What are mycorrhizae?

Dr. Sobia Ilyas

What are Mycorrhizae?

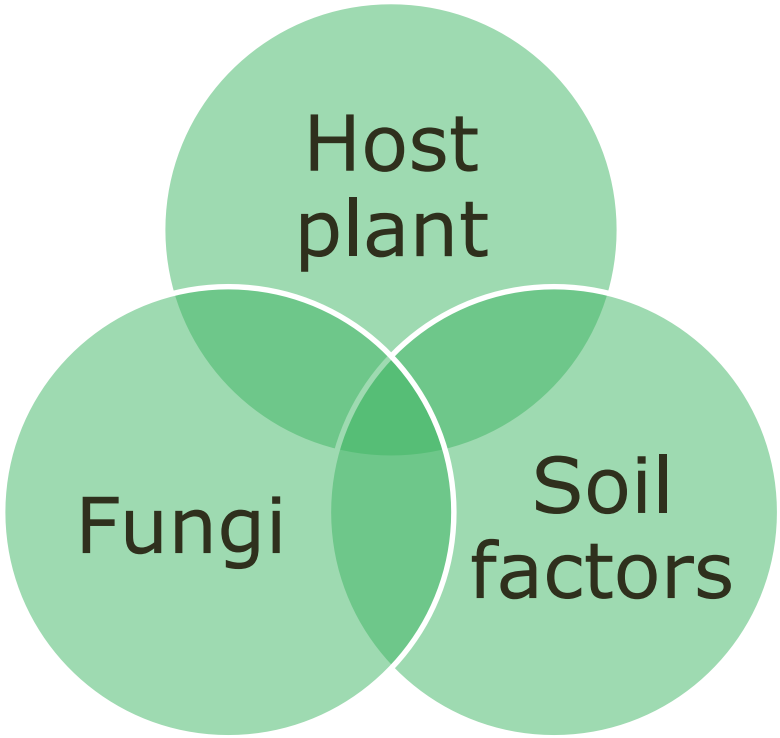
What are Mycorrhizae?

- The word **Mycorrhizae** was first used by german researcher A.B Frank in 1885 and originates from the Greek mycos, meaning “fungus” and “rhiza” meaning “root”.
- Mycorrhizae is a symbiotic **mutualistic relationship** between special soil fungi and fine plant roots: it is neither the fungus nor the root but rather the structures from these two partners.

- Since the association is mutualistic, both organisms benefit from the associations.
- The fungus receives carbohydrates (sugars) and growth factors from the plant, which in turn receives many benefits, including increased nutrient absorption.
- In this association, the fungus takes over the role of the plant's root hairs and Acts as an extension of the root systems.

- **Mycorrhizae are highly evolved, mutualistic associations between soil fungi and plant roots. It is commonly known as root fungi.**
- **This asociation are members of the fungus kingdom (Basidomycetes, Ascomycetes and Zygomycetes) and most vascular plants.**
- **Host plant receives mineral nutrients while the fungus photosynthetically derived carbon compounds from the plants.**

- **Mycorrhizal associations involve 3-way interactions between host plants, mutualistic fungi and soil factors.**



Types of Associations

Types of Associations

- Mycorrhizas are commonly divided into ectomycorrhizas (extracellular)and endomycorrhizas (Intracellular).
- The two types are differentiated by the fact that the hyphae of
  - ectomycorrhizal fungi do not penetrate individual cells within the root
  - endomycorrhizal fungi penetrate the cell wall and invaginate the cell membrane.

- **Endomycorrhizas are variable and have been further classified as arbuscular, ericoid, arbutoid, monotropoid, and orchid mycorrhizas.**
- **Arbuscular mycorrhizas, or AM (formerly known as vesicular-arbuscular mycorrhizas, or VAM), are mycorrhizas whose hyphae enter into the plant cells, producing structures that are either balloon-like (vesicles) or dichotomously branching invaginations (arbuscules).**

- **Ectomycorrhizas, or EcM, are typically formed between the roots of around 10% of plant families, mostly woody plants including the birch, dipterocarp, eucalyptus, oak, pine, and rose families, orchids, and fungi belonging to the Basidiomycota, Ascomycota, and Zygomycota.**
- **Some EcM fungi, such as many Leccinum and Suillus, are symbiotic with only one particular genus of plant, while other fungi, such as the Amanita, are generalists that form mycorrhizas with many different plants.**

Association	Occurrence
Vesicular Arbuscular Mycorrhizal (VAM) plants	• Plants with VAM are common in most habitats
Ectomycorrhizal (ECM) plants	• Trees with ECM are dominant in coniferous forests, especially in cold boreal or alpine regions • ECM trees and shrubs common in many broad-leaved forests in temperate or Mediterranean regions • Also occur in some tropical or subtropical savanna or rain forests habitats

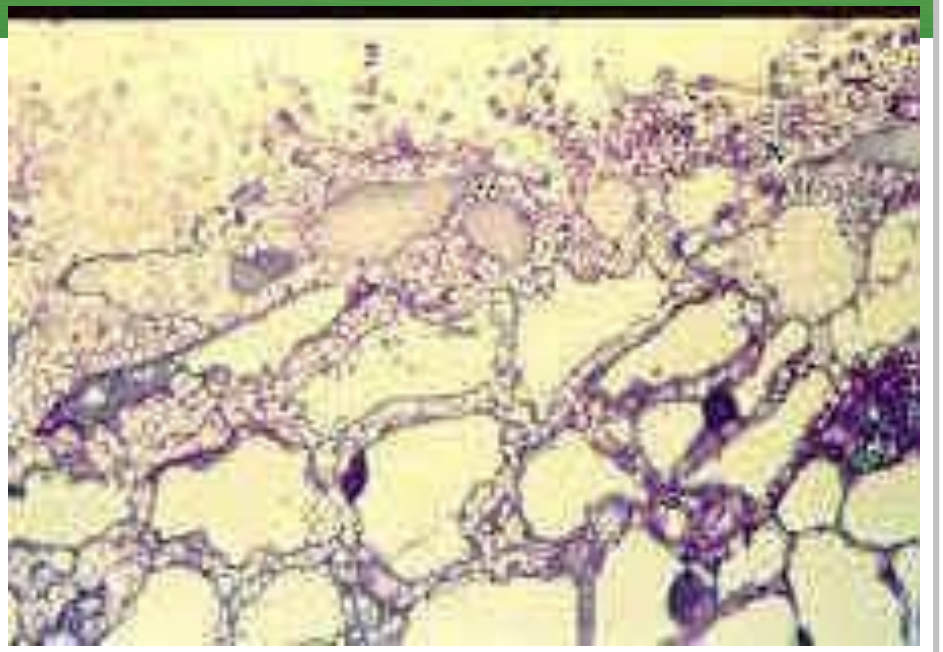
Ectomycorrhizae

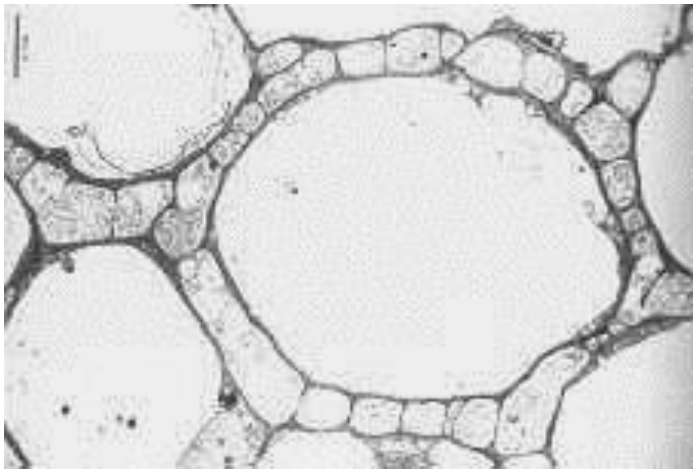
Ectomycorrhizae

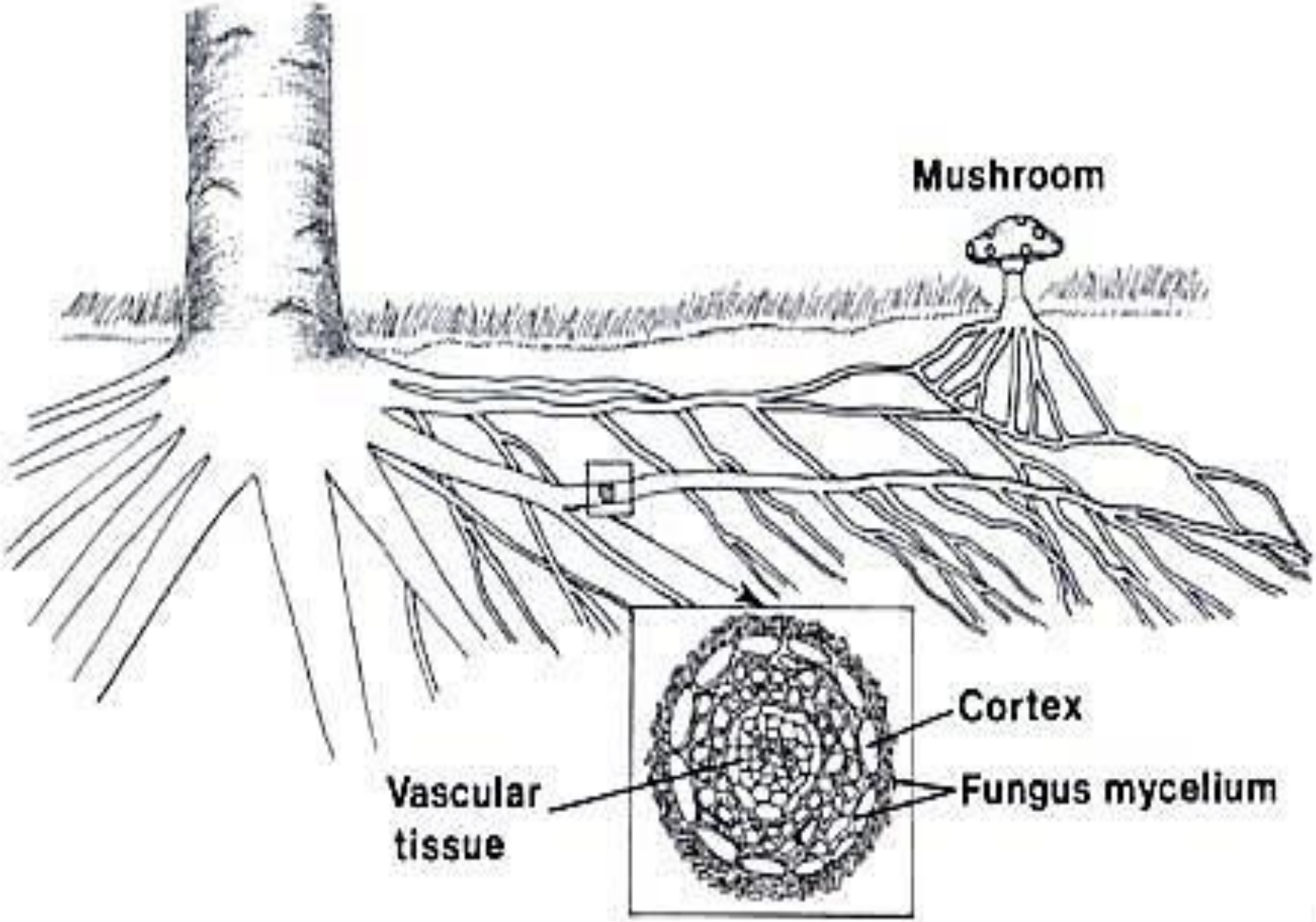
- Most conspicuous and easily recognized
- Best characterized
- Plant roots are enclosed by a sheath of fungal hyphae – fungal mycelium penetrates between cells in cortex of the root
- Fungal tissue may account for up to 40% mass of root
- Hyphae also extend out into the soil – extramatrical hyphae

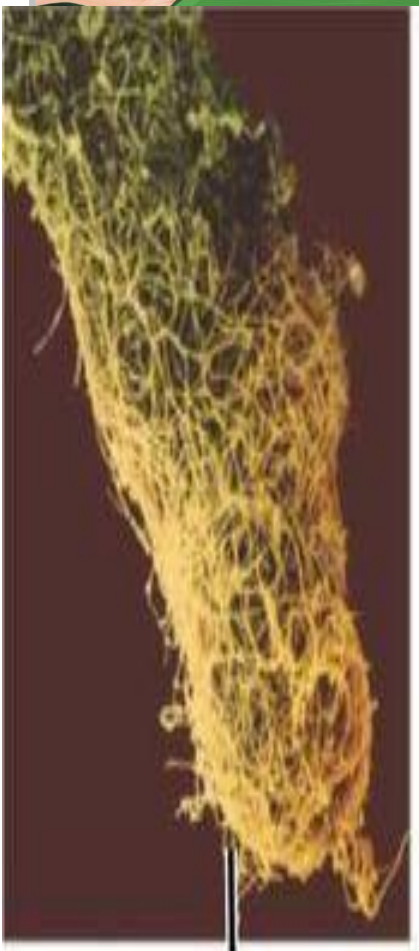
Ectomycorrhizae

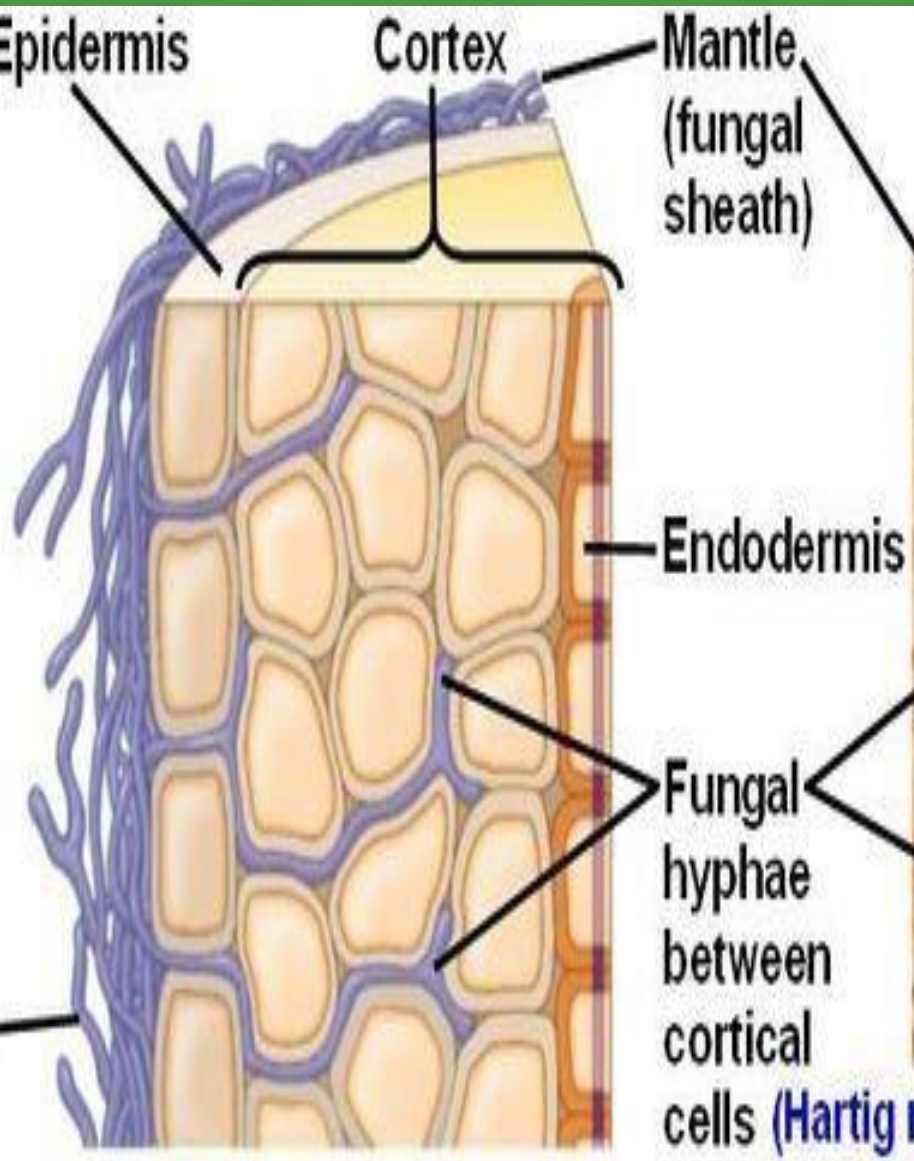
- Contains a fungal sheath
- Parenchyma of root cortex is surrounded by hyphae – Hartig net

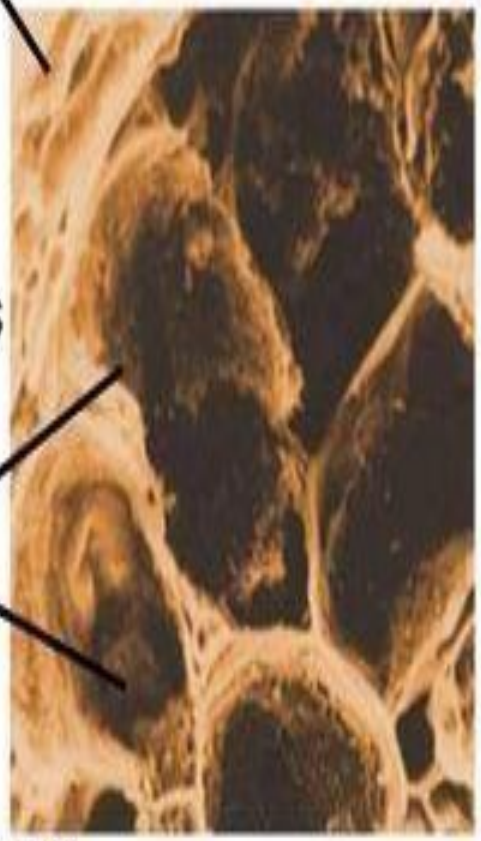





Mushroom
Cortex
Vascular tissue
Fungus mycelium







(colorized SEM)

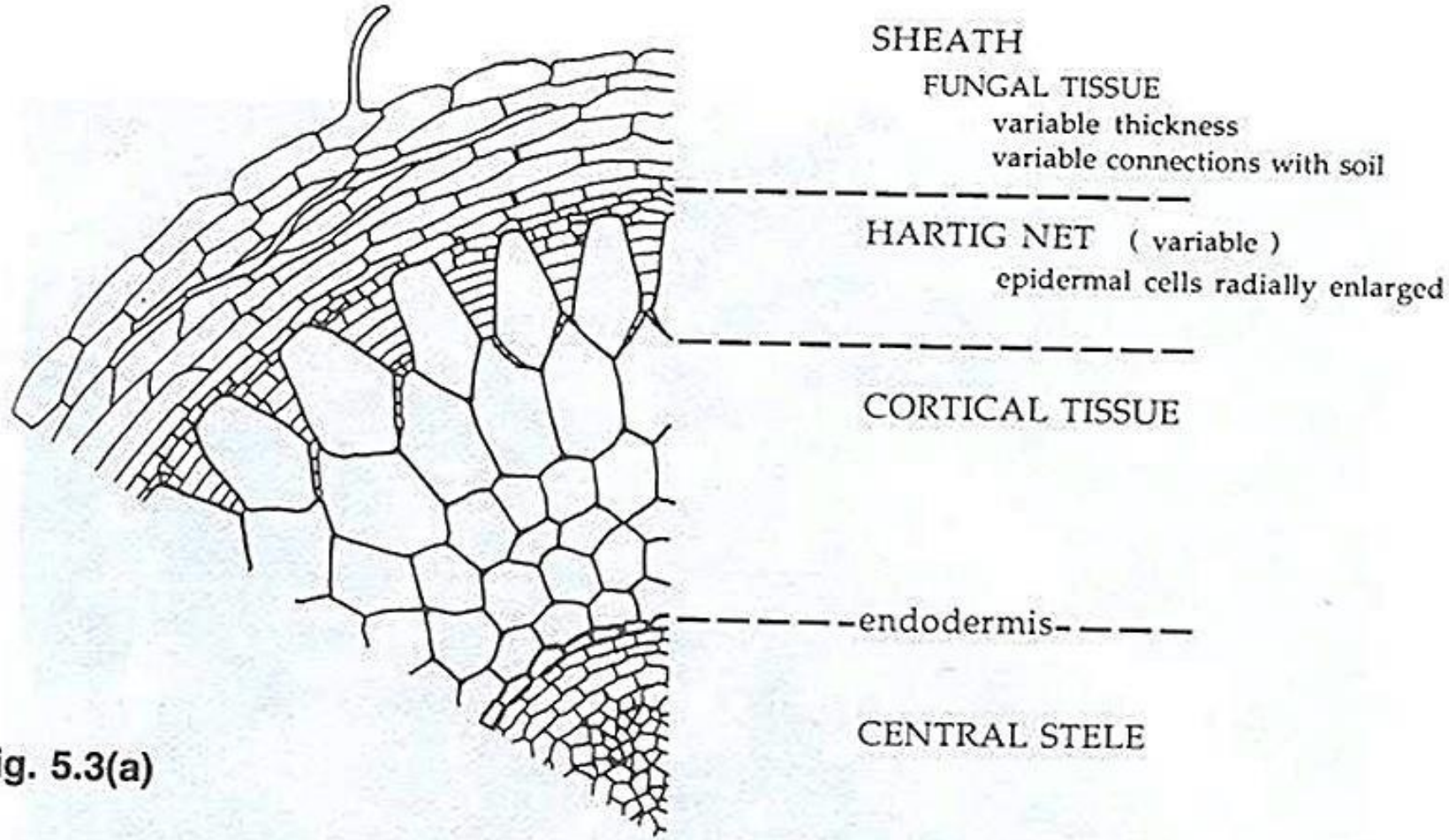
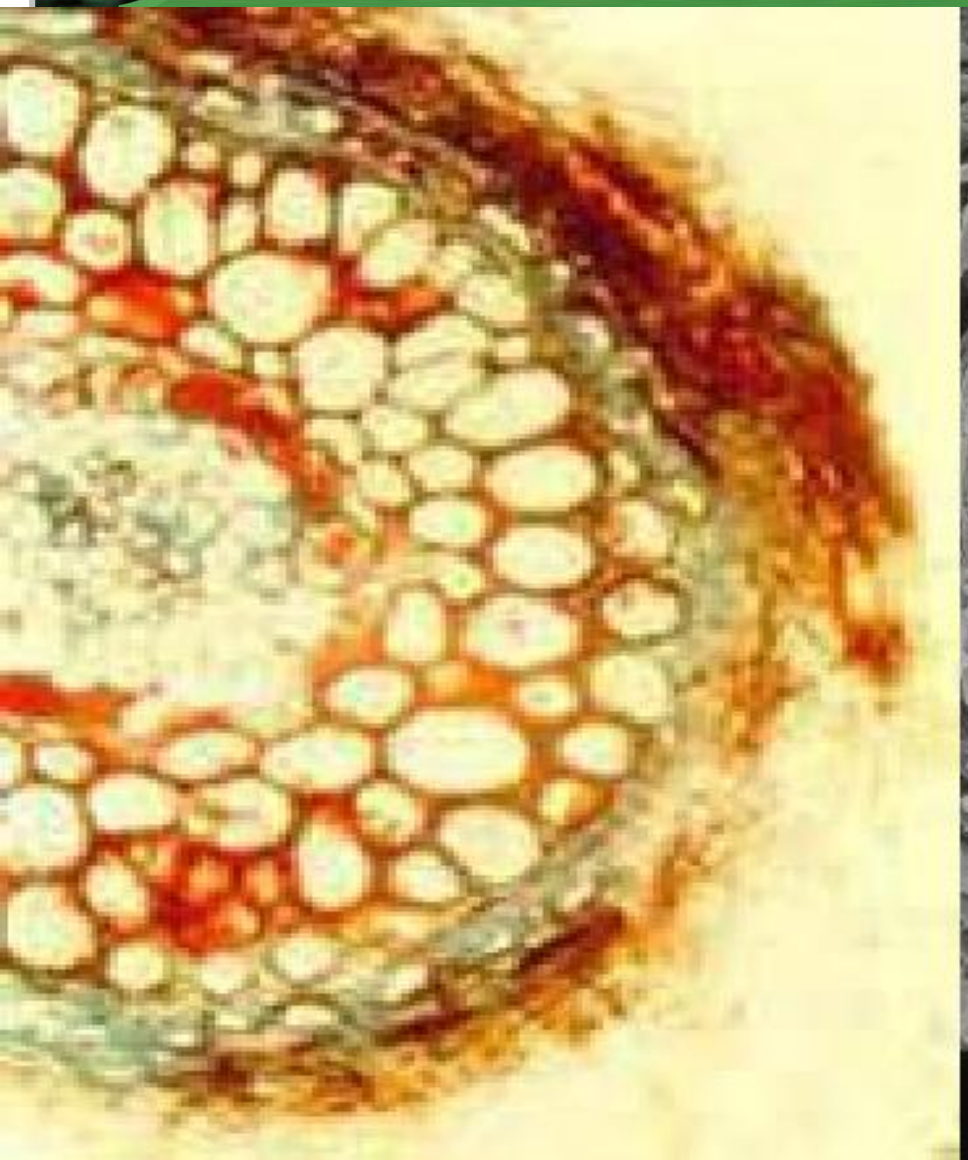
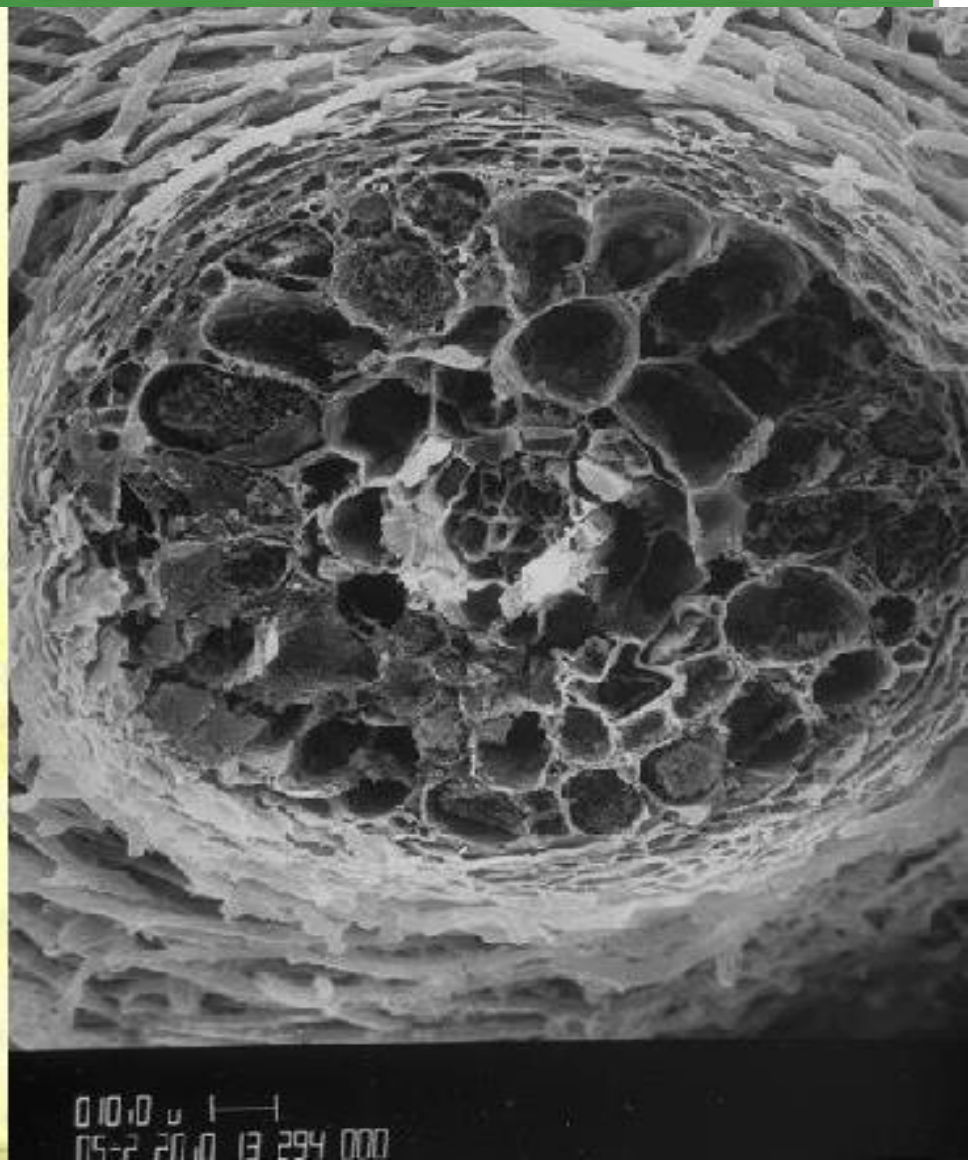

SHEATH
FUNGAL TISSUE
variable thickness
variable connections with soil
HARTIG NET (variable)
epidermal cells radially enlarged
CORTICAL TISSUE
endodermis
CENTRAL STELE

Fig. 5.3(a)

Ectomycorrhizal root





Ectomycorrhizae

- Absorbing roots are those that are affected
- Become thicker and repeatedly branched after infection

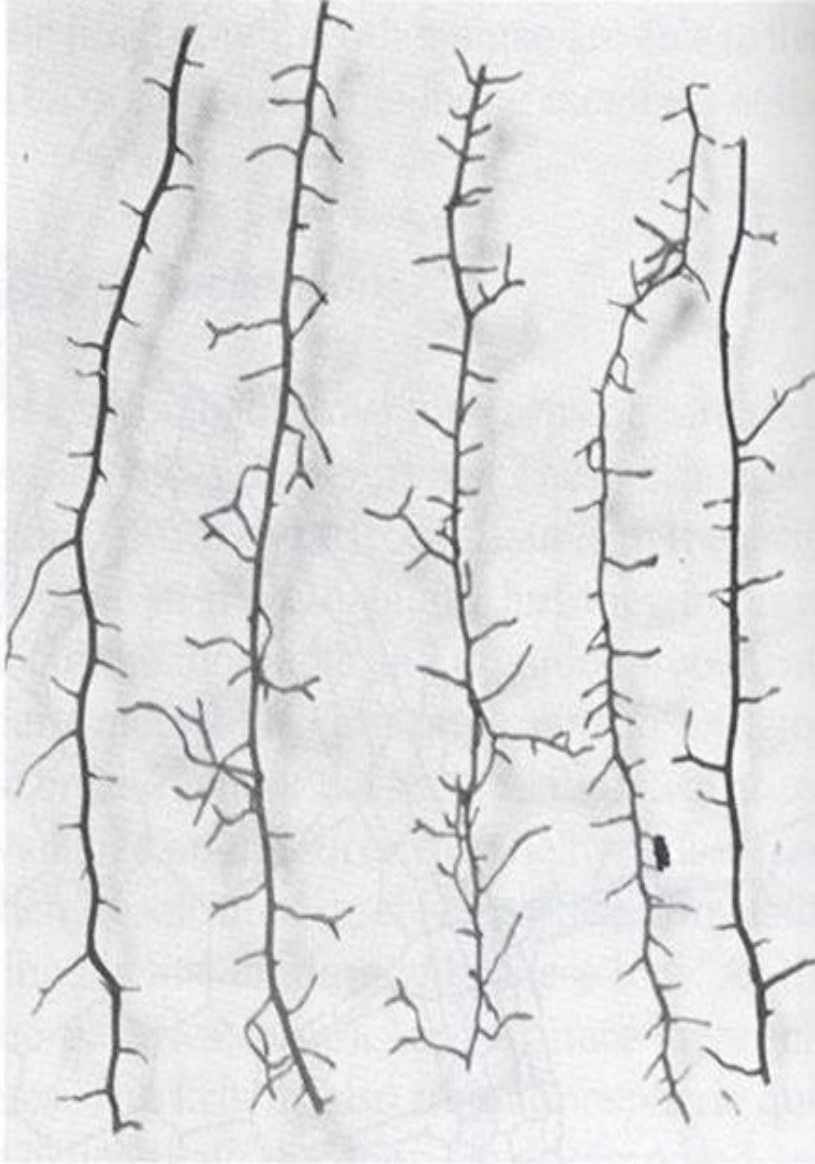


Figure 16-7 Roots of pine seedlings with (left) and without (right) the ectomycorrhizal fungus *Pisolithus tinctorius*. These are roots from the seedlings shown in Fig. 16-8. [Courtesy D. H. Marx, U.S. Department of Agriculture, Forest Service.]

Ectomycorrhizae

Ectomycorrhizae Symbionts

- 2000 plant species – primarily temperate trees and eucalyptus
- Major species of coniferous and deciduous trees
- Rare to find uninfected trees
- In some trees, the association is obligate, in others facultative
- Mycorrhizal association important in forestry

Ectomycorrhizae Symbionts

- **Basidiomycetes – Agaricales (many mushroom species), Lycoperdales, Sclerodermatales, few Aphyllophorales**
  - *Pisolithus tinctorus* – used to form commercial inoculum for nursery trees, common in southern pine
- **Ascomycota – Pezizales – cup fungi and truffles**
- **Over 5000 species of fungi have been shown to form ectomycorrhizae**

Specificity of association

- Great deal of variability
- Most tree species form mycorrhizal associations with a number of different fungal species
- May have **different** mycorrhizal fungi on roots of one plant
- Some fungi are **fairly specific** and will form associations with only one plant species – these mushrooms are common in stands of that tree
- Others are not specific

Specificity

- Douglas fir has been extensively studied and 2000 species of fungi have been identified from its roots
- In forests, a high percentage of fruiting bodies are mycorrhizal fungi

Methods for detection

1) Census of fruiting bodies produced by different species
2) Soil cores – separate and identify mycorrhizal roots by morphology, Hartig net
3) Recently molecular methods have been used to identify the fungi present in mycorrhizal roots – e.g. RFLP

Ectomycorrhizal fungi

- Can also grow saprotrophically
- Many have been cultured
- Most that have been studied do not have the capability to degrade complex plant polymers (e.g. cellulose and lignin)
- Depend on soluble carbohydrates
- Many have organic growth factor requirements – vitamins, amino acids
- Not decomposers but depend on plant

Benefits to fungus

- Provided with source of C and energy
- Plants provided with CO_2 demonstrated that C appears in fungus
- Sucrose from plant converted into trehalose, mannitol by fungus
- Estimates that up to 10% (or more) of photosynthate produced by trees is passed to mycorrhizae and other rhizosphere organisms

Benefits to trees

- Numerous studies have shown that tree growth is better when mycorrhizae are present

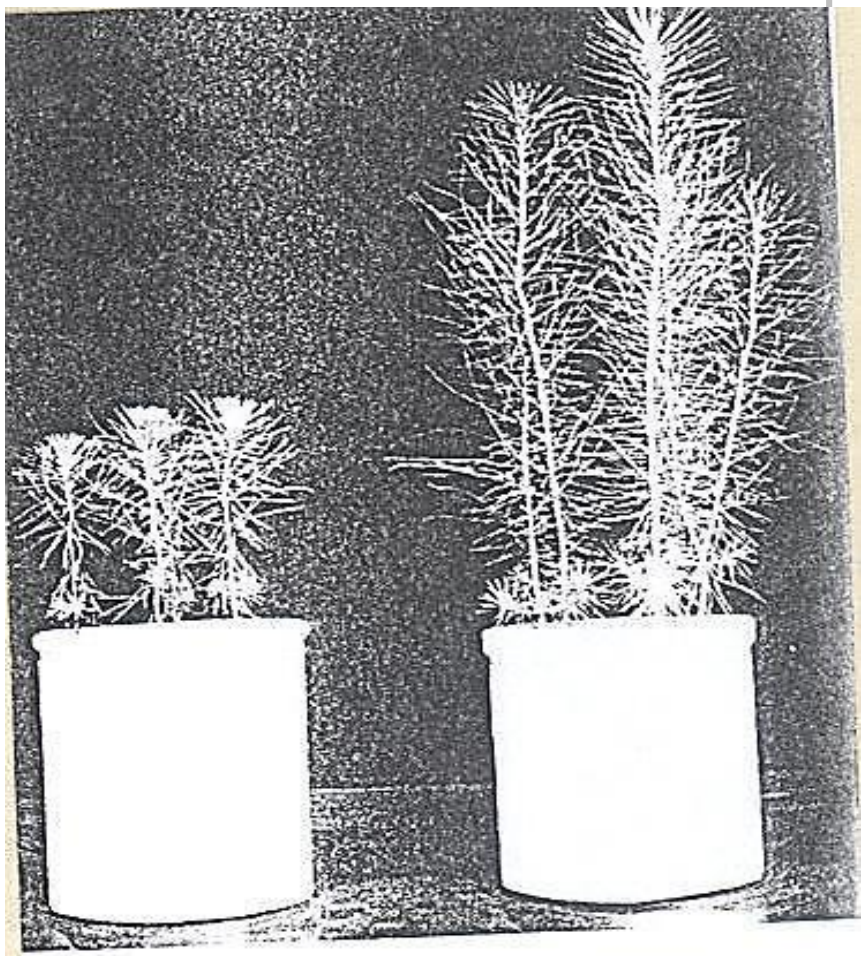


Figure 17.53 Six-month-old seedlings of Monterey Pine (*Pinus radiate*) growing in prairie soil: left, nonmycorrhiza right, mycorrhizal.

Benefits to trees

Table 5.3 Growth of Sitka spruce (*Picea sichensis*) seedlings inoculated with *Lactarius rufus* in aseptic culture under greenhouse conditions (data from Alexander, 1981)

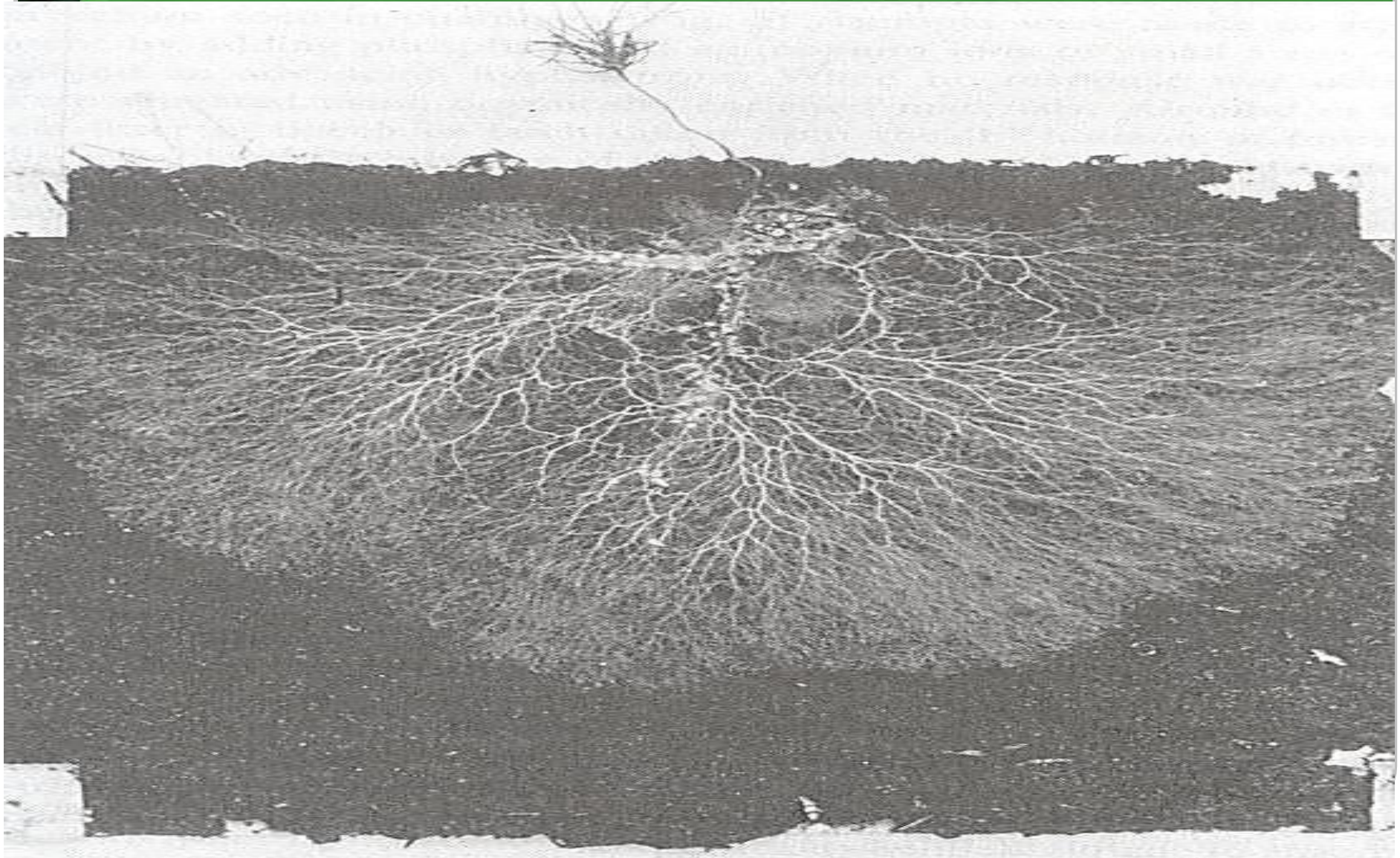
	Control	Inoculated	Significant difference between means p<
Mycorrhizal infection (%)	0	58.2	0.05
Shoot height (cm)	5.8	9.2	0.05
Shoot dry weight (mg)	47.1	100.2	0.01
Root dry weight (mg)	25.5	74.0	0.001
Total biomass (mg)	72.6	174.2	0.001
Root: shoot ratio	0.59	0.76	ns
Length lateral root (cm)	98.2	219.0	0.01
Total number root tips	60.8	236.7	0.05

Incubation time 14 weeks.
The slight rise in root:shoot ratio in infected tissue may have been attributable to fungal biomass.

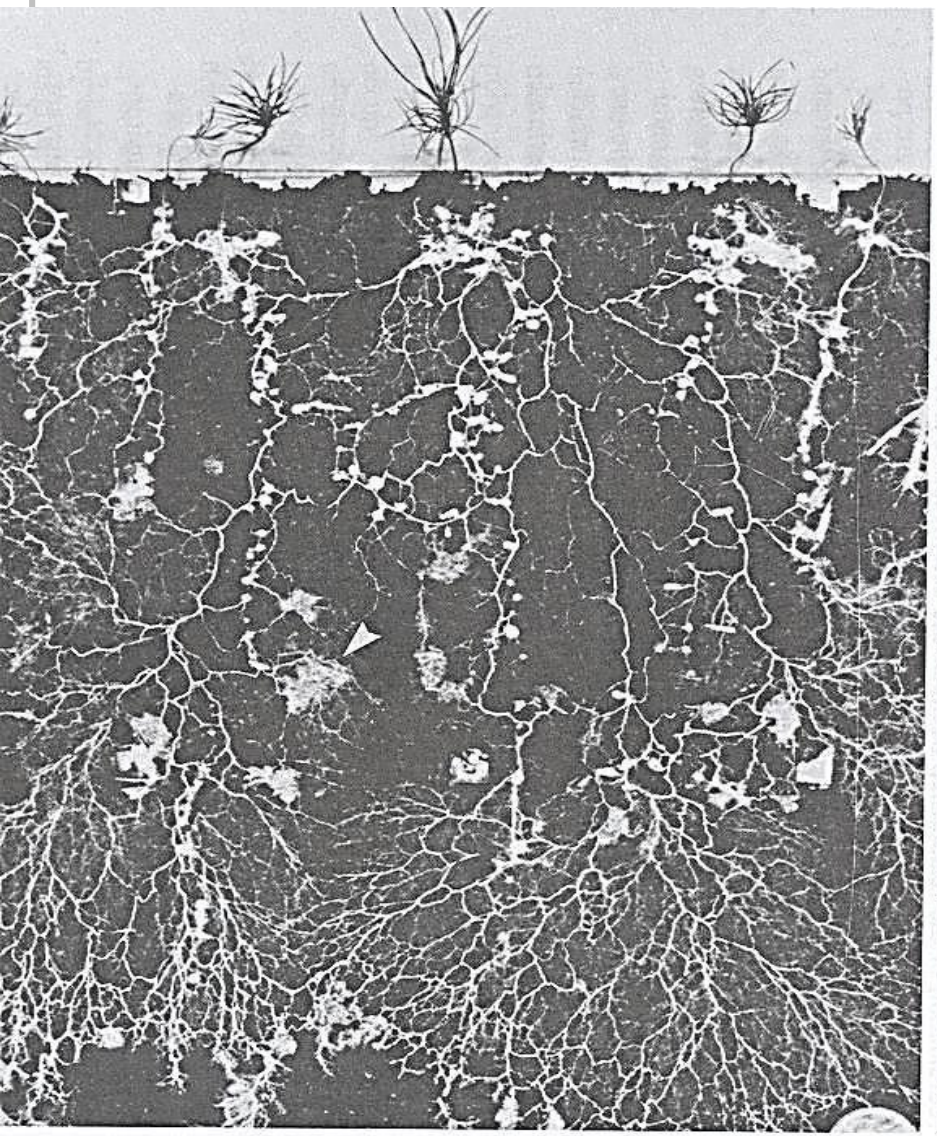
Benefits to trees

- Fungi increase supply of inorganic nutrients to tree
- P is insoluble in most soils
- Extramatrical hyphae extend over a larger volume of soil than roots can – increase ability to absorb insoluble nutrients such as P

Extramatrical hyphae



Volume of soil explored



Benefits to trees

- Plant hormones produced by fungus changes the physiological state of roots – physiologically active root area for nutrient and water absorption is increased
- Increases tolerance of plant to drought, high temperatures, pH extremes, heavy metals
- Increases resistance to infection by root pathogens – provides a physical barrier