Mucoromycota
Glomeromycotina

Mainly Symbiotic Fungi –with roots of vascular plants, non-vascular plants (liverworts, mosses, hornworts), and Cyanobacteria
Glomeromycotina

General characteristics:

• Obligate symbionts – cannot grow without host (plant, Cyanobacterium)
  - endomycorrhizae or vesicular-arbuscular mycorrhizae (VAM) or (AM)
    1. occur in the root cells of numerous vascular plants
    2. hyphae nonseptate or less commonly septate
    3. often produce vesicles in or between plant root cells
    4. produce arbuscules in plant cells
  - rhizoids and tissues of non-vascular plants
  - symbiosis with Cyanobacteria (Geosiphon with Nostoc) – a large single cell
• Recent evidence supports “cryptic form” of sexual reproduction
• Reproduce by a variety of asexual spores.
• About 80 % of plants have Arbuscular mycorrhizae
Evolutionary importance of mycorrhizae
success of land plants!

Plants colonized land approx. 400-500 MYA fossils of Devonian land plants contain VAM fungi
90% of all plant species are characterized as mycorrhizal
70% of plant families form VAM/AM – endomycorrhizae
Estimated that 300,000 plant species have VAM
- only ~150 spp. fungi participate
Glomeralean fungus symbiotic with a cyanobacterium, *Nostoc*
Liverwort showing fungus in plant tissue

**Figure 1.** Maintenance culture of *Lunularia cruciata* with *Glomus proliferum* grown for 100 days in 30 ml SRV medium with 29.2 mM of sucrose and used as inocula source for the experiments. Plant discs sowed asymmetrically in Petri dishes allowed the fungus to grow undisturbed on more than half of the dish area. (arrow) Indicates high concentration of hyphae and spore clusters with the inset showing external mycelium and spores imbedded in the medium. Bars 10 mm; inset, 1 mm.
A model for the evolution of plant-fungal mutualisms leading to the greening of the Earth. Arbuscular mycorrhizas are formed with Glomeromycotina fungi, and the newly discovered symbiosis with Mucoromycotina fungi.

<table>
<thead>
<tr>
<th>Atmosphere:</th>
<th>4,500 ppm CO₂</th>
<th>4,500 ppm CO₂</th>
<th>3,000 ppm CO₂</th>
<th>350 ppm CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate:</td>
<td>Brackish water</td>
<td>Moist, mineral soil</td>
<td>Mineral and organic soil</td>
<td>Mineral and organic soil</td>
</tr>
<tr>
<td>Water and nutrient uptake:</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct and symbiotic</td>
<td>Direct and symbiotic</td>
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<tr>
<td>Specialised structures:</td>
<td>Rhizoids</td>
<td>Rhizoids</td>
<td>Rhizoids, rhizomes and fungal symbionts</td>
<td>Roots, root hairs and fungal symbionts</td>
</tr>
</tbody>
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Fungi:
- Mutualists of photosynthetic bacteria
- Commensalsists
- Pathogens

Cambrian green algae → First land plants → Devonian land plants → Living land plants
26. The Structure of a Plant Root Tip

- Root hair
- Cortex
- Xylem
- Phloem
- Pericycle
- Endodermis
- Epidermis
- Zone of maturation
- Zone of elongation
- Root cap
- Apical meristem

- Root hair
- Epidermis
- Endodermis
- Xylem
- Phloem
- Pericycle
- Cortex
- Stele
Figure 3. Date palm seedlings inoculated (B) or un inoculated (A) with a commercial mycorrhizae inoculum (German BioMyc™ Vital, Germany).
Root colonization by Glomeromycota

• VAM do not significantly alter root morphology
  • fine roots possess root hairs
  
  hyphae enter the root through root hairs or by forming appressoria between epidermal cells;
  
  hypha grow intracellularly and also penetrate the cell walls of cortical cells, causing invagination of the plasma membrane

  form arbuscules and vesicles
VAM/AM endomycorrhizae: occur in the fine root system of vascular plants, hyphae penetrate the cortex cells forming vesicles and arbuscules

**Arbuscules** - highly branched structures that are the site of nutrient transfer; they do not penetrate cell membrane; short-lived structures

**Vesicles** - oval-shaped, darkly staining structures that are thought to function as nutrient reservoir
Arbuscules

highly branched haustorium-like structures
• extend through the host cell wall, but not cell plasma membrane
• increased surface area between the fungus and the host cell plasma membrane
• bidirectional transfer of metabolites and nutrients between the two mycorrhizal partners
• short-lived: remains alive only for a few days before disintegrating and being digested by the cells of the plant
• in a healthy VAM mycorrhizal relationship there is a continuous sequence of development and disintegration of arbuscules
Vesicles
- terminal hyphal swellings; darkly staining
- not formed by all species of Glomerales
- formed either between or within host cell walls
- thought to function as energy stores for use by the fungus when the supply of host metabolites is low
The Glomeromycotina reproduce asexually through blastic development of the hyphal tip to produce spores (Glomerospores) with diameters of 80–500 μm. In some, complex spores form within a terminal saccule.
Benefits to fungus

- Provided with source of C and energy
- Plants provided with $^{14}\text{CO}_2$ demonstrated that $^{14}\text{C}$ 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

Recent studies show that roots release factors that enhance hyphal growth following spore germination.
Plant benefits
• hyphae provide greater absorptive area for uptake of water and soil nutrients
• enhance uptake of P, N, Ca, K, Cu, Mb, Mg, Zn
• water
• protection against soil borne pathogens

AM mycorrhizal fungi allow plants to draw more nutrients and water from the soil. They also increase plant tolerance to different environmental stresses. Moreover, these fungi play a major role in soil aggregation process and stimulate microbial activity.

Potential Benefits of AM Mycorrhizae:

- Enhanced water and nutrient uptake
- Reduction of irrigation requirements
- Reduction need for fertilizer
- Increased drought resistance
- Increased pathogen resistance
- Increased plant health and stress tolerance
- Higher transplanting success
Figure 1. Positive effects of arbuscular mycorrhizal (AM) colonization. The hyphal network of arbuscular mycorrhizal fungi (AMF) extends beyond the depletion zone (grey), accessing a greater area of soil for phosphate uptake. A mycorrhizal-phosphate depletion zone will also eventually form around AM hyphae (purple). Other nutrients that have enhanced assimilation in AM-roots include nitrogen (ammonium) and zinc. Benefits from colonization include tolerances to many abiotic and biotic stresses through induction of systemic acquired resistance (SAR).