General Biology: The Colonization Of Land By Plants And Fungi

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

Introduction and Phylogenetic Relationship
Both Plants and Fungi are eukaryotes but are categorized separately from Protists (eukaryotes that are not animals, plants, or fungi). Although they share a chapter because they co-evolved and appeared on land about the same time, they are not closely related phylogenetically.
• Fungi are more closely related to Animals than they are to Plants.
• Plants have their closest sister taxon in Charophyte algae.
• The relationship between Plants and Charophyte algae is supported by molecular evidence, including the shared presence of cell walls made primarily of cellulose and unique circular protein arrangements that function as cellulose-building machines in the plasma membrane.
• Trophic Status: Plants are photoautotrophs (producers) using photosynthesis. Fungi are heterotrophs, like animals, meaning they must obtain nutrition from other organisms.
Fungal Structure, Nutrition, and Life Cycle
Nutrition and Body Plan
• Fungi are heterotrophs, obtaining nutrients by secreting enzymes outside their bodies onto their food source, digesting large molecules, and then absorbing the smaller molecules (absorption). This process is functionally similar to animal digestion, although animals use an internal tube (alimentary canal).
• The body of a multicellular fungus is composed of highly branched, slender filaments called hyphae (singular: hypha).
• The entire network of hyphae is called the mycelium. The slender, highly branched structure of the mycelium maximizes surface area for efficient digestion and absorption.
• Unicellular fungi are called yeasts.
• Fungi cell walls contain chitin, a polysaccharide.
Fungal Life Cycle
Fungi generally spend their multicellular lives as haploid (n) individuals, which is the converse of animals.
• Ploidy: Ploidy refers to the number of each type of chromosome a cell has. Haploid (n) cells have one of each type; diploid (2n) cells have two of each type.
• Sexual Reproduction: Any sexual species must alternate between fertilization (fusing two n gametes to form a 2n zygote) and meiosis (halving the ploidy from 2n back to n).

◦ In many fungi, fertilization is separated into two steps:

1. Plasmogamy: Fusion of the cytoplasm of two gametes, resulting in a single cell with two distinct nuclei.
2. Heterokaryotic Stage: The temporary stage where the cell contains two separate, unfused nuclei.
3. Karyogamy: Fusion of the two nuclei, completing fertilization and forming the diploid (2n) zygote.

◦ The diploid zygote immediately undergoes meiosis to produce haploid (n) spores, which then grow by mitosis (called germination) into the multicellular haploid adult (mycelium).

• Asexual Reproduction: Fungi can also reproduce asexually by making spores via mitosis. These offspring are genetically identical to the parent.

Fungal Diversity

Fungi are grouped into five major taxa:

1. Chytrids (1,000 species): Includes many unicellular fungi; mostly aquatic.
2. Zygomycetes (1,000 species): Includes common bread molds.
3. Glomeromycetes (160 species): Ecologically crucial, predominantly forming mycorrhizae.
4. Ascomycetes (65,000 species): The largest group, known as the sac fungi.
5. Basidiomycetes (30,000 species): Known as the club fungi, including most familiar mushrooms.

Plant Life Cycle: Alternation of Generations

Plants exhibit alternation of generations, meaning they have multicellularity in both their haploid (n) and diploid (2n) phases.

• Gametophyte (n): The multicellular haploid plant version. It produces gametes by mitosis (since it is already haploid).

• Sporophyte (2n): The multicellular diploid plant version. It develops from the 2n zygote and produces haploid spores via meiosis in specialized structures called sporangia.

Plant Evolution and Adaptations to Land

Plants evolved from aquatic algal ancestors and colonized land approximately 475 million years ago. A major evolutionary challenge of life on land was desiccation (drying out).

• Sporopollenin: A stable, desiccation-resistant polymer that protects spores and pollen, enabling success on land.

• Multicellular Dependent Embryos: The young embryo develops inside the body of the previous generation (the sporophyte) and is dependent upon it for protection and sustenance.

• Pressure to Get Big: There is a strong selective advantage for plants to grow taller to outcompete others for sunlight. However, large size in all three dimensions requires a vascular system.

Major Plant Groups and Innovations

Group	Innovation/Characteristic	Time of Evolution	Dominant Generation	Examples

Nonvascular Plants (Bryophytes)	Nonvascular (lack xylem/pholem vessels). Use rhizoids for anchoring, not absorption.	475 million years ago	Gametophyte (Sporophyte is dependent on it).	Mosses, Liverworts, Hornworts.
Seedless Vascular Plants	Vascularity (vessels) allows large size. Lack seeds.	425 million years ago	Sporophyte (Gametophyte is tiny, free-living).	Ferns, Lycophytes.
Seeded Plants	Seeds (protective, desiccation-resistant package containing the embryo and food supply).	300 million years ago	Sporophyte (Gametophyte is reduced to 2-3 cells, living inside the sporophyte).	Gymnosperms, Angiosperms.

Seeded Plant Subdivisions

- **Gymnosperms (Naked Seed): Seeds are open and exposed to the surroundings (e.g., conifers).**
- **Angiosperms (Chamber Seed/Flowering Plants): The most successful plant group. Seeds develop inside a protective chamber.**
    - **The Three Fs: Angiosperms are characterized by Flowers (reproductive structures acting as advertisements for pollinators), Fruit (seed-bearing structure developed from the ovary), and Double Fertilization (a unique reproductive process).**

Flower Structure (Angiosperms)

Flowers are reproductive structures that may consist of four major whorls:

- **Sterile Parts: Sepals and Petals.**
- **Fertile Parts:**
    - **Stamens (Male): Produce pollen grains in the anther.**
    - **Carpels (Female): Composed of the stigma (sticky surface to catch pollen), the style, and the ovary (which contains ovules, or potential seeds).**

Symbiotic Relationships Involving Fungi and Plants

Mutualistic Symbiosis

- **Mycorrhizae (Fungus Roots): A mutualistic relationship between fungi (often Glomeromycetes) and plant roots. The hyphae create extensive surface contact with the root cells (without piercing the plasma membrane), facilitating the mutual exchange of materials.**

- **Endophytes: Fungi that live inside plant tissues (e.g., leaves). They receive food from the plant and, in return, produce substances that protect the plant from pathogens, reducing leaf mortality.**
- **Lichens: A close living association that looks like a single organism but is a mutualistic symbiosis between a fungus and a unicellular photosynthetic organism (either alga or cyanobacterium). Lichens are ecologically vital for initiating soil formation by breaking down bare rock.**

Co-evolution in Angiosperms

The evolution of flowering plants is strongly linked to the evolution of their animal pollinators.

- **Flower Symmetry and Speciation:**
    - **Bilaterally Symmetrical Flowers: Have only one way for a pollinator to enter. This restrictive entry method limits gene flow between populations, leading to increased isolation and thus higher rates of speciation.**
    - **Radially Symmetrical Flowers: Have multiple entry points. This allows for greater gene flow and less isolation, leading to lower rates of speciation.**