Mucoromycota
Glomeromycotina

Mainly Symbiotic Fungi – with Cyanobacterium liverworts, mosses, hornworts, vascular plant roots
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
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.
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.
Glomeralean fungus symbiotic with a cyanobacterium, *Nostoc*
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.
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
- Stele
- Endodermis
- Xylem
- Phloem
- Cortex
- Epidermis
- Root hair
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;

Hyphae 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.
Genetic diversity in this species varies among isolates and is structured in a homo-dikaryon-like manner usually linked with the existence of a sexual life cycle. We also identify a putative AMF mating-type locus, containing two genes with structural and evolutionary similarities with the mating-type locus of some Dikarya. Our analyses suggest that this locus may be multi-allelic and that AMF could be heterothallic and bipolar.

Recently it was shown that Glomus species contain 51 genes encoding all the tools necessary for meiosis. Based on these and related findings, it was suggested that Glomus species may have a cryptic sexual cycle.
The symbiotic relationships between mycorrhizal fungi and plants have an enormous impact on terrestrial ecosystems. Most common are the arbuscular mycorrhizas, formed by fungi belonging to the phylum Glomeromycotina. Arbuscular mycorrhizal fungi facilitate the uptake of soil nutrients by plants and in exchange obtain carbohydrates, thus representing a large sink for atmospheric plant-fixed CO2. However, how carbohydrates are transported through the symbiotic interface is still unknown. Here we report the characterization of the first known glomeromycotan monosaccharide transporter, GpMST1, by exploiting the unique symbiosis of a glomeromycotan fungus (Geosiphon pyriformis) with cyanobacteria.
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

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 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

Soil aggregation
Recent studies shown that roots release factors that enhance hyphal growth following spore germination.

**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