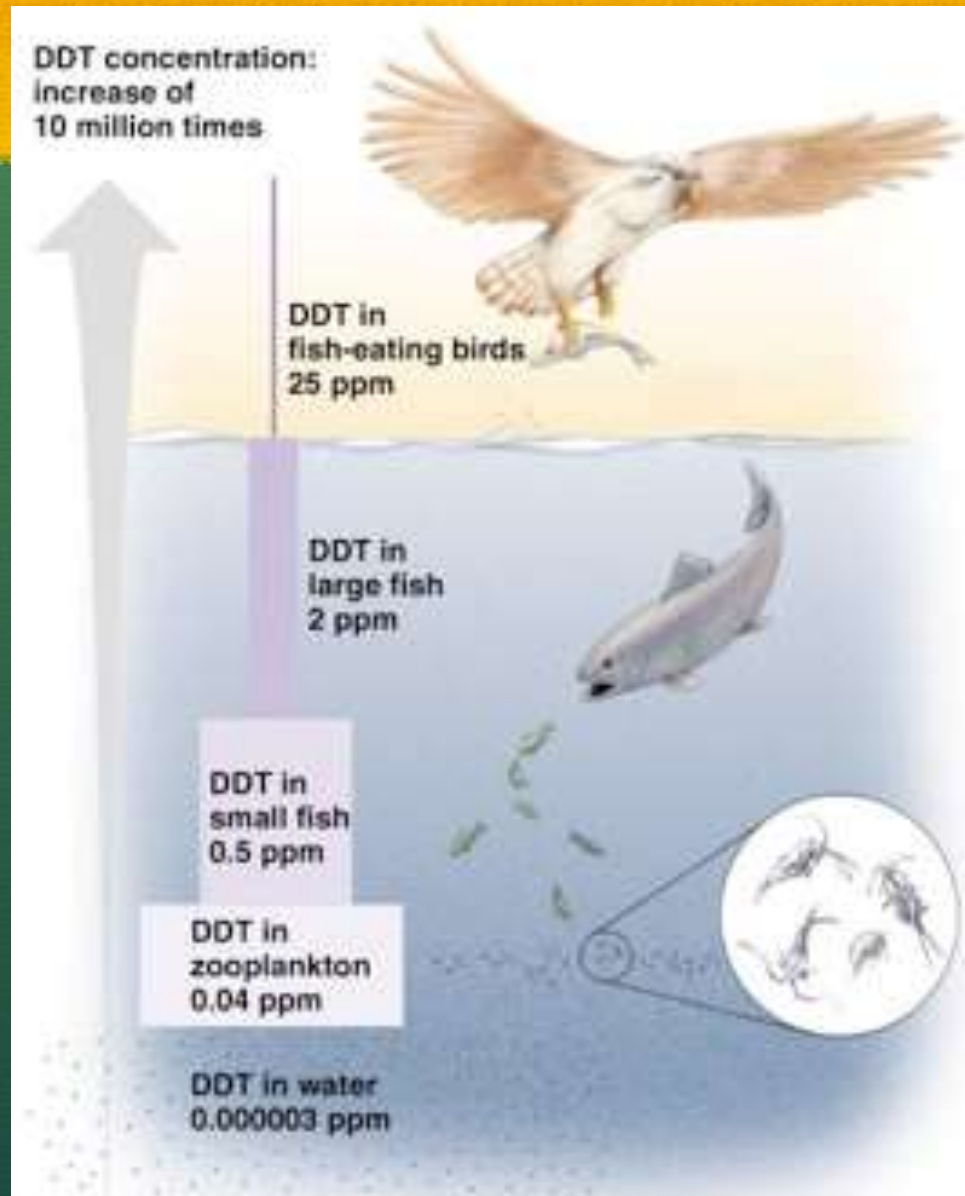
<http://www.fungi.com/blog/items/the-petroleum-problem.html#sthash.Sy4geITu.dpuf>

Myco-Filters eat pathogens and toxins

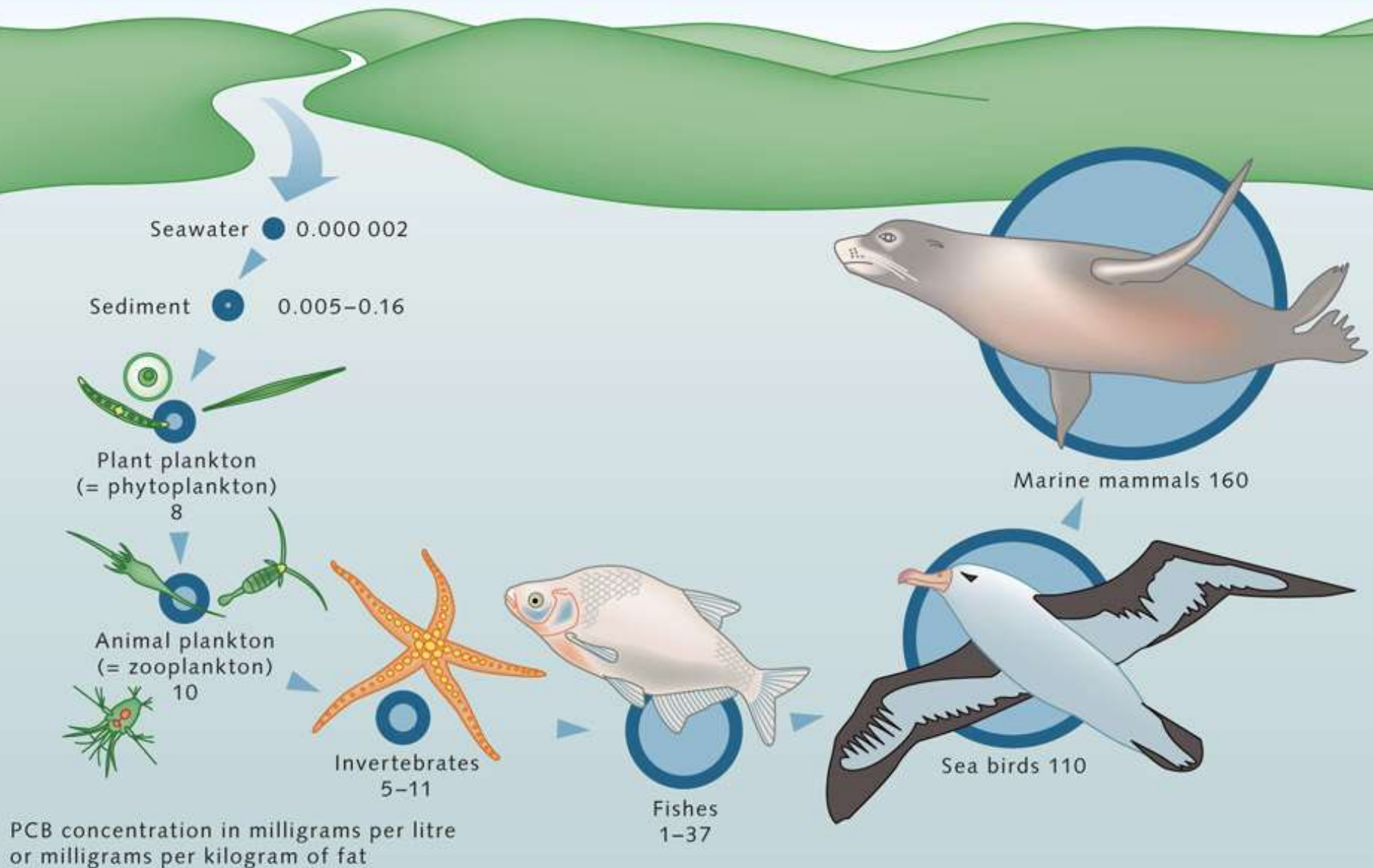


Pollutants bioaccumulate

- Pesticides
- Petrochemicals
- PCB, PCP

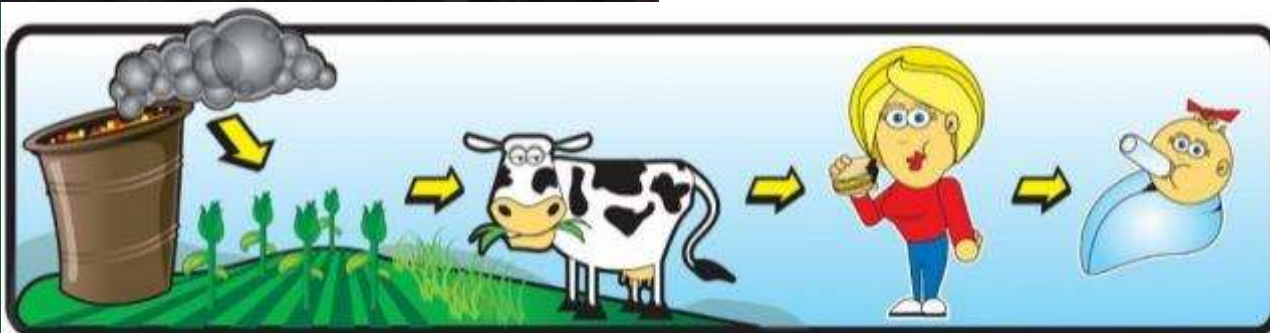


Biomagnification



Biomagnification

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



Pollutants harm people



Pollutants harm animals



Fungi eat poisonous pollutants



Fomitopsis pinicola



Daedalea dickinsii



Phlebia lindtneri and *P. brevispora*



Gloeophyllum trabeum

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

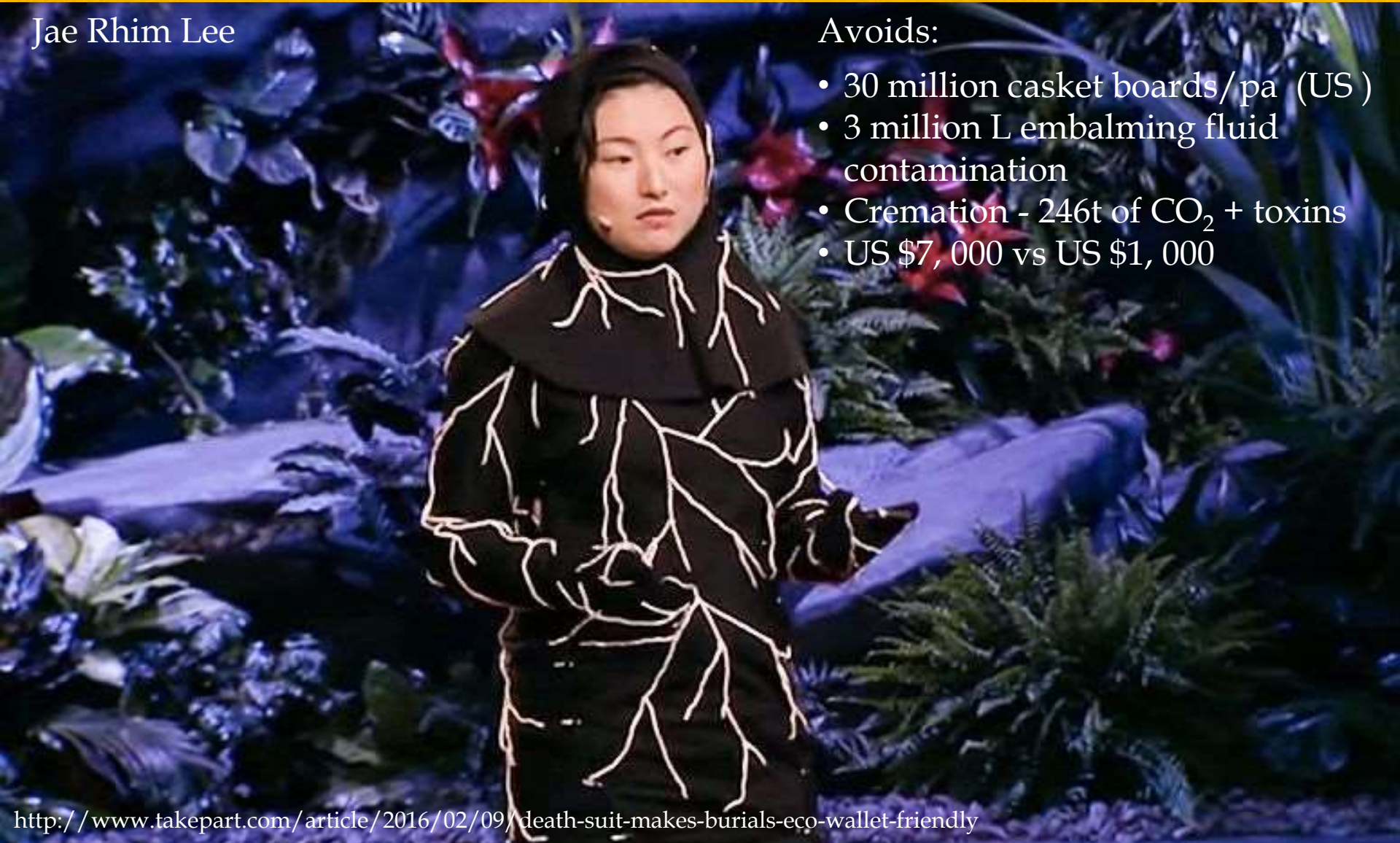


The Myco-Death-Suit

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



Myco-design and technology



Maurizio Montalti

Myco- Design

Jonas Edvard



Myco Foam





Myco-Ford



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



<http://www.dezeen.com/2014/07/01/tower-of-grown-bio-bricks-by-the-living-opens-at-moma-ps1-gallery/>

Myco-Dress

Aniela Hoitink



<http://www.dezeen.com/2016/04/01/aniela-hoitink-neffa-dress-mushroom-mycelium-textile-materials-fashion/>

Myco-Design

Kristel Cojak



Muskin - Leather



<http://www.mycoworks.com/>

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



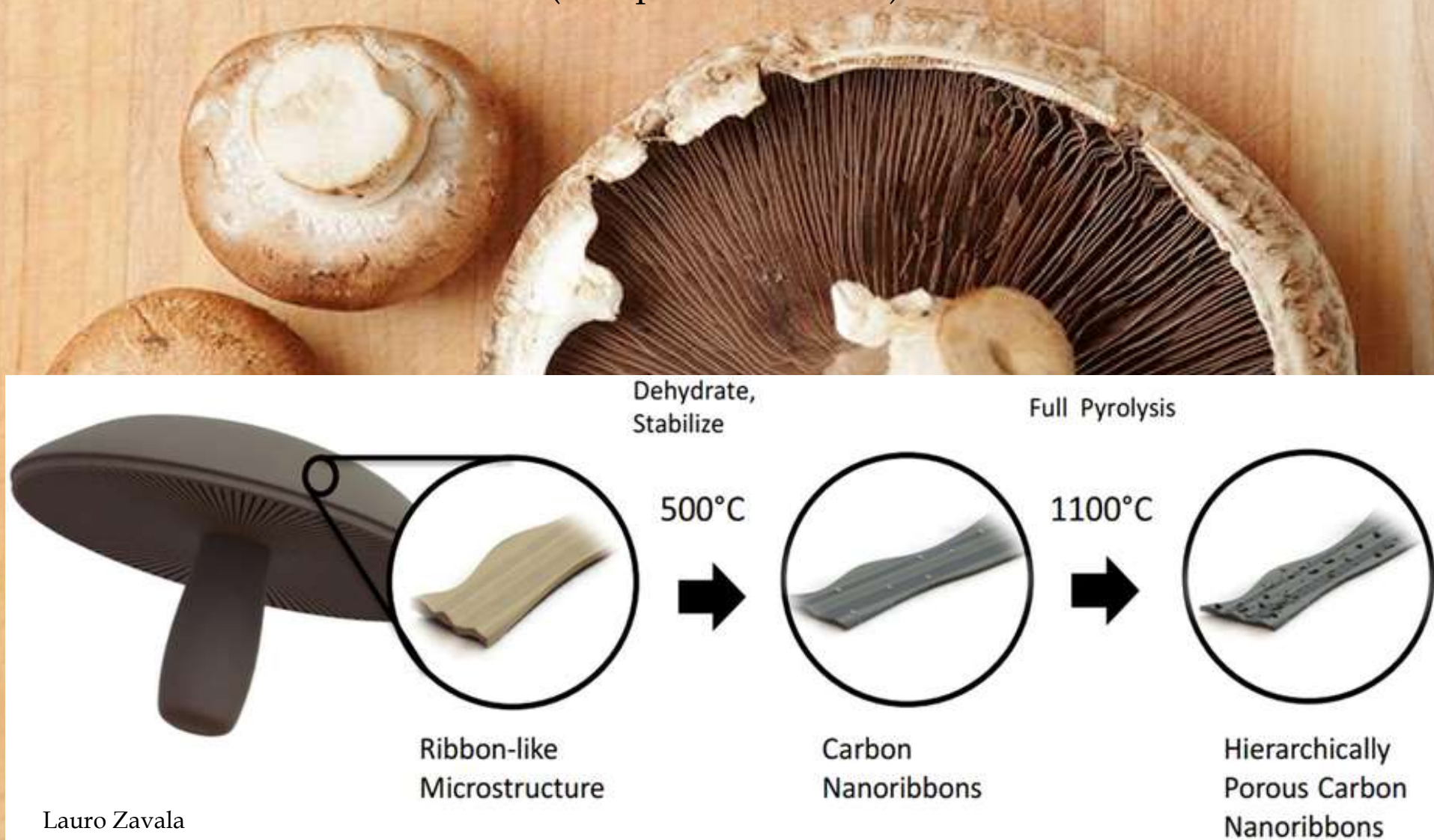
Lowe-White

Mushroom Batteries



Portobello Mushroom Batteries

(Campbell et al., 2015)



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...





Thank You

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www.mycologymania.facebook.com