SLE 132 – Form and Function
Introduction to Plants

DEAKIN COLLEGE
in association with
DEAKIN UNIVERSITY AUSTRALIA

Why Study Plants?

Plants sustain life on Earth:

- All energy in the ecosystem comes from the sun.
- O_2 and Organic sugars – created via photosynthesis
- **Feeds us** directly when we eat plants
  - indirectly when we eat other animals that consume plants
- **Major food crops:** Soy, Potatoes, Rice, Wheat, Corn
- **Shelter/Building materials**

Why Study Plants?

Chemical extracts

- plant products used to produce plastics, clothing, resins, rubber

Medicines

- Anticancer drugs – taxol.
- plants as vaccines
- Quinine – anti malaria drug
- Coca/opium poppy- drugs for anaesthetics

The Rise of Plants

- Since colonising land, plants have diversified into ~**290,000** living species.

Non-vascular plants - Bryophytes (~24,000)

Vascular plants:

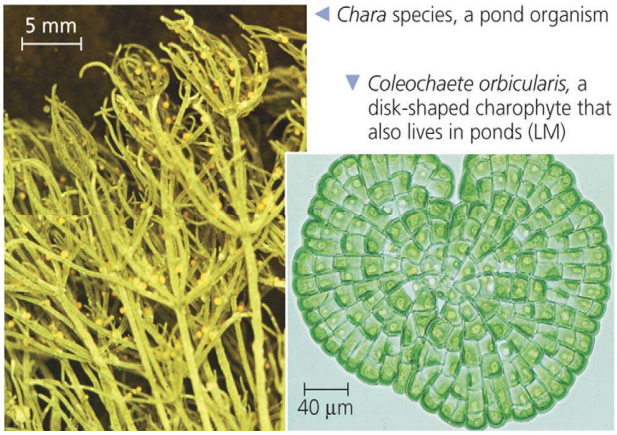
- Angiosperms (flowering plants) - ~250,000
- Gymnosperms (conifers)

The Rise of Plants

- Plants inhabit all but the harshest regions of the Earth
- Mountain tops, polar regions, deserts

Land plants evolved from green algae

Green algae called **Charophytes** are the closest relatives of the land plants



◀ *Chara* species, a pond organism

▼ *Coleochaete orbicularis*, a disk-shaped charophyte that also lives in ponds (LM)

Land plants evolved from green algae

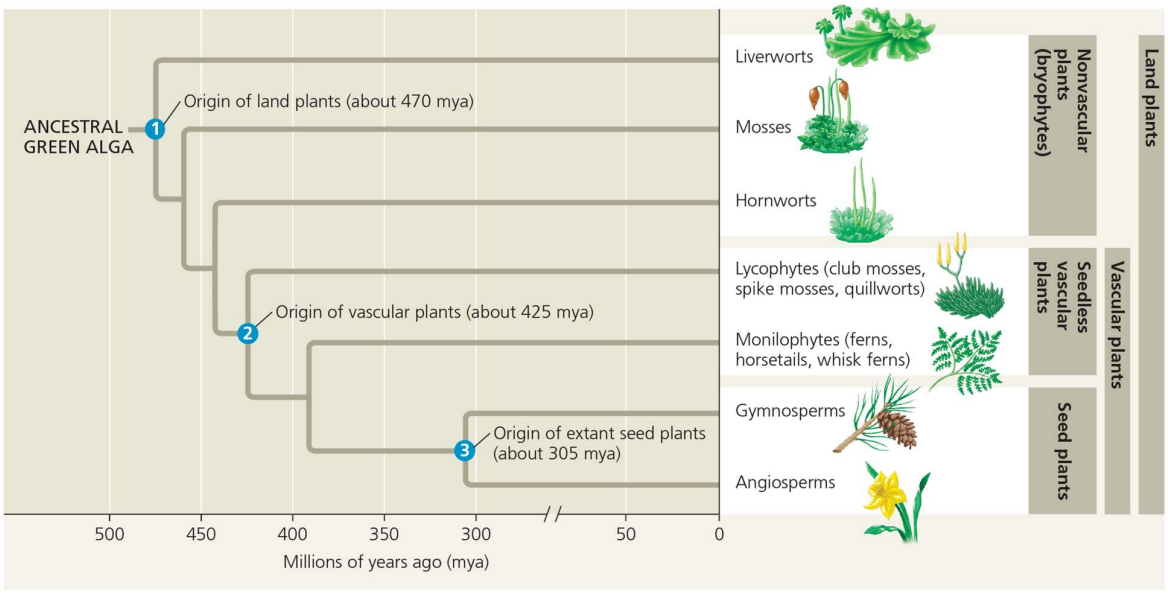
- Many morphological characteristics of land plants also appear in a variety of algae
- Evidence for Charophytes as closest living relatives of land plants in comparisons of both **nuclear and chloroplast genes**
- Land plants did not evolve from modern Charophytes, but they do **share a common ancestor**

Plant Evolution

The boundaries of the plant kingdom are currently debated. Some studies include green and red algae in Kindgom Plantae.

For this unit we retain the **Embryophyte definition** of kingdom Plantae

i.e. plants nurture the embryo sporophyte within the tissues of parent gametophyte. (Algae don't)



▲ **Figure 29.5 Highlights of plant evolution.** The phylogeny shown here illustrates a leading hypothesis about the relationships between plant groups.

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5 Key Traits in (nearly all) land plants

1. Apical meristems
2. Alternation of Generations
3. Walled spores produced in sporangia
4. Multicellular gametangia (gamete producing organ)
5. Dependant embryos

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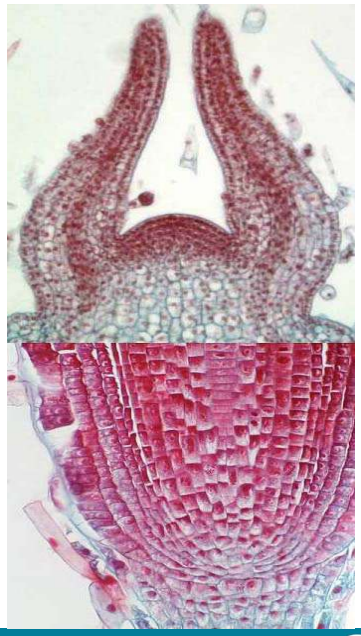
1. Apical Meristems

- Found in **roots and shoots**

- Plants sustain continual growth in their apical meristems
- Continuously regenerate/divide
- Increases exposure to environmental resources
- Cells from the apical meristems have the ability to differentiate into various tissues



2. Alternation of Generations

- Animals have only one multicellular stage, which is diploid (2n).
- At sexual maturity they produce haploid (n) gametes via meiosis.
- Plants have a system which **alternates** between **two multicellular stages**

2. Alternation of Generations

The gametophyte:

- Multicellular haploid stage.
- Produces haploid **gametes** by mitosis.

The sporophyte:

- Multicellular diploid stage.
- Produces haploid **spores** by meiosis.

2. Alternation of Generations

Use the following structures and processes to produce a life cycle of a plant showing the alternation of generation. Include the ploidy of the structures (haploid or diploid).

Structures

Gametophyte

gamete
gamete

Spore

Zygote

Sporophyte

Processes

Meiosis

Mitosis

Fertilisation

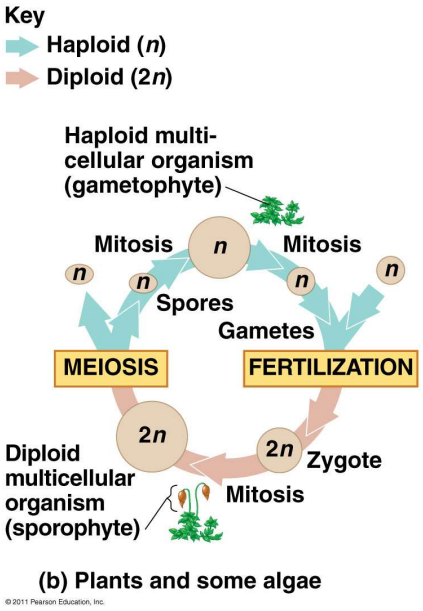
2. Alternation of Generations

The gametophyte:

- Multicellular haploid stage.
- Produces haploid **gametes** by mitosis.

The sporophyte:

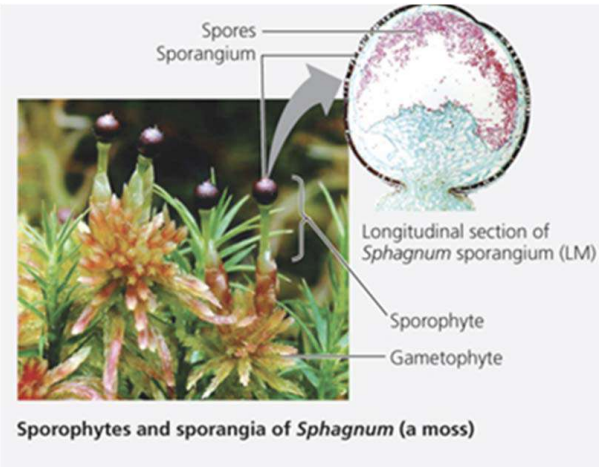
- Multicellular diploid stage.
- Produces haploid **spores** by meiosis.



(b) Plants and some algae

3. Walled Spores produced in Sporangia

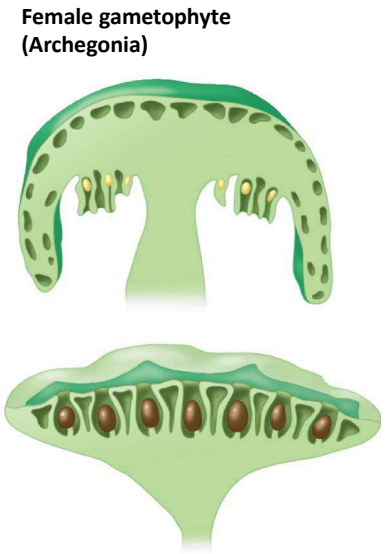
- The sporophyte produces **spores** in organs called **sporangia**
- **Diploid** cells called sporocytes **undergo meiosis** to generate haploid spores
- Spore walls contain **sporopollenin**, which makes them <u>resistant to harsh environments</u>



Sporophytes and sporangia of *Sphagnum* (a moss)

4. Multicellular Gametangia

- Gametes are produced within organs called **gametangia** via **mitosis**
- Female gametangia, called **archegonia**, produce **eggs** and are the site of fertilisation
- Male gametangia, **antheridia**, are the site of sperm production and release



5. Dependent embryo

- The **diploid embryo** is retained within tissue of the female gametophyte.
- Nutrients transferred from parent to embryo through **placental transfer cells**.
- Land plants are called **embryophytes** because of the dependency of the embryo on the parent

5 Key Traits in (nearly all) land plants

1. Apical meristems
2. Alternation of Generations
3. Walled spores produced in sporangia
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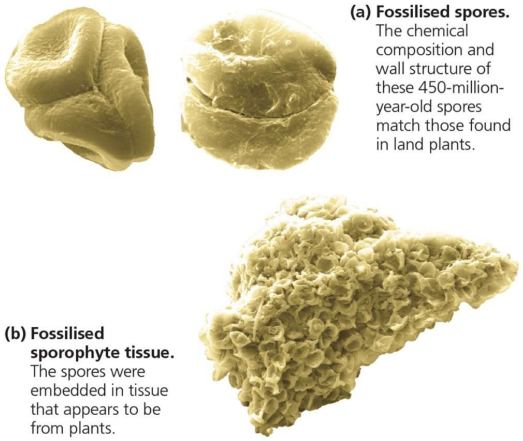
5. Dependant embryos

The origin and diversification of plants

- Fossil evidence indicates that plants were on land at least **475 million years ago**
- Fossilised **spores and tissues** have been extracted from 475-million-year-old rocks



(a) Fossilised spores. The chemical composition and wall structure of these 450-million-year-old spores match those found in land plants.

(b) Fossilised sporophyte tissue. The spores were embedded in tissue that appears to be from plants.

▲ **Figure 29.4** **Ancient plant spores and tissue** (colourised SEMs).

The origin and diversification of plants

- Those ancestral species gave rise to the vast diversity of modern plants
- Land plants can be informally grouped based on the **presence or absence of vascular tissue**
- **Non-vascular** plants are commonly called bryophytes
- Most plants have vascular tissue; these constitute the **vascular plants**

Table 29.1 Ten Phyla of Extant Plants

	Common Name	Number of Known Species
Nonvascular Plants (Bryophytes)		
Phylum Hepatophyta	Liverworts	9,000
Phylum Bryophyta	Mosses	15,000
Phylum Anthocerophyta	Hornworts	100
Vascular Plants		
Seedless Vascular Plants		
Phylum Lycophyta	Lycophytes	1,200
Phylum Monilophyta	Monilophytes	12,000
Seed Plants		
Gymnosperms		
Phylum Ginkgophyta	Ginkgo	1
Phylum Cycadophyta	Cycads	130
Phylum Gnetophyta	Gnetophytes	75
Phylum Coniferophyta	Conifers	600
Angiosperms		
Phylum Anthophyta	Flowering plants	250,000

Taxonomy

Scientific names provide accuracy and prevent confusion.

- Common names can be misleading:
  - E.g. **She-oaks** belong to genus *Allocasuarina* and are not oaks which belong to genus *Quercus*
  - "**Mountain Ash**" - In UK is *Sorbus aucuparia,* In USA is *Sorbus americana,* In Australia *Eucalyptus regnans.*
- One common name can be given to more than one plant
- One plant may have more than one common name

Binomial Nomenclature

- Two part format (**binomial**)
- Instituted in 18th Century by Carolus Linnaeus

- **1st part:** Genus (plural is Genera) to which the species belong
- **2nd part:** species name

The first letter of the Genus is capitalised
Entire binomial is **in italics**
– *Arabidopsis thaliana*

Taxonomy – International Code of Botanical Nomenclature

Plant nomenclature and animal nomenclature are independent

1. Names of plants or plant groups are **based on types**
2. Nomenclature is based on **priority of publication**
3. Each plant or group of plants can only bear one correct name – the earliest in accordance with the rules
4. Scientific names are in **Latin**
5. Rules of the code are **retrospective**

Taxonomy – International Code of Botanical Nomenclature

- Nomenclature is based on priority of publication
  – **plant names have authors**

– Person who named/ID the plants

eg) *Lomandra filiformis* R. Br

– Named/ found by Robert Brown

Plant hierarchy

- Domain
- Kingdom
- Division **(Phylum)**
- Class
- Order
- Family
- Genus
- Species
- **Sub species**
- **Variety**
- **Form**

Plant Diversity - Bryophytes

Bryophytes are represented today by three phyla of small herbaceous (non-woody) plants:

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

All are small, **lacking vascular systems**
(xylem and phloem - water and sugar transport systems).

- Occasionally they have a cuticle
- Usually they dry out in warm conditions but many are desiccation tolerant, having the ability to rehydrate rapidly.

Bryophytes

In all three bryophyte phyla, the **gametophyte stage (haploid) is larger and longer-living** than sporophyte (diploid) stage.

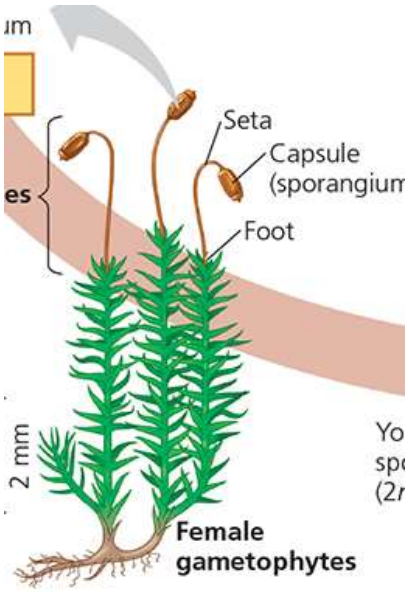
Sporophytes are typically present only part of the time

- **Gametophytes** – green (photosynthesize)
- **Sporophytes** - brown (depend on gametophyte)

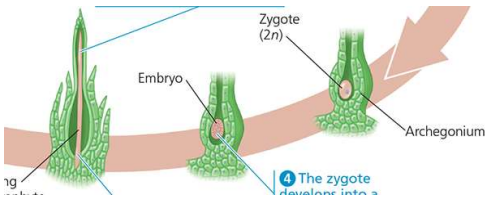
Bryophytes

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

- **Rhizoids** are root like structures
  - anchor gametophytes to substrate
- The height of gametophytes is constrained by lack of vascular tissues.
- Mature gametophytes produce **flagellated sperm** in antheridia and an egg in each archegonia.
- Sperm **swim through a film of water** to reach and fertilise the egg.

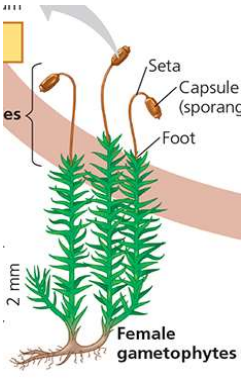


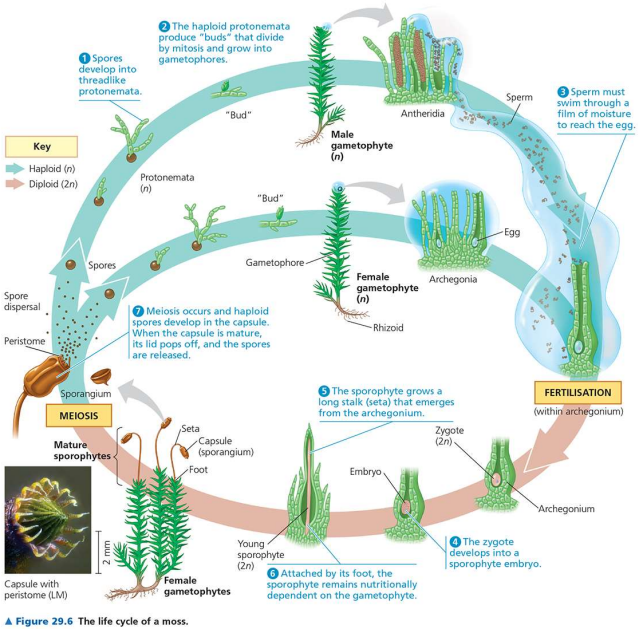
Bryophytes



- **Sporophytes** grow out of archegonia

- Sporophyte of Bryophytes is the simplest of the plant groups, consists of
  - **Foot, seta** (stalk) and **sporangium** (capsule)
  - The sporangium discharges spores through a **peristome**
- Hornwort and moss sporophyte

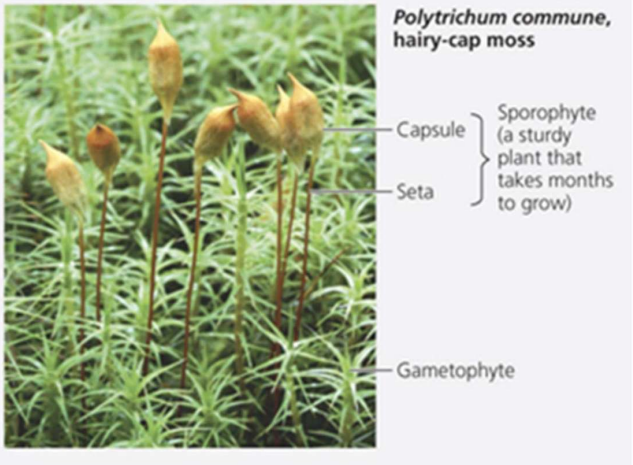




▲ **Figure 29.6** The life cycle of a moss.

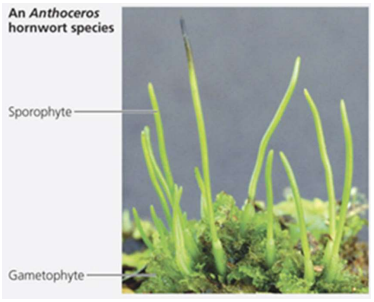
Phylum Bryophyta: Moss

- **Gametophyte** – green and photosynthetic
- **Sporophytes** – green and photosynthetic when young, brown when mature and ready to release spores



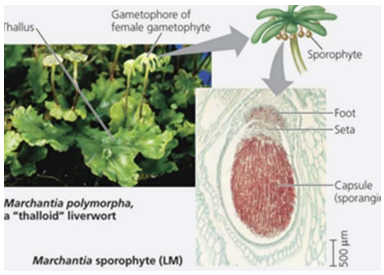
Hornworts: Phylum Anthocerophyta

- Sporophytes grow to approx. 5cm
- Releases spores by splitting open



Liverworts: Phylum Hepatophyta

- So named because of liver shaped gametophytes



Ecological & Economic Importance of Mosses

Moses 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
- **Prevent Erosion**
- Provide **moist bed for germination** of vascular plants
- Provide **Habitat** for invertebrates

Ecological & Economic Importance of Mosses

- Provide **nesting material** for birds
- Provide invertebrate **food source** for birds and other animals
- Some have **antibiotic properties**
- Used as **Bioindicators/biomonitors** of aquatic and terrestrial environments
- **Start of new ecosystems**

Ecological and Economic Importance of Mosses

- **Sphagnum**, or "peat moss," forms extensive deposits of partially decayed organic material known as peat - useful in formation of fossil fuels
- Sphagnum is an important global **reservoir of organic carbon** – worlds most efficient Carbon sink

(a) Thin peat soils support low-growing shrubs in Tasmania's south-west.

(b) "Tollund Man", a bog mummy dating from 405–100 BCE. The acidic, oxygen-poor conditions produced by *Sphagnum* can preserve human or other animal bodies for thousands of years.

▲ **Figure 29.9** ***Sphagnum*, or peat moss: a bryophyte with ecological and archaeological significance.**

Seedless Vascular Plants

Plants evolved vascular tissue:

Xylem: Water and mineral conducting cells

Phloem: distributes sugars, amino acids, and other organic products.

What does this mean for plant evolution?

- Allowed for plants to increase height - **evolutionary advantage**
  - Taller trees shade other plants and outcompete them for sunlight
- **Vascular plants became more successful** than non vascular plants

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 (419– 298.9mya)
- **Vascular tissue allowed these plants to grow tall**
- Formed the first forests
- Seedless vascular plants have **flagellated sperm** and are usually restricted to moist environments

Seedless Vascular Plants

Living vascular plants are characterised by:

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

- In contrast with bryophytes, **sporophytes of seedless vascular plants are the larger generation**, as in the familiar leafy fern
- The gametophytes are tiny plants that grow on or below the soil surface

Vascular Tissue: Evolution of Roots and Leaves

Roots: specialized organs that anchor vascular plants

– Enable vascular plants to absorb water/nutrients from the soil

Leaves: specialised organs that increase the surface area of vascular plants

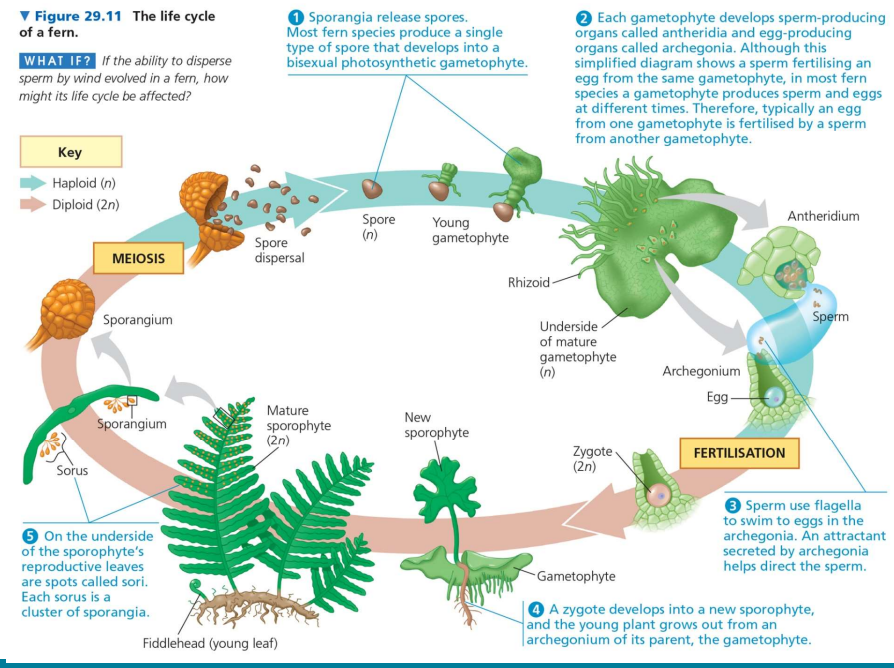
– Capture more solar energy for photosynthesis

Seedless Vascular Plants

There are two phyla of seedless vascular plants:

Phylum Lycophyta
- club mosses
- spike mosses
- quillworts

Phylum Monilophyta (Pterophyta)
- Ferns
- Horsetails
- whisk ferns and their relatives



Phylum Lycophyta: club mosses, spike mosses, and quillworts

- Giant lycophytes 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**

Phylum Monilophyta (Pterophyta): ferns, horsetails, whisk ferns and relatives

- 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

Monilophytes (Phylum Monilophyta)

Athyrium filix-femina, lady fern

Ferns

Unlike the lycophytes, ferns have megaphylls (see Figure 29.12). The sporophytes typically have horizontal rhizomes that give rise to large leaves called fronds, often divided into leaflets. A frond grows as its coiled tip, the fiddlehead, unfurls, although a few ferns, such as tree ferns, have upright stems.

Almost all species are homosporous. The gametophyte in some species shrivels and dies after the young sporophyte detaches itself. In most species, sporophytes have stalked sporangia with springlike devices that catapult spores several metres. Airborne spores can be carried far from their origin. Some species produce more than a trillion spores in a plant's lifetime.

Equisetum telmateia, giant horsetail

Horsetails

The group's name refers to the brushy appearance of the stems, which have a gritty texture that made them historically useful as "scouring rushes" for pots and pans. Some species have separate fertile (cone-bearing) and vegetative stems. Horsetails are homosporous, with cones releasing spores that typically give rise to bisexual gametophytes.

Horsetails are also called arthrophytes ("jointed plants") because their stems have joints. Rings of small leaves or branches emerge from each joint, but the stem is the main photosynthetic organ. Large air canals carry oxygen to the roots, which often grow in waterlogged soil.

Psilotum nudum, a whisk fern

Whisk Ferns and Relatives

Like primitive vascular plant fossils, the sporophytes of whisk ferns (genus *Psilotum*) have dichotomously branching stems but no roots. Stems have scalelike outgrowths that lack vascular tissue and may have resulted from the evolutionary reduction of leaves. Each yellow knob on a stem consists of three fused sporangia. Species of the genus *Tmesipteris*, closely related to whisk ferns and found only in the South Pacific, also lack roots but have small, leaflike outgrowths in their stems, giving them a vine-like appearance. Both genera are homosporous, with spores giving rise to bisexual gametophytes that grow underground and are only about a centimetre long.

Quick Question

1) Liverworts, hornworts, and mosses are grouped together as the Bryophytes. Besides not having vascular tissue, what do they all have in common?

A) They require water for reproduction.

B) They can reproduce asexually by producing gemmae.

C) They are heterosporous.

D) They are all wind pollinated.

Quick Question

2) Which of these are spore-producing structures?

A) archegonium of a moss or fern

B) sporophyte (capsule) of a moss

C) gametophyte of a moss

D) antheridium of a moss or fern

Quick Question

3) _____ are seedless vascular plants.

A) Ferns

B) Angiosperms

C) Bryophytes

D) Gymnosperms