THE POWER OF SOIL BIOLOGY

DANI KUSNER

CCA, TERRAIN ADVOCATE

DEEP SOIL LLC

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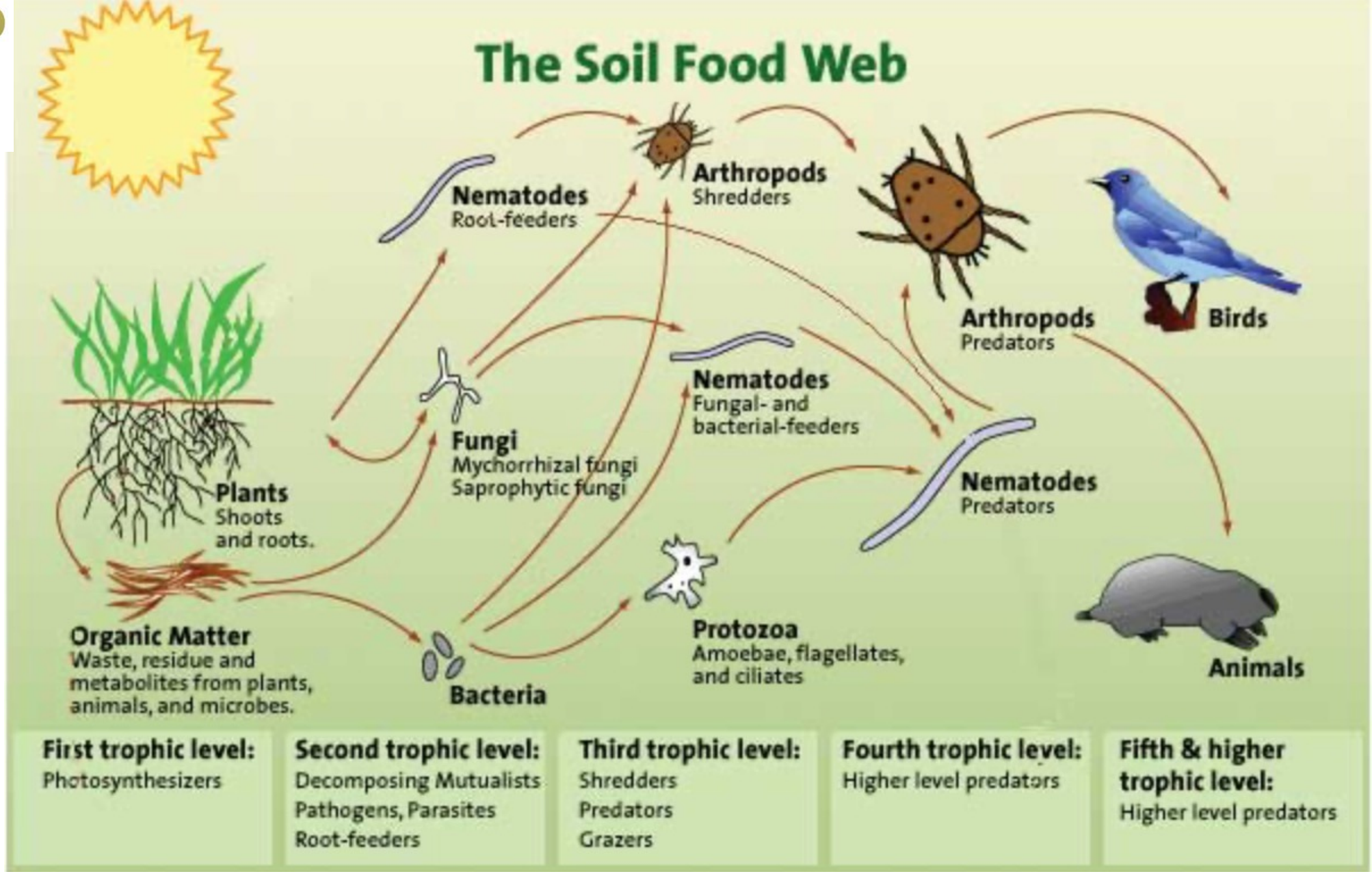

https://www.soilfoodweb.com.au/about-our-organisation/benefits-of-a-healthy-soil-food-web


DEEP
SOIL
“THE MORE WE
KNOW ABOUT SOIL,
THE LESS WE KNOW…”


DEEP
SOIL
FUNGI
BACTERIA
POSSIBILITIES AND QUESTIONS

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"ON THE EFFICIENCY OF THIS MYCORRHIZAL ASSOCIATION, THE HEALTH AND WELL-BEING OF MANKIND MUST DEPEND."
~SIR ALBERT HOWARD (1940)

WHERE DID WE COME FROM?

- How did life evolve from existing only in water to migrating onto land?
- How did raw rock / inert earth elements transform into soil?
- Where did photosynthesis come from?


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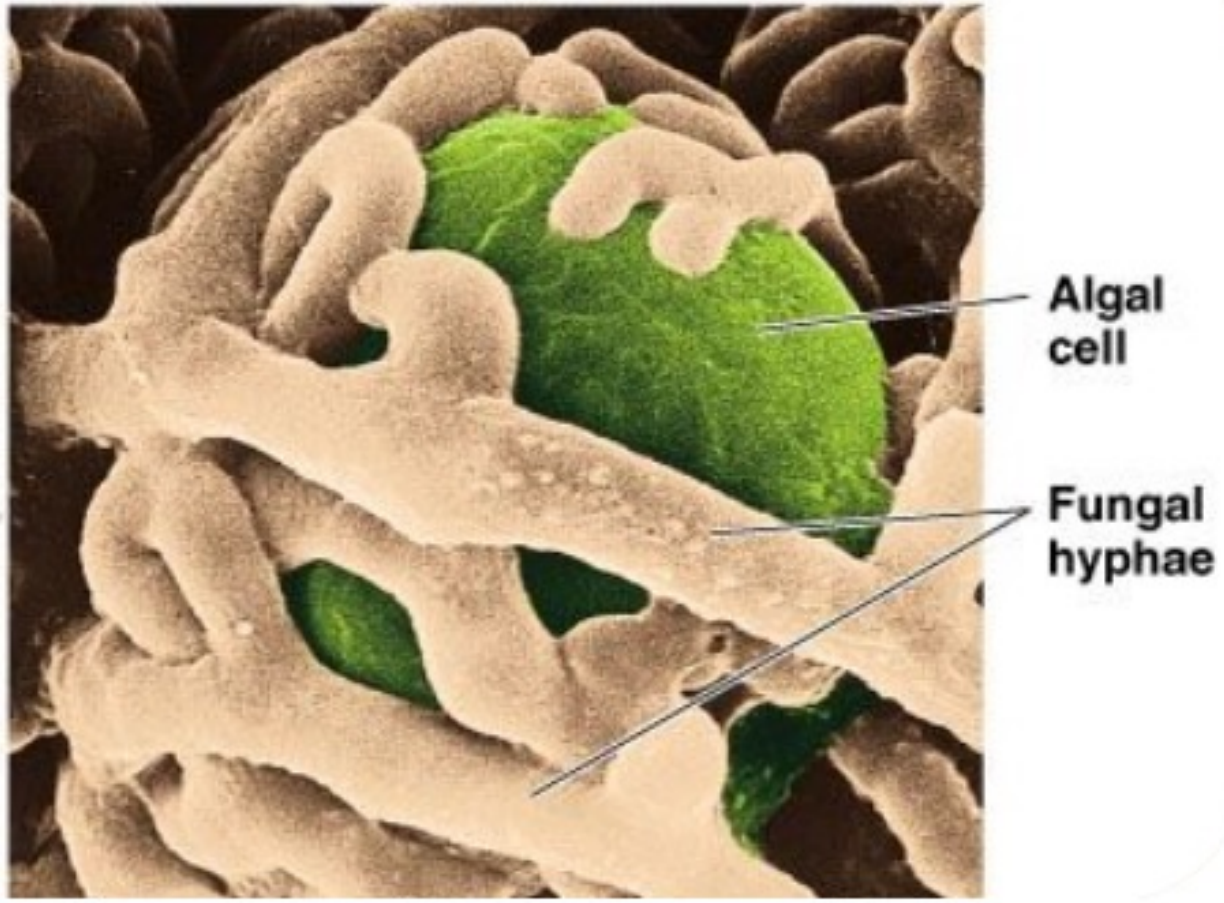
“Lichens
start where
the seaweeds
stop”
~Sheldrake

- 1885: scientists first discovered that fungi help plants obtain nutrients from the soil, using lichens as the example.
- This dismantled foundational sciencific theory of the time:
  - Survival of the fittest
  - Life is all competition and conflict.
- Lichens' symbiosis discovery was first example of collaboration.



https://www.pinterest.com/pin/lichen-anatomy--494199759089051694/

SYMBIOSIS

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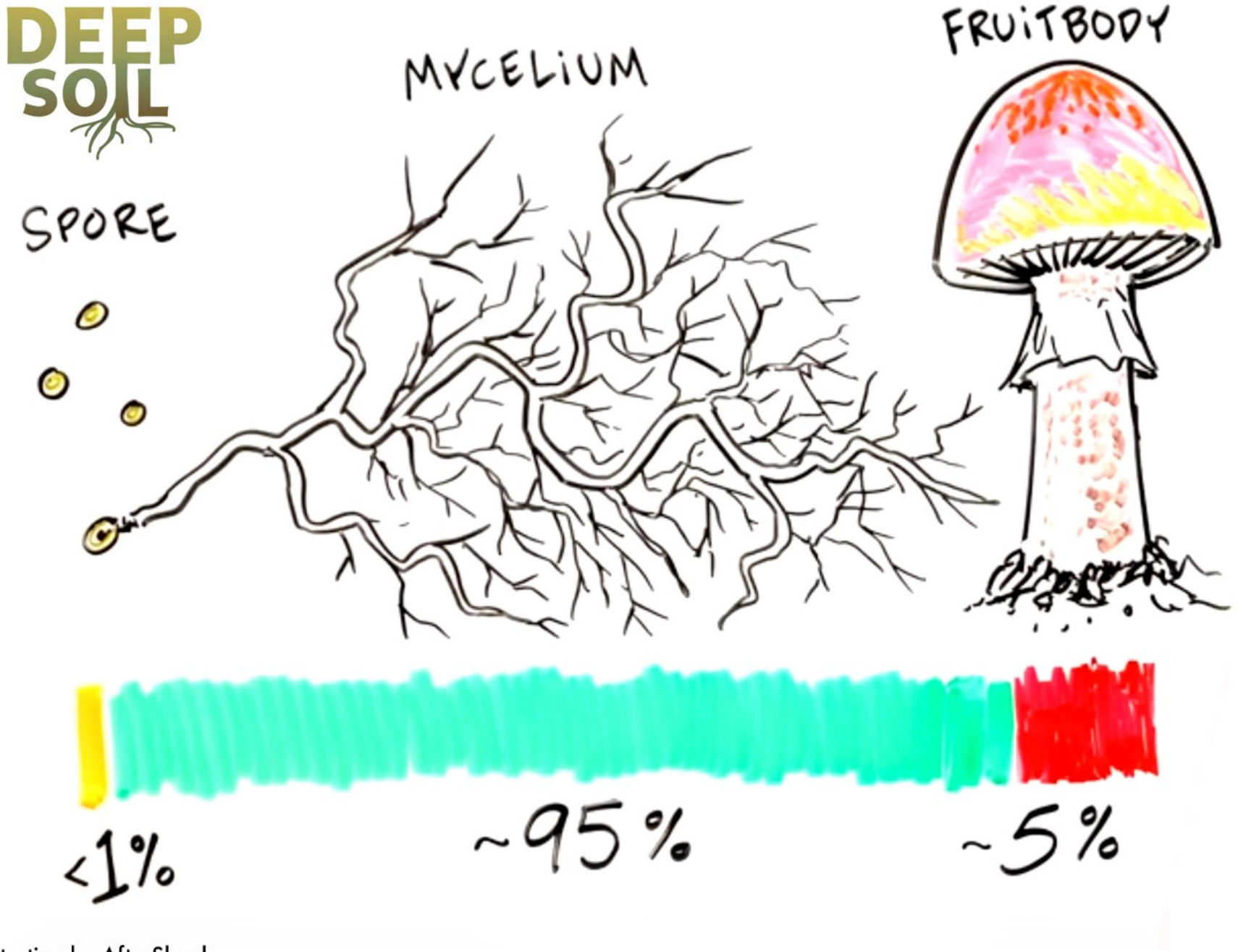


FUNGI

- Mycelium have persisted for some 2 billion years, more than 50% of life's 4 billion year history.
- Over 90% of fungal species remain undocumented.

https://hostdefense.com/blogs/host-defense-blog/mycelium-explained

FUNGI – THE "ROOT BRAIN"

- The Latin root of the word intelligence means "to choose between"
- Many "brainless" organisms – **plants, fungi – are making decisions** between different actions
- Suggests **flexibility** and/or using algorithms/computing capacity to "choose"
- Sometimes to the extent of **sophisticated problem solving**
  - Slime molds (a form of fungus) that solves mazes!
- Is it the "**network**" with its ability to communicate/respond that leads to "intelligence"?

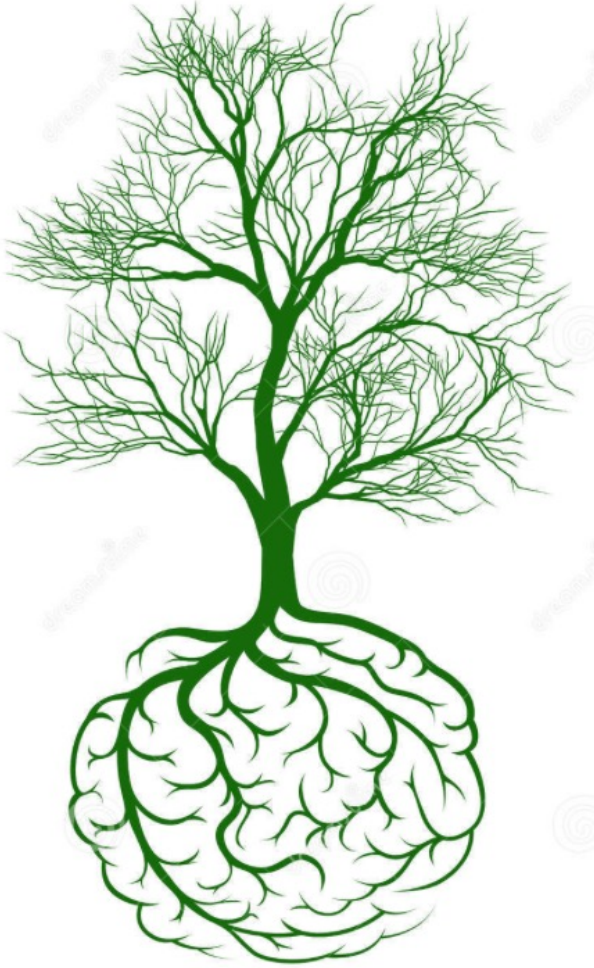


Image credit: Christos Georghiou

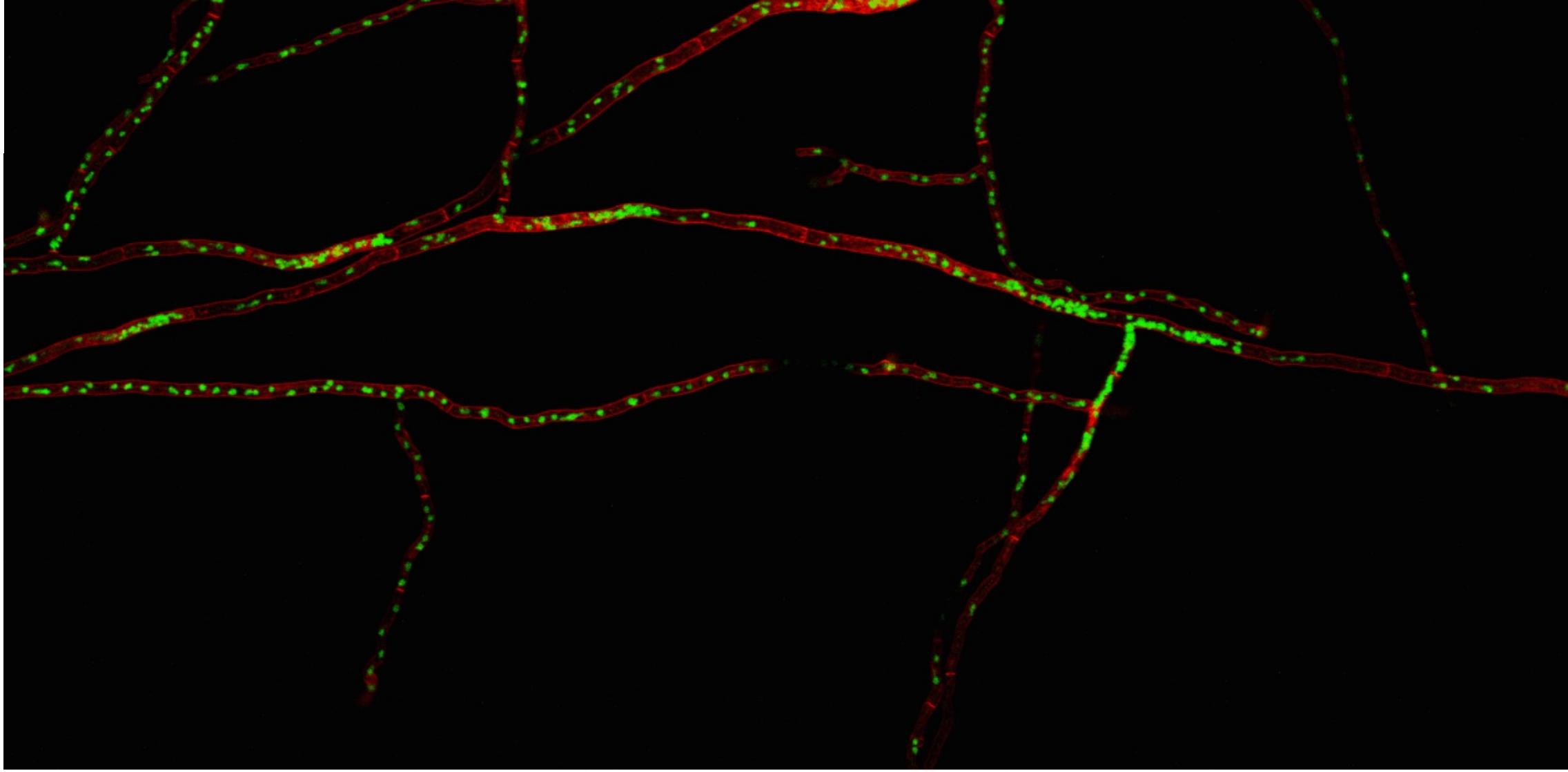
- Plants make up 80% of the mass on earth.
- More than 90% of all plants depend on Mycorrhizal fungi (MF).
- MF ~ from the Greek words for fungus (mykes) and root (rhiza)
- MF make up 1/3-1/2 of the living mass of all soils.

https://www.gardenmyths.com/mycorrhizae-fungi-inoculant-products/

"METABOLIC WIZARDS"

- Chemical transformers and decomposers
  - Explore, scavenge and salvage
- Transform some of the toughest compounds on earth (rocks, wood, etc) into plant usable nutrients

- "80% of a plant's productivity is connected to the bioavailability of essential nutrients, not to the amount/quantity of them." ~Walter Jehne

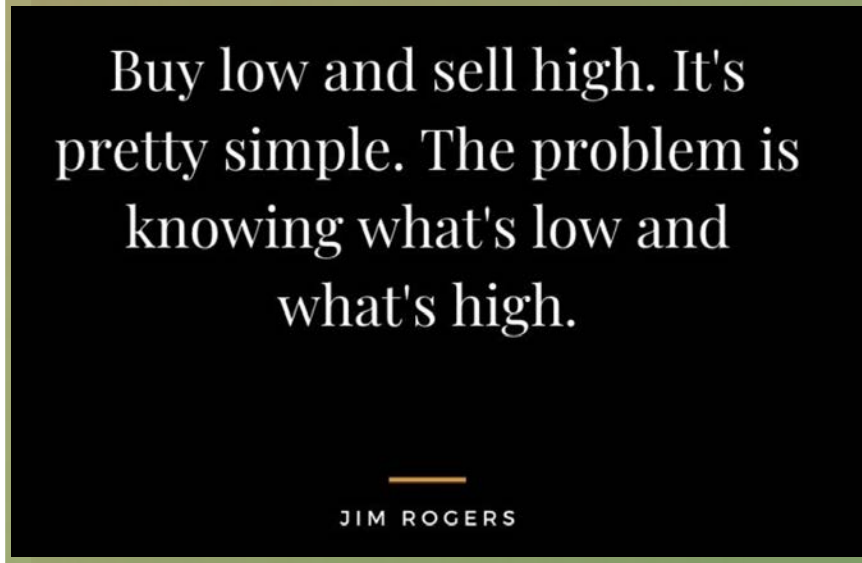


Time lapse video showing how nuclei (in green) and membranous organelles (in red) travel through mycelium. Like an underground highway, mycelium allows for dynamic transport of nuclei, organelles, and mitochondria. This is the manner in which mycelium communicates with its surrounding ecosystem. © Dr. Patrick Hickey, 2008.

https://hostdefense.com/blogs/host-defense-blog/mycelium-explained

PHOSPHORUS

- MF actively transport phosphorus from areas of abundance (a low price) to areas of scarcity (where it is in high demand, high price.)
- As the fungus moves the phos around to create more equilibrium, it receives larger quantities of carbon in return.
- So when we apply P fertilizers, including manure, how does this affect MF and phosphorus?



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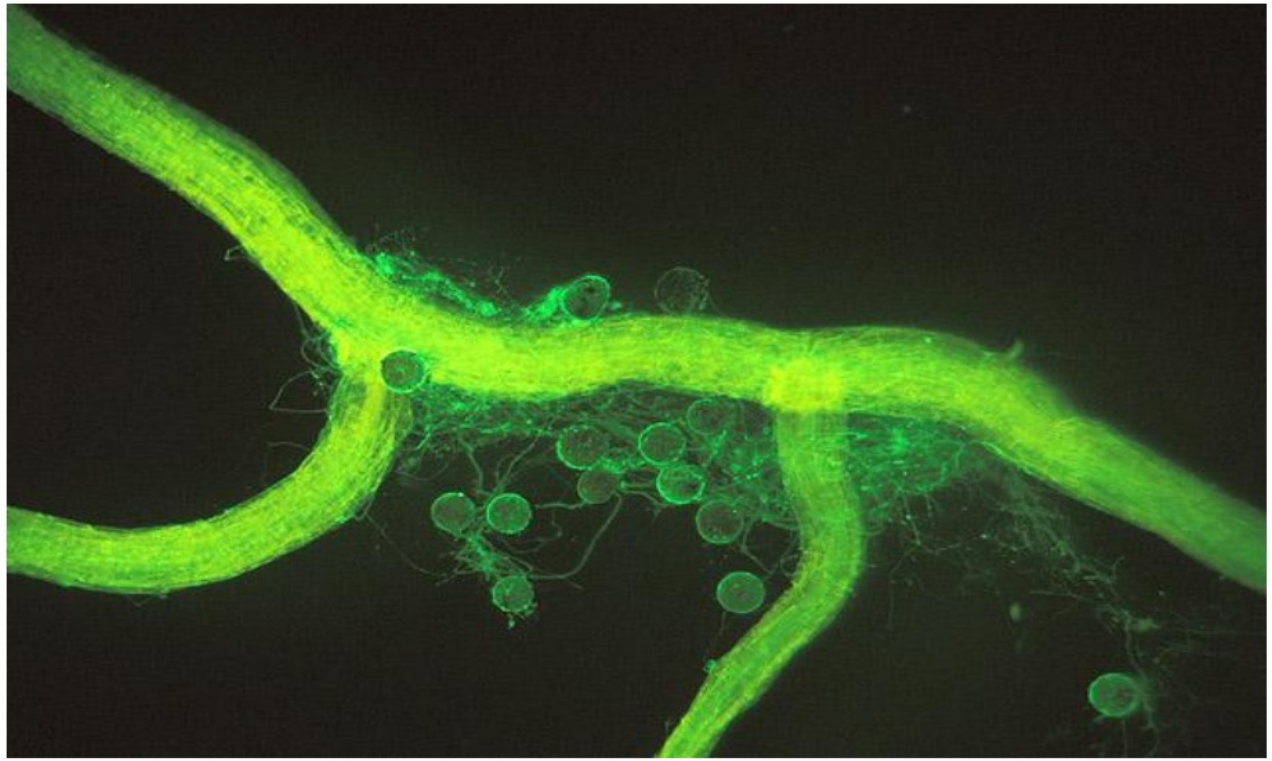
EVERY PLACE THAT A MYCORRHIZAL NETWORK EMERGES, “THE HEALTH AND VITALITY IS ACCELERATED – IN THE PLANTS, IN THE SYSTEM.” ~PAUL STAMETS



A microscopic view of an arbuscular mycorrhizal fungus growing on a corn root. The round bodies are spores, and the threadlike filaments are hyphae. Photo by Sara Wright, USDA Agricultural Research Service.

MYCORRHIZAE IN AG

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- 2019 – Agroscope in Zurich
- Organic versus conventional farming practices
- Measured fungi on the roots of crops by sequencing DNA to identify species and map which species were associating and forming networks

- Results
  - MF numbers were higher in organic.
  - MF communities were more complex with 27 species identified that were highly connected versus 0 in the conventional.

MF FARM MGT COMPARISON

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MYCORRHIZAE




- Increase the quality of harvest as demonstrated in experiments with basil, strawberries, tomatoes and wheat
- Different species of MF influence the flavor
  - Therefor could nutrient density be tied to MF?

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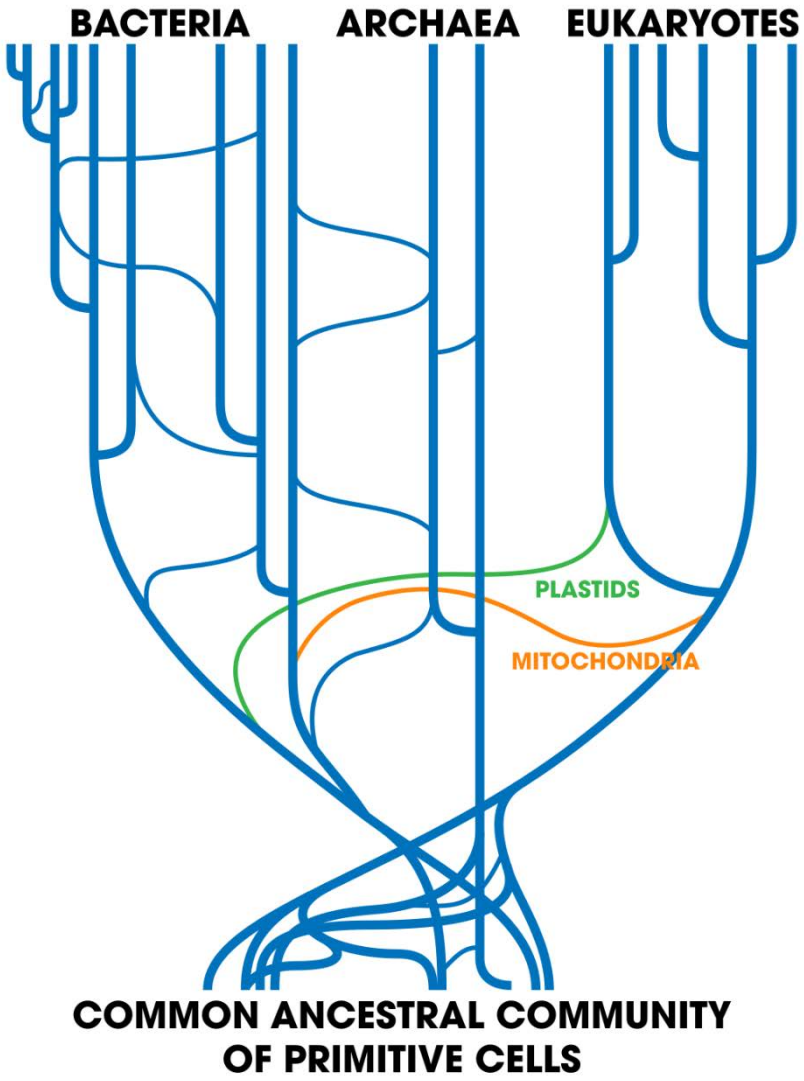
BACTERIA



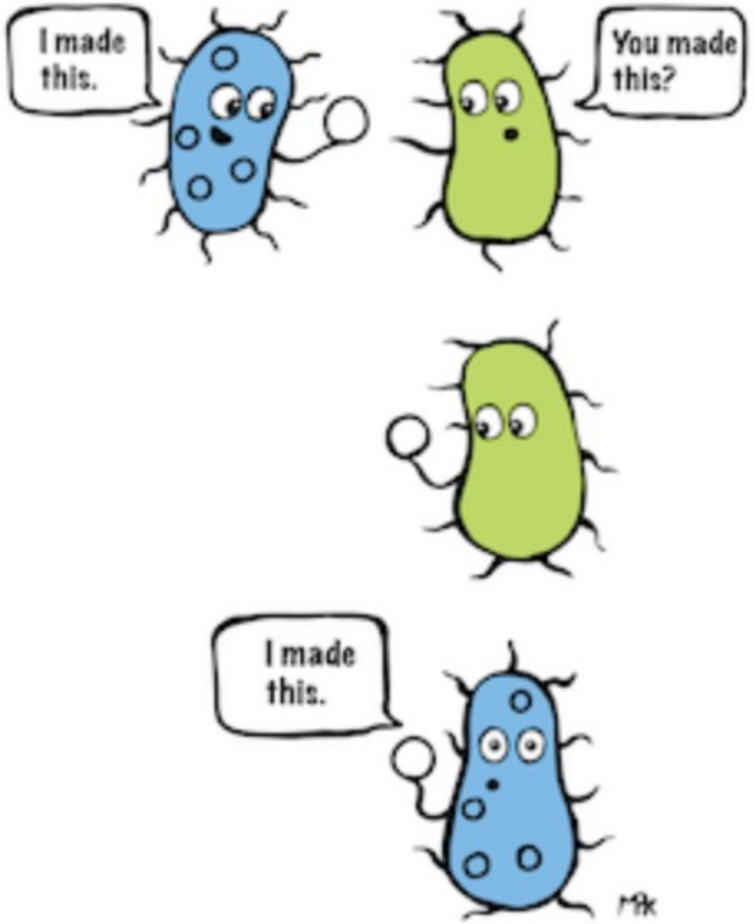
- LUCA (Last Universal Common Ancestor) for every life form on earth = bacteria
- Humans are complex innovation of bacterial communities that have evolved over millenia.
- **Mitochondria** (energy production in human cells) were once free-living bacteria.
- **Chloroplasts** (photosynthesis in plants) were once free-living bacteria.

Andrew Z. Colvin - Barth F. Smets, Tamar Barkay (September 2005). "Horizontal gene transfer: perspectives at a crossroads of scientific disciplines". *Nature Reviews Microbiology* **3**(9): 675–678. DOI:10.1038/nrmicro1253.

LUCA

- Bacteria pass down genetic information rapidly due to high reproduction rates.
- AND they can trade genes with each other "horizontally" without reproduction.
- Example: a single bacteria species is exposed to a lethal dose of a new antibiotic; it develops resistance to that antibiotic and 12 other antibiotics it did not encounter, some of which are structurally dis-similiar to the first.

~Stuart Levy, The Antibiotic Paradox



Comic credit: Maya Kostman

HORIZONTAL GENE TRANSFER

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WHAT MAKES IT RAIN?

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"WATER UNDER THE GROUND HAS MUCH TO DO WITH RAIN CLOUDS. IF YOU TAKE THE WATER FROM UNDER THE GROUND, THE LAND WILL DRY UP."

~HOPI ELDER

THE SOIL CARBON SPONGE

- Coined by Walter Jehne
- Bacteria released from stomata when trees exhale help form clouds to make it rain.
- Deforestation affects the local hydrology cycles which are driven by microbes.

DEEP SOIL

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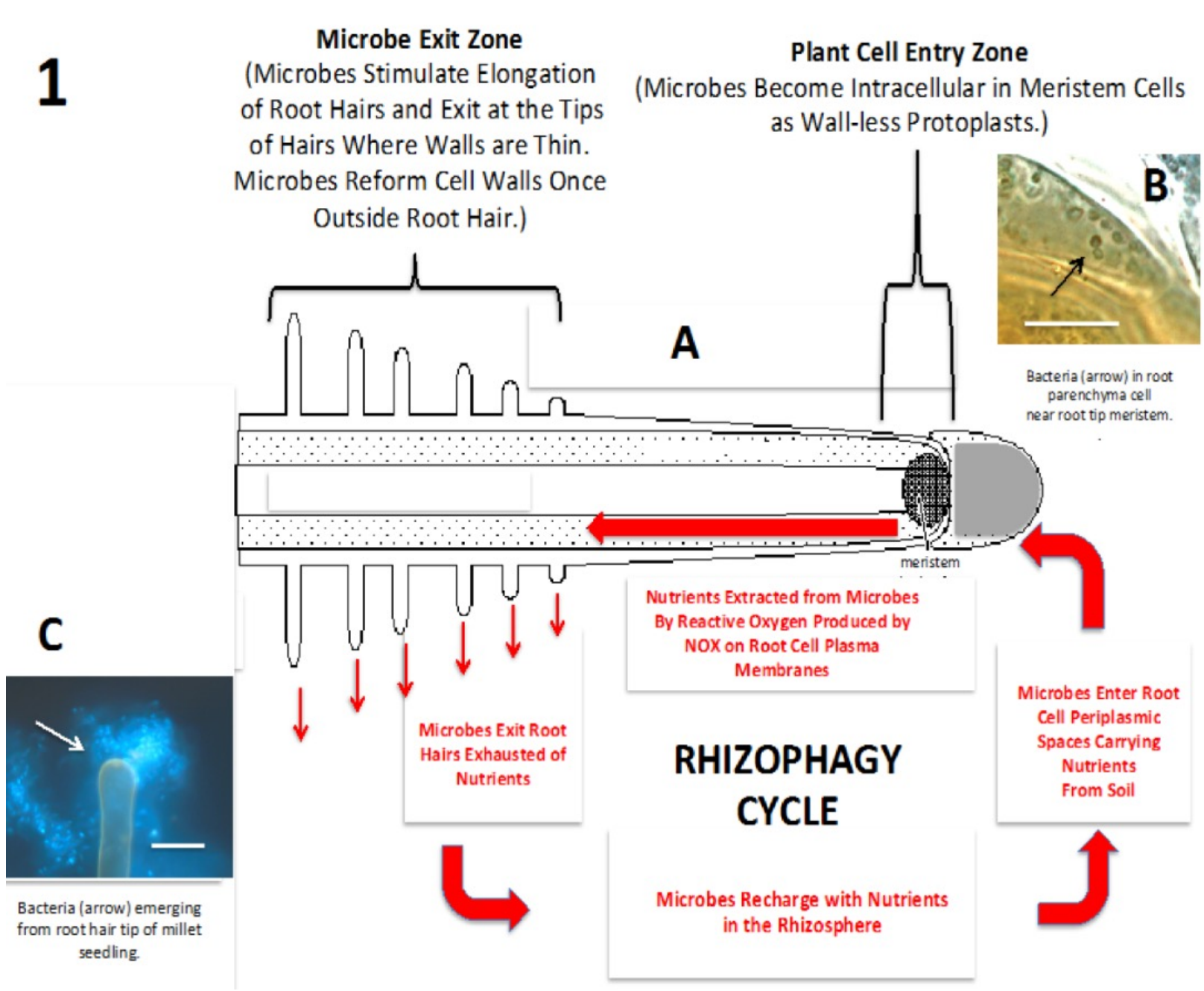
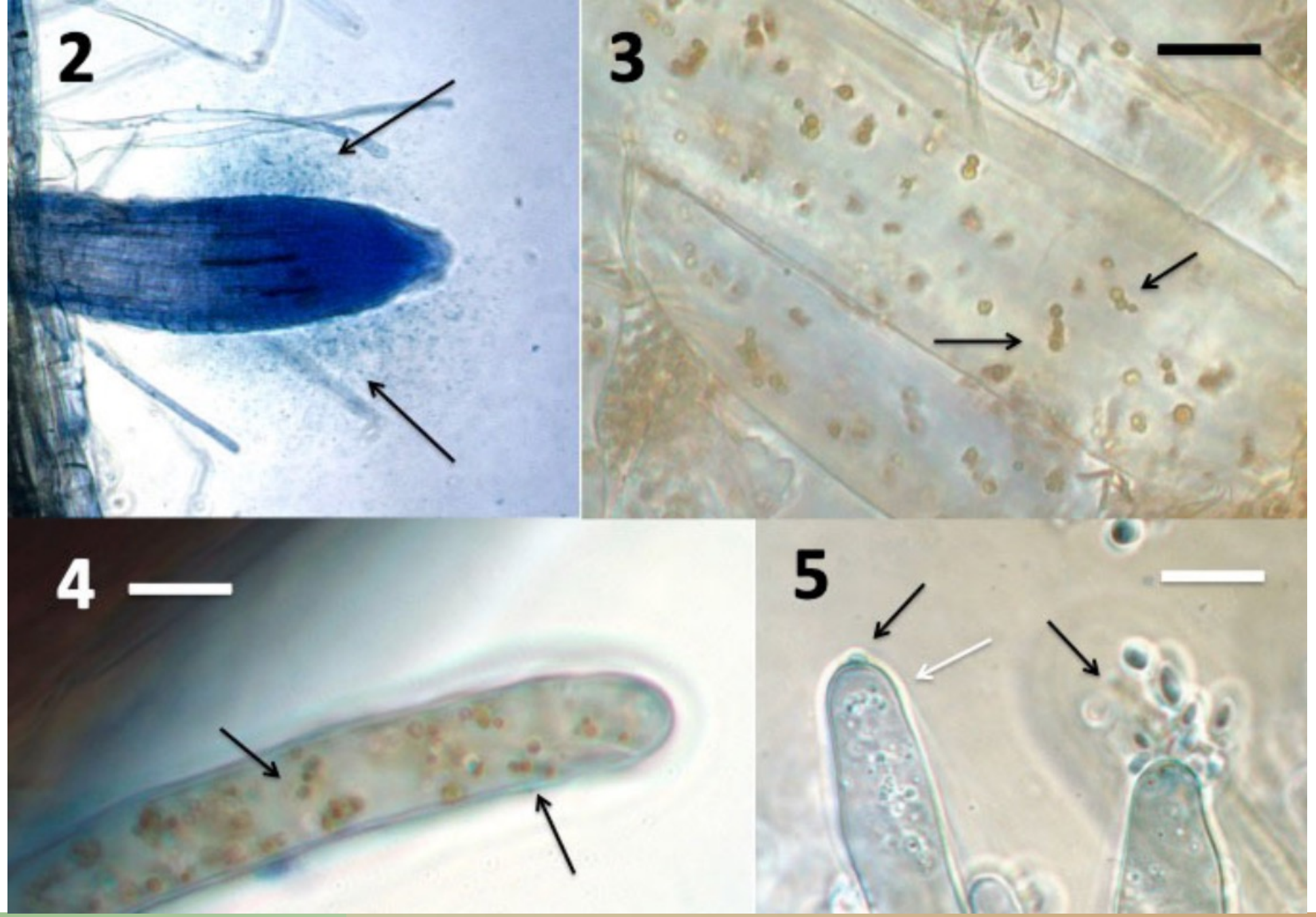


Credit: James White; https://www.researchgate.net/figure/A-C-Diagrammatic-representation-of-the-rhizophagy-cycle-1A-Diagram-of-the-rhizophagy_fig6_333878220



Credit: James White

https://letgrow.org/benefits-of-soil-microbes/

POSSIBILITIES, QUESTIONS

BIOLOGY OR ECOLOGY?

- Biology: the study of living organisms
- Ecology: the study of the relationships between living organisms

- Seed varieties – what is their capacity for high-functioning mycorrhizal relationships? Or have they been bred for high nitrogen inputs?
- Fertility – source, rate, and application methods for how it is influencing the soil ecology?
- Chemical technologies – any input into the system will alter biological and physical characteristics of the soil.

GET CURIOUS

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- Total Digestion Test
- Haney Testing – primarily for Nitrogen
- SAP analysis
- Possible soil microbe testing: microscope identification, PLFA, metagenomics

  * Remember that isolating will not represent the whole of the parts!

TESTING POSSIBILITIES

Nitrate

Ammonium

Amino Acids

A NOTE ON NITROGEN

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THE SEEN VERSUS UNSEEN

Credit: Nick NA/Shutterstock

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“A MYCELIAL NETWORK IS A HELPFUL REMINDER THAT ALL LIFE-FORMS ARE IN FACT *PROCESSES* NOT *THINGS*. NATURE IS AN EVENT THAT NEVER STOPS.”
~SHELDRAKE


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- More **collaboration**; more **relationship**
- Think in **communities** and **networks**, not as singular individuals competing for resources
  - Engaging with **multiple partners**
  - The **whole** of a **self-organizing system**, not the parts
- Expanded thinking and awareness of new **possibilities, discoveries, connections**
  - Where does a plant start/end? Where does the microbial community start/end?
- **Reciprocity** - reciprocal rewards to the plant and the fungus
- **Flexibility** - flexible networks, flexible decision making

TO BE MORE LIKE SOIL BIOLOGY

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RESOURCES - THANK YOU!

dani@deepsoilhealth.com

- "Entangled Life" ~Merlin Sheldrake
- "The Lost Language of Plants" and "Plant Intelligence and The Imaginal Realm" by Stephen Harrod Buhner
- Walter Jehne
- Back to the Roots Podcast – "The Crux of Regenerative Agriculture with John Kempf" and additional notes from lectures by John Kempf