Symbiosis Defined

- Most commonly defined as ***"the intimate association between two distantly, related species that are mutually benefiting from this association."***
- Definition in the biological sense is broader and was first defined in this sense by **Anton deBary 1879**

According to Encarte Dictionary

sym·bi·o·sis

sym·bi·o·sis (sĭm′bē-ō′sĭs, -bī-)
noun
plural **sym·bi·o·ses** (-sēz)
1. *Biology.* A close, prolonged association between two or more different organisms of different species ***that may, but does not necessarily, benefit each member***.

According to Encarte Dictionary

sym·bi·o·sis

2. A relationship of mutual benefit or dependence.

[Greek *sumbiōsis*, companionship, from *sumbioun*, to live together, from *sumbios*, living together : *sun-*, syn- + *bios*, life.]

— **sym′bi·ot′ic** (-ŏt′ĭk) or **sym′bi·ot′i·cal** (-ĭ-kəl) *adjective*

— **sym′bi·ot′i·cal·ly** *adverb*

Variations in Symbioses

- **Phoresy**: A loose association where a usually, smaller organism is using a larger one as a transport host.
- Remora: One of several species of marine fishes able to attach to large fish, whales, manta rays, ships, etc., with sucking mouth part.

Variations in Symbiosis

- **Parasitism**: A relationship in which one species (**parasite**) has an obligatory dependence upon another organism (**host**) for its food and shelter.

Puccinia graminis, parasite on wheat

Variations in Symbiosis

- **Commensalism**: An association in which one species, usually the smaller, benefits from the association while the other species *seems* to be unaffected. Usually not obligate.

Clown fish sheltered by anemone's tentacles protecting it from other fish that may prey on it. Anemone *does not appear* to benefit from this relationship.

Fungi-Plant Symbiosis

- **Mycorrhiza** (pl.=**mycorrhizae**)is defined as a symbiotic relationship between the roots of a plant and a fungus.
- Includes plants that do not have roots, such as bryophytes (mosses and liverworts).

Characteristics of Mycorrhizae

- Enhances mineral transport to plants, especially phosphorous.
- Infection occurs only at root tips.
- Relationships obligate and facultative.
- Plants with mycorrhizae more drought resistant.
- Plants with mycorrhizae more resistant to plant pathogens.

Characteristics of Mycorrhizae

- Occurs in almost all plants. Some exceptions are Crucifers and aquatic plants.
- It is thought that plants would never have made the transition to the terrestrial environment without mycorrhizal fungus.

Categories of Mycorrhizae

- **Two Major Categories:**
  - **Ectomycorrhizae**: Mycelium forms an external sheath around root tip. Does not penetrate cells of root.
  - **Endomycorrhizae**: Mycelium does not form sheath and does penetrate root cells.

Ectomycorrhizae

- Fungus groups involved are mostly mushrooms and related groups with large fruiting bodies, e.g. mushrooms, truffles and puffballs.
- Reason why this group was discovered first.
- Fungus receives carbohydrate from plant and plant has enhanced mineral uptake.

Ectomycorrhizae

- Association only occurs with trees in a few groups of plants.
  - Conifers, e.g. pines, douglas firs, firs, spruces, etc.
  - Eucalyptus
  - Oaks
  - Beeches
  - Iron Wood
- Reason why relatively few mushrooms occur in Hawai'i.

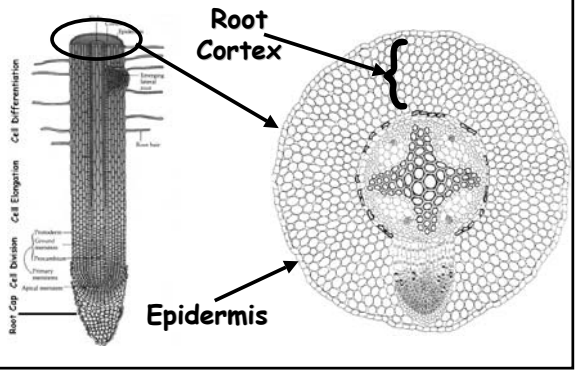
Ectomycorrhizae

- Routinely inoculated into seedlings during reforestation to ensure survival.
- Group used to enhanced resistance to plant pathogens entering through roots.
- More recently, used in cultivation of some species of mushrooms, e.g. truffles.

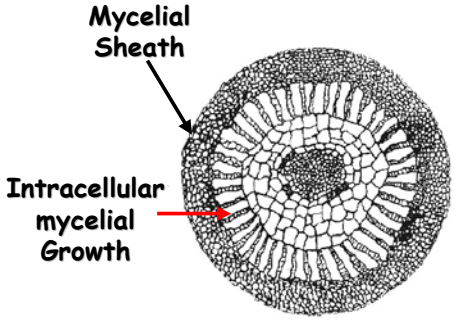
Ectomycorrhizae

- Mycelium forms only around the root tips, forming an external sheath around root.
- Fungus penetrates epidermis and grows *between* root cells in cortex.
- Fungus *does not* penetrate cells of root.

Normal Uninfected Root



Infected Ectomycorrhizal Root



Ectomycorrhizae

- Ectomycorrhizal fungus also induces root tips to branch, dichotomously.

Ectomycorrhizae

- Economically significant symbiotic relationship.
  - Conifers, which is much of our lumber trees have obligate mycorrhizal relationships.
  - Also some of our hardwood trees, such as oaks and alders.

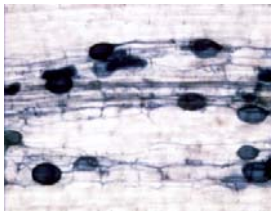
Endomycorrhizae

- Most mycorrhizal fungi in this group.
- Occurs in almost all groups of plants, including agricultural and horticultural plants.
- Occurrence of ectomycorrhizae decreases and endomycorrhizae increases, from temperate to tropical regions.
- Endomycorrhizae inconspicuous due to lack of large fruiting body.

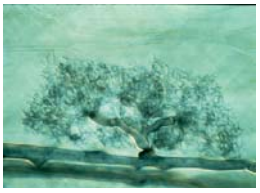
Categories of Endomycorrhizae

- This group is very variable and is divided into further categories:
  - Vesicular-Arbuscular Mycorrhizae (VAM). Now **Arbuscular mycorrhizae**
  - The name comes from the distinct structures that can be seen inside the cells of the infected roots, the rounded **vesicles** and the branched tree-like **arbuscules**.

Vesicles and Arbuscules of VAM Fungus



Vesicles



Arbuscules

AM Endomycorrhizae

- Vesicles and arbuscules within cells are lysed by host-root cells where the stored minerals needed by plant is stored.
- Identified by the large spores that are produced in the soil.
- Spores are just visible to the naked eye.

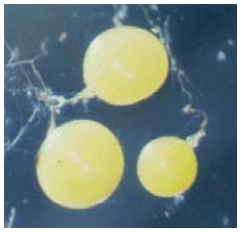
Classification

- Once classified in Zygomycota because:
  - Coenocytic mycelium
  - Morphological similarity to Endogonales, an order in Zygomycota.
- Taken out because:
  - Sexual reproduction unknown, i.e. no zygosporangia.
  - SSU rRNA indicates not related to Zygomycota and polyphyletic

Spores of VAM Fungus

Round, yellow-orange structures are VAM spores.

VAM Spores Under Microscope



Gigaspora gigantea spores

Relevance of VAM

- Because of the wide host range of VAM fungi, there were efforts to use them in agricultural and horticultural plants, but not always successful.
- There has been a study carried out in Hawai'i demonstrating its relevance in conservation of native Hawaiian plants.

Study by Drs. Richard Koske and Jane Gemma

- Many native Hawaiian plants' seeds cannot be germinated and if germinated do not readily grow.

Plants With and Without Mycorrhizal Fungi

Young *Scaevola* plants ± VAM fungus.

Young *Hibiscus* plants ± VAM fungus.

Other Categories of Endomycorrhizae

- **Orchid Endomycorrhizae**: Very different type of mycorrhiza.
- Orchid, if not photosynthetic, derives carbohydrate from fungus, until it is able to produce its own food.
- Even then, it is still dependent upon fungus for minerals.

Other Categories of Endomycorrhizae

- **Ericaceous Endomycorrhizae** divided into further subcategories.
  - **Ericoid Mycorrhizae** found with plants in stress environment and requires fungus to grow normally.
  - **Monotropoid Mycorrhizae** found with *non-photosynthetic* plants. Plant is entirely dependent upon fungus for food.

Other Categories of Endomycorrhizae

- **Monotropoid Mycorrhizae (continued)**: Fungus forms link with two hosts, one which is photosynthetic.
- Fungus transports carbohydrate from photosynthetic plant to non-photosynthetic plant.
- Fungus supplies minerals to both plants.

Monotropoid Plant

- ***Sarcodes sanguinea***, An example of a non-photosynthetic plant that is entirely dependent upon the mycorrhizal fungus for its food.

Lichens

- Not of great economical importance and poorly known.
  - Antibiotics have been extracted from lichens.
  - Have been used as pollution indicators.
  - Some species used for food, e.g. *Lecanora esculenta*?.

Lichens

- An association between a fungus and an alga that develops into a unique morphological form that is distinct from either partner is termed a lichen.
- Swiss Botanist Simon Schwendener, described dual nature of lichens in 1868.
- The fungus is referred to as the **mycobiont** and the alga is the **phycobiont**.

Lichens

- **Mycobionts**, in the *traditional* sense of lichens, belong in the phylum **Ascomycota**.

Omphalina umbellifera, a mushroom, but also considered a lichen.

Lichens

- **Mycobiont**, in traditional sense, belongs to the divisions **Ascomycota**

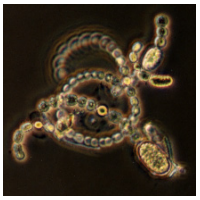
Fruitbodies

Asci & ascospores

Lichens

- **Phycobionts** belong to the divisions **Chlorophyta** and **Cyanobacteria** (=**Cyanophyta**).

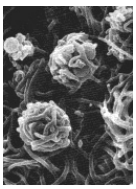
Trebouxia

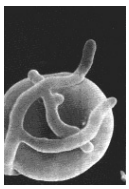


Anabena

Lichens

- Do lichens represent a true mutualistic type of symbiosis?
  - Some believe fungus is parasitic on alga

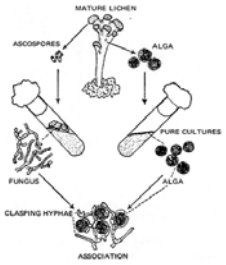




- **Haustoria** can be seen entering alga

Lichens

- Do lichens represent a true mutualistic type of symbiosis?
  - Some believe fungus and alga truly symbiotic:



Lichens

- The lichen thallus can be divided into four categories:
  - **Foliose**: A thallus, which is leaf-like, and attached to the substrate at various points
  - **Crustose**: A thallus, which is flattened against the substrate and its lower surface entirely attached.

Lichens

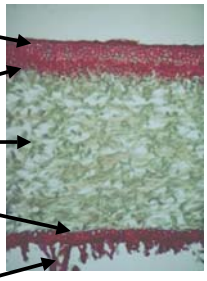
- The lichen thallus can be divided into four categories (continued):
  - **Fruticose**: A thallus, which is mainly made up of pendulous or less commonly upright branches. Attached at a ***single*** point.
  - **Squamulose**: A thallus, which starts off like a foliose lichen, but then develops erect branches called **podetia**

Foliose Lichen

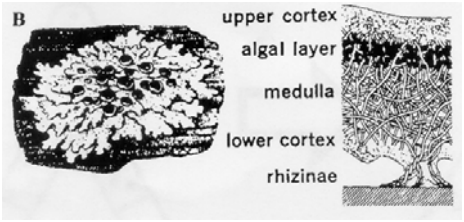
- **Foliose:** A thallus, which is leaf-like, and attached to the substrate at various points

Section of Foliose Thallus

- **Upper Cortex**: Tightly woven mycelial layer.
- **Algal Layer**: Algal Cells and mycelium.
- **Medullary Layer**: Loosely interwoven mycelium.
- **Lower Cortex**: Tightly woven mycelial layer.
- **Rhizines**: Outgrowth of lower cortex that attaches to substrate



Section of Foliose Thallus

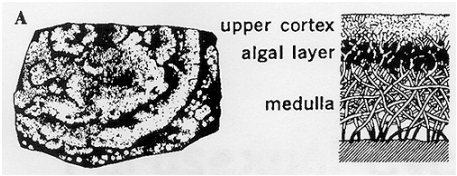


Thallus is attached at numerous points by rhizines on the lower cortex.

Lichen Thallus Type

Crustose thallus: Flattened against substrate, attached by medulla. Often looks like a painted surface.

Section of Crustose Lichen

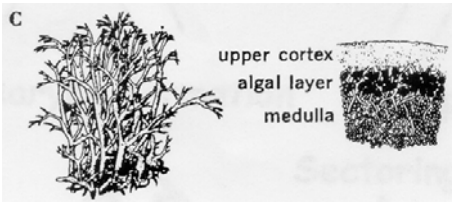


Unlike the foliose thallus, the crustose is **attached to its substrate by the medulla.**

Fruticose Lichen

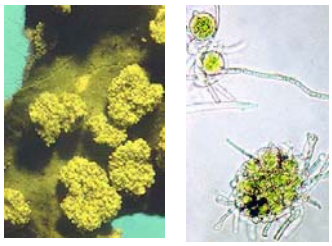
Fruticose thallus: Often stringy in appearance and attached at a single point. Commonly found hanging on trees.

Section of Fruticose Thallus



Fruticose thallus is ± round in section. Thus, the upper cortex and algal layers form a circle and the medulla is in the center.

Reproduction of Lichens



Soredia (sing: **Soredium**) fragments of algal layer that is dispersed through a rupture in upper cortex. Each soredium can give rise to a lichen.

Reproduction of Lichens

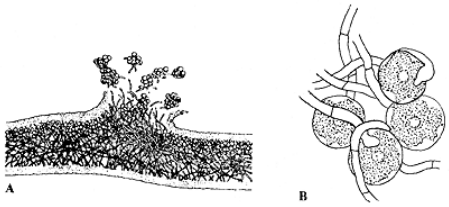
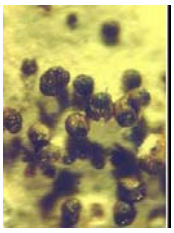


Illustration showing soredia rupturing upper surface of lichen.

Reproduction of Lichens



Isidium (pl.= **Isidia**): Often upright cylindrical to swollen outgrowth of the lichen thallus that fragments to give rise to another lichen.