Introduction

Plant Diversity:

Plant Colonization of Land

Ch. 29

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Syllabus

What is Biology

Biology is the scientific study of life

Such ?’s as:

How do plants interact with one another?

How does the human mind work?

Life is characterized by what living things do

Thus, it can be somewhat quantified by researchers

Plant Diversity

First 3 billion years of Earth’s history, terrestrial surface was lifeless

Cyanobacteria likely existed on land 1.2 b.y.a.

500 m.y.a. small plants, fungi, & animals emerged on land

Since arriving on land, ~290,000 living species of plants

Land plants defined as having terrestrial ancestors

DO NOT include photosynthetic protists (algae)

Supply oxygen and serve as base of land food webs/chains

Land plants evolved from green algae

Charophytes (green algae) are the closest relatives of land plants

Characters also appear in a variety of algal clades (primarily algae)

Share 4 key traits with only charophytes
**Land plants are not descended from modern charophytes, but share a common ancestor with modern charophytes**

Moving to land

In charophytes a layer of a durable polymer called **sporopollenin** prevents exposed zygotes from drying out.

Sporopollenin is also found in plant spore walls.

The movement onto land by charophyte ancestors provided unfiltered sun, more plentiful CO₂, nutrient-rich soil, and few herbivores or pathogens.

Land presented challenges: a scarcity of water and lack of structural support.

The accumulation of traits that facilitated survival on land may have opened the way to its colonization by plants.

Systematists are currently debating the boundaries of the plant kingdom.

Some biologists think the plant kingdom should be expanded to include some or all green algae.

Until this debate is resolved, we define plants as embryophytes, plants with embryos.

Derived traits

4 key traits appear in ‘nearly’ all land plants – but absent in charophytes:

- Alternation of generations and multicellular, dependent embryos
- Walled spores produced in sporangia
- Multicellular gametangia
- Apical meristems

**Alternation of Generations**

Plants alternate between two multicellular stages, a reproductive cycle called **alternation of generations**.

The **gametophyte** is haploid and produces haploid gametes by mitosis.

Fusion of the gametes gives rise to the diploid **sporophyte**, which produces haploid **spores** by meiosis.

The diploid embryo is retained within the tissue of the female gametophyte.

Nutrients are transferred from parent to embryo through **placental transfer cells**.

Land plants are called **embryophytes** because of the dependency of the embryo on the parent.

Walled spores produced in Sporangia.
The sporophyte produces spores in organs called sporangia. Diploid cells called sporocytes undergo meiosis to generate haploid spores. Spore walls contain sporopollenin, which makes them resistant to harsh environments.

Multicellular Gametangia

Gametes are produced within organs called gametangia. Female gametangia, called archegonia, produce eggs and are the site of fertilization. Male gametangia, called antheridia, produce and release sperm.

Meristematic Growth

Plant growth is modular. Repeated units continue growth occurs in apical meristems. Meristem cells differentiate into various tissues. Equivalent to human stem cells.

Additional derived traits

- Cuticle, a waxy covering of the epidermis
- Mycorrhizae, symbiotic associations between fungi and land plants that may have helped plants without true roots to obtain nutrients
- Secondary compounds that deter herbivores and parasites

Origin & Diversification

Fossil evidence indicates that plants were on land at least 475 million years ago. Fossilized spores and tissues have been extracted from 475-million-year-old rocks. Land plants can be informally grouped based on the presence or absence of vascular tissue. Most plants have vascular tissue; these constitute the vascular plants. Nonvascular plants are commonly called bryophytes. Bryophytes are not a monophyletic group; their relationships to each other and to vascular plants is unresolved.

Seedless vascular plants can be divided into clades

- Lycophytes (club mosses and their relatives)
- Pterophytes (ferns and their relatives)

Seedless vascular plants are paraphyletic, and are of the same level of biological organization, or grade. A seed is an embryo and nutrients surrounded by a protective coat.
Seed plants form a clade and can be divided into further clades

- **Gymnosperms**, the “naked seed” plants, including the conifers
- **Angiosperms**, the flowering plants

Non-vascular plants

Bryophytes are represented today by three phyla of small herbaceous (nonwoody) plants

- **Liverworts**, phylum Hepatophyta
- **Hornworts**, phylum Anthocerophyta
- **Mosses**, phylum Bryophyta

Bryophyte refers to all nonvascular plants, whereas Bryophyta refers only to the phylum of mosses

Bryophyte Gametophytes

In all three bryophyte phyla, gametophytes are larger and longer-living than sporophytes

Sporophytes are typically present only part of the time

A spore germinates into a gametophyte composed of a **protonema** and gamete-producing **gametophore**

The height of gametophytes is constrained by lack of vascular tissues

**Rhizoids** anchor gametophytes to substrate

Mature gametophytes produce flagellated sperm in antheridia and an egg in each archegonium

Sperm swim through a film of water to reach and fertilize the egg

Bryophyte Sporophytes

Bryophyte sporophytes grow out of archegonia, and are the smallest and simplest sporophytes of all extant plant groups

A sporophyte consists of a **foot**, a **seta** (stalk), and a sporangium, also called a **capsule**, which discharges spores through a **peristome**

Hornwort and moss sporophytes have **stomata** for gas exchange; liverworts do not

Moss importance

Mosses are capable of inhabiting diverse and sometimes extreme environments, but are especially common in moist forests and wetlands

Some mosses might help retain nitrogen in the soil

**Sphagnum**, or “peat moss,” forms extensive deposits of partially decayed organic material known as **peat**

Peat can be used as a source of fuel

**Sphagnum** is an important global reservoir of organic carbon

Overharvesting of **Sphagnum** and/or a drop in water level in peatlands could release stored CO$_2$ to the atmosphere
Seedless Vascular Plants

Bryophytes and bryophyte-like plants were the prevalent vegetation during the first 100 million years of plant evolution.

Vascular plants began to diversify during the Devonian and Carboniferous periods.

Vascular tissue allowed these plants to grow tall.

Seedless vascular plants have flagellated sperm and are usually restricted to moist environments.

Fossils of the forerunners of vascular plants date back about 425 million years.

These early tiny plants had independent, branching sporophytes.

Living vascular plants are characterized by:

- Life cycles with dominant sporophytes
- Vascular tissues called xylem and phloem
- Well-developed roots and leaves

Life Cycles with Dominant Sporophytes

In contrast with bryophytes, sporophytes of seedless vascular plants are the larger generation, as in familiar ferns.

The gametophytes are tiny plants that grow on or below the soil surface.

Transport in Plants

Vascular plants have two types of vascular tissue: xylem and phloem.

**Xylem** conducts most of the water and minerals and includes dead cells called **tracheids**.

Water-conducting cells are strengthened by **lignin** and provide structural support.

**Phloem** consists of living cells and distributes sugars, amino acids, and other organic products.

Vascular tissue allowed for increased height, which provided an evolutionary advantage.

Roots

**Roots** are organs that anchor vascular plants.

They enable vascular plants to absorb water and nutrients from the soil.

Roots may have evolved from subterranean stems.

Leaves

**Leaves** are organs that increase the surface area of vascular plants, thereby capturing more solar energy that is used for photosynthesis.

Leaves are categorized by two types:

- **Microphylls**, leaves with a single vein.
- **Megaphylls**, leaves with a highly branched vascular system

According to one model of evolution, microphylls evolved as outgrowths of stems. Megaphylls may have evolved as webbing between flattened branches.

**Sporophylls & Spore Variations**

**Sporophylls** are modified leaves with sporangia.

**Sori** are clusters of sporangia on the undersides of sporophylls.

**Strobili** are cone-like structures formed from groups of sporophylls.

Most seedless vascular plants are **homosporous**, producing one type of spore that develops into a bisexual gametophyte.

All seed plants and some seedless vascular plants are **heterosporous**. Heterosporous species produce **megaspores**, which give rise to female gametophytes, and **microspores**, which give rise to male gametophytes.

**Two phyla of Seedless Vascular Plants**

There are two phyla of seedless vascular plants:

- Phylum Lycophyta includes club mosses, spike mosses, and quillworts.
- Phylum Pterophyta includes ferns, horsetails, and whisk ferns and their relatives.

**Lycophytes: Club Mosses, Spike Mosses, & Quillworts**

Giant lycophytes trees thrived for millions of years in moist swamps.

Surviving species are small herbaceous plants.

Club mosses and spike mosses have vascular tissues and are not true mosses.

**Pteridophyta: Ferns, Horsetails, & Whisk Ferns**

Ferns are the most diverse seedless vascular plants, with more than 12,000 species.

They are most diverse in the tropics but also thrive in temperate forests.

Horsetails were diverse during the Carboniferous period, but are now restricted to the genus *Equisetum*.

Whisk ferns resemble ancestral vascular plants but are closely related to modern ferns.

**SVP significance**

The ancestors of modern lycophytes, horsetails, and ferns grew to great heights during the Devonian and Carboniferous, forming the first forests.

Increased growth and photosynthesis removed CO₂ from the atmosphere and may have contributed to global cooling at the end of the Carboniferous period.

The decaying plants of these Carboniferous forests eventually became coal.