

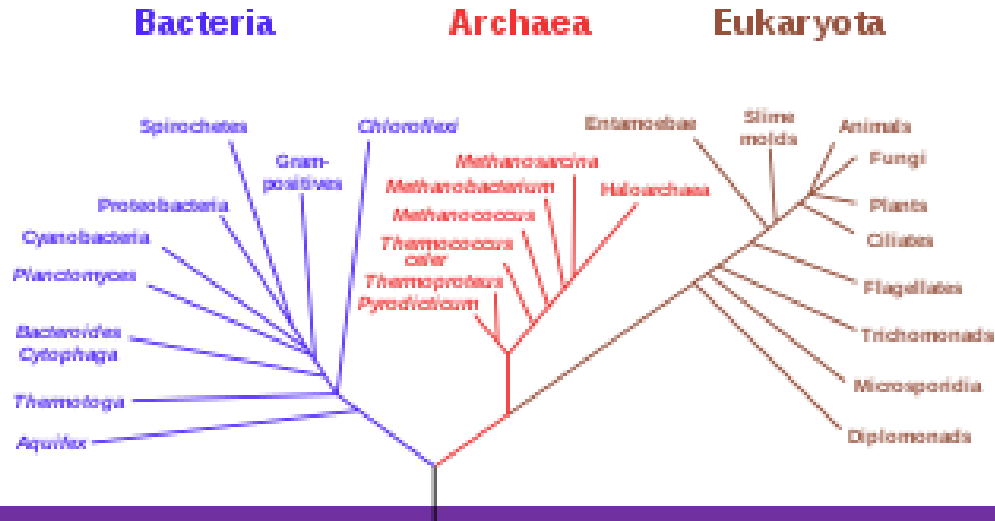
Soil microbes

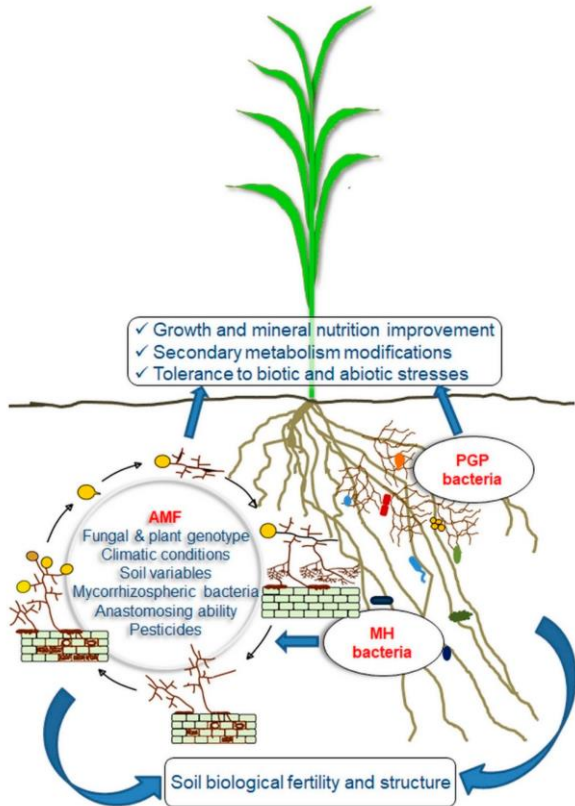
- Soil microbes
- Mycorrhiza
- PIPS3 soil microbiology
- Underpants

Soil microbes; per gram of soil

- Bacteria; $10^8 - 10^9$
- Fungi; $10^5 - 10^6$
- Actinomycetes; $10^5 - 10^8$
- Algae; $10^3 - 10^6$
- Protozoa; $10^3 - 10^5$
- Viruses; $10^7 - 10^9$

- Fix nitrogen
- Solubilise P
- Stabilise soil structure
- Recycle dead plant and animal material
- Inhibit plant pathogens (antibiotic production)
- Soil carbon





What is a mycorrhiza?

Myco – fungus (Latin)

Rhiza – root (Greek)

Plural – mycorrhizae, mycorrhizas, mycorrhiza

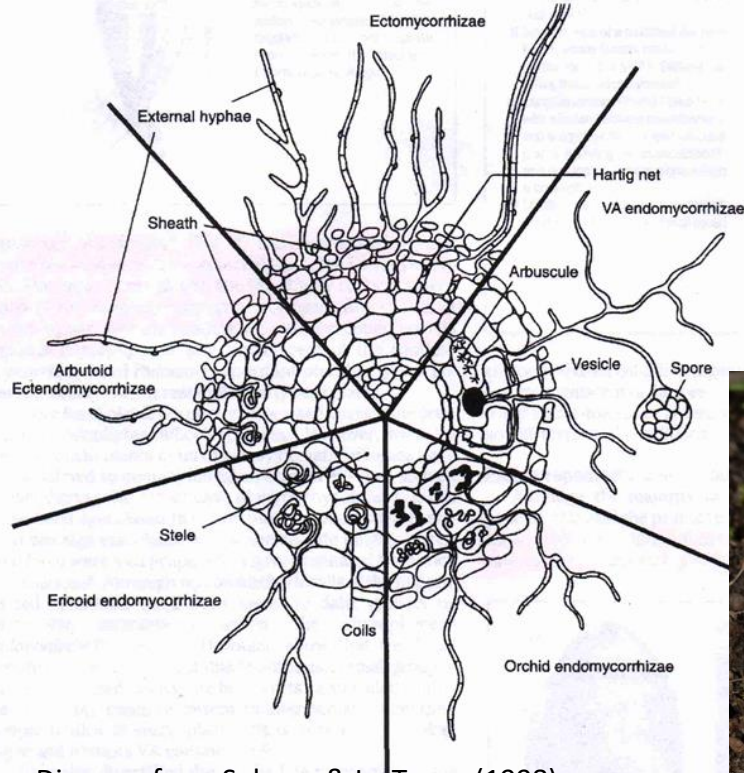
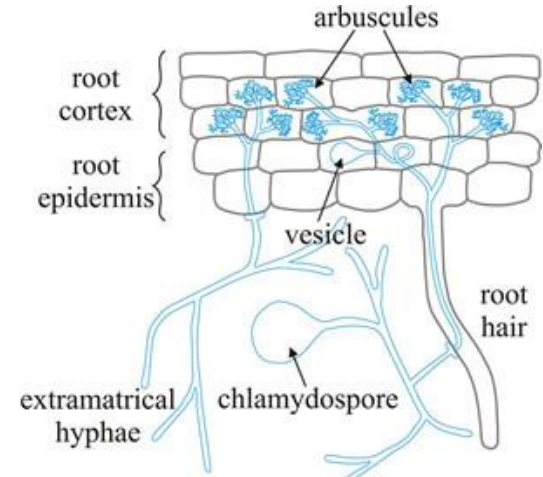
What mycorrhizae do

- Fungal mycelium acts as an extension of plant roots
- The plant and fungal cells are in close contact, allowing nutrient exchange
- Fungi can take up nutrients in forms that are unavailable to plants
- Mycelium is finer than roots and penetrates soil more thoroughly
- Fungi provide minerals to host plants in exchange for sugars
- Plants can decide whether the partnership is beneficial



Different types of mycorrhizae

- Arbuscular
- Ericoid
- Arbutoid
- Monotropoid
- Orchid
- Ectendomycorrhiza
- Ectomycorrhiza**



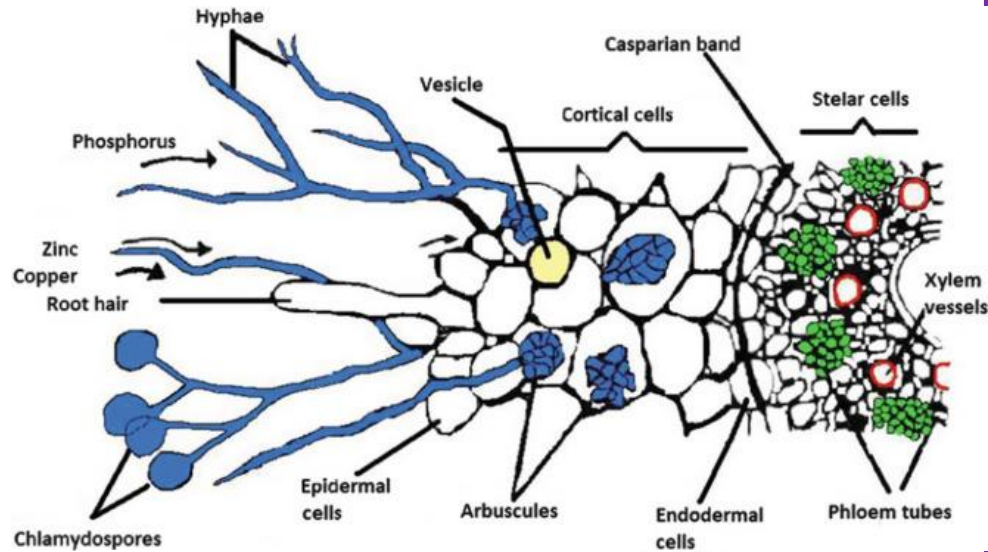
Amanita xanthocephala



Glomus macrocarpum

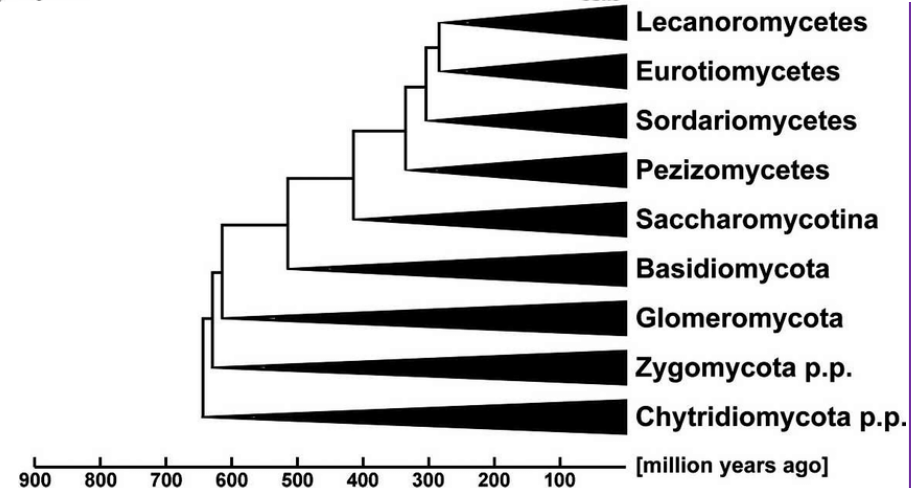
Diagram from Moore et al (2011)
21st Century Guidebook to Fungi,
Cambridge University Press

Diagram from Selosse & Le Tacon (1998)
Trends in Ecology & Evolution 13, 15-20.



Arbuscular mycorrhizae

- AM fungi belong to a phylogenetically defined group, the Glomeromycota
- Ancient symbiosis – found in fossil plants dating back to Early Devonian (>345 Mya)
- Molecular clocks indicate they diverged ~600 Mya
- AM species have a global distribution, very low endemism, in contrast to ECM
- Low host specificity
- Most crop plants associate with AM fungi



Mycorrhizae in horticulture

Studies have shown:

- AM colonisation reduces heat stress in lettuce, pepper and cucumber and a range of abiotic stresses in tomato
- AM colonisation affects root architecture of fig trees
- Increased fruit yield in jujubes and sapota
- AM inoculation alleviated drought and salinity stress in pistachios
- Alleviate iron deficiency in quince grown in calcareous soils
- Common mycorrhizal networks transferred N from white clover to citrus seedlings
- Am inoculation was more effective than zeolites in growth enhancement of un-irrigated young olive trees
- Cereals used as green mulches or intercrop drive weed selection towards species that increase mycorrhization

Mycorrhizae and apples

- In combination with PGPR, mycorrhizal inoculation increased N and Mg concentrations in apple leaves and trunk diameter
- AM colonisation increases heavy metal tolerance in apple trees
- AM inoculation of apple rootstock increased water use efficiency
- Root microbiomes of apple rootstock differ in their composition
- Apple rootstocks vary in their level of mycorrhization
(Plants that have been bred to perform well in high input systems may form mycorrhiza less frequently)
- Cereals used as green mulches or intercrop drive weed selection towards species that increase mycorrhization

Mycorrhizal inoculum

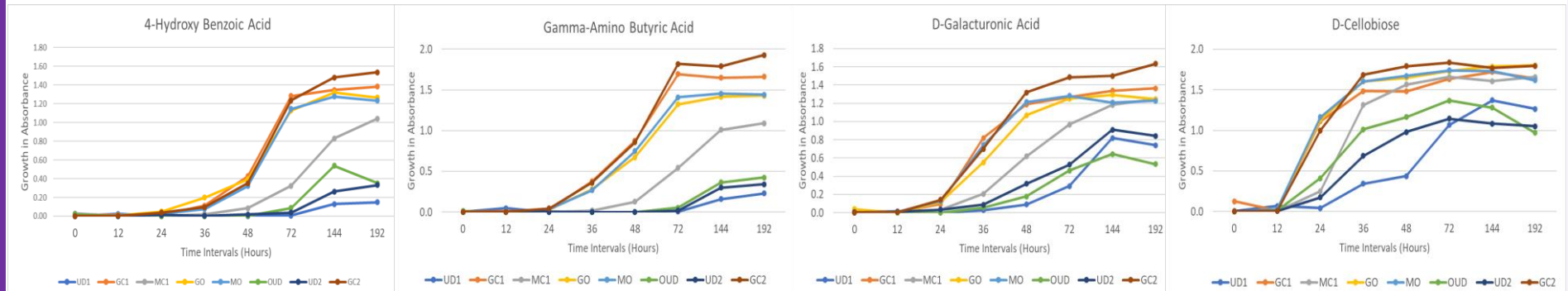
- Commercially available
 - Few species, up to 5 or 6
 - May not persist long-term
- Present in most soils
 - Appropriate land management
 - High plant available nutrients decrease mycorrhizal infections

PIPS and mycorrhizae

- Previous TIA research in cherries has shown that an organic fertiliser regime leads to increased abundance of AM fungi in soil
- In PIPS3, examining mycorrhizal inoculum under different cover crops
 - Trap cultures
 - Root colonisation
 - Soil microbiome
 - VOCs involved in signalling

Soil microbial abundance and activity under different treatments

- Viable counts were highly variable, though tended to be higher in cover crop treatments compared to conventional inter-row management.
- Functional diversity was assessed by growth on 31 different substrates as sole C source;
- Growth was negligible on 9 substrates
- On all the others, Grower's Mix (organic and conventional) had higher activity than untreated soils
- Meadow mix (organic) was similar to Grower's Mix
- Meadow mix (conventional) was intermediate between Grower's Mix and untreated



How do underpants contribute to soil health?

- Cotton is 99% cellulose – a polymer of glucose molecules
- Unbranched chains of β -glucose
- Very stable, not soluble in water and many organic solvents
- Cellulase enzymes are secreted by bacteria and fungi
 - Endocellulases – cleave cellulose chains internally
 - Exocellulases – cleave units of 2 glucose molecules (cellobiose) from ends
 - Cellobiases – produce monosaccharides (glucose) from di- or tetrasaccharides

