First Forays: Intertidal Marine Algae
Problems with Moving to Land

1. Conserving water - not drying out
2. Obtaining & circulating water, food & gases
3. Overcoming gravity
4. Reproduction
5. Exposure to UV

Sunlight above ground
Nutrients below ground
Plant Solutions to Dry Living

1. Conserving water - not drying out
   - Developed waxy coating
2. Obtaining & circulating water, food & gases
   - Vascular tissue and roots, and pores
3. Overcoming gravity
   - Thicker cells - wood/cellulose
4. Reproduction
   - First spores, then pollen, seeds, & flowers
5. Exposure to UV
   - Pigments
Fossil of an early green algae
Dasycladales
Paleozoic Plant Evolution

Non-vascular plants

- Nontracheophytes
  - Club mosses
  - Horsetails
  - Whisk ferns
  - Ferns

Vascular plants

- Pteridophytes
  - Nonseed tracheophytes
  - Tracheophytes

Vascular + spores

Vascular + seeds

Vascular + cooler seeds + flowers

LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 29.10 The Evolution of Today’s Plants
Vascular Plant Evolution

**GEOLOGIC TIME SCALE**
Millions of years before present

- **CENOZOIC**
- **CRETACEOUS**
- **JURASSIC**
- **TRIASSIC**
- **PERMIAN**
- **CARBONIFEROUS**
- **DEVONIAN**
- **SILURIAN**

**SEEDLESS VASCULAR PLANTS**
- Psilopsida
- Lycopsida (Scale Trees)
- Sphenopsida (Sphenopsids)
- Pteropsida (True Ferns)

**GYMNOSPERMS (Naked Seeds)**
- Pteridospermophyta (Seed Ferns)
- Cycads and Cycadeoids
- Ginkgophyta (Ginkgoes)
- Conifera (Conifers)

**ANGIOSPERMS (Flowering Plants)**

Mixed evolutionary timeline with various plant groups.
First Plants Reproduced Using Spores
(Still required water)
First Colonists: Bryophytes

BRYOPHYTES

Hornworts  Liverworts  Mosses

No “Plumbing System” - small low to the ground
Early Plants:

1. Stabilized soil and reduced physical erosion

2. Created the first modern soils with organic matter

3. Increased chemical weathering by pumping CO$_2$ into the soil via roots and decay of organic matter

4. Provided food so that animals could move to land
Silurian

Artist rendition of Cooksonia
The earliest vascular plant
Only a few cm high

Cooksonia fossil
Cooksonia fossils from the Early Devonian of the Paraná Basin (Brazil), interpreted as five sporophytes attached to a thalloid gametophyte. [Scale bar = 1 cm].
Silurian

Cooksonia fossils
Silurian

*Baragwanathia*
An early Vascular plant
Silurian

*Baragwanathia*
An early Vascular plant
Silurian

Baragwanathia
An early Vascular plant
Silurian

Baragwanathia
An early Vascular plant
Late Devonian

Rhynia
Vascular plant
Early Devonian
Late Devonian

Rhynia vascular tissue
Late Devonian

*Aglaophyton* vascular tissue

*Aglaophyton* stoma and guard cells
Archaeopteris, the first tree (30 feet tall)
Late Devonian

Archaeopteris foliage
Carboniferous

Fossil seed fern
Fossil spore-forming fern
Pecopteris

A tree-sized fern

Devonian to Permian, but flourishing in the Carboniferous
Fossil seed fern
Calamites
A horsetail reaching up to 100 feet tall
Living horsetails
Carboniferous

Calamites leaves
Carboniferous

Calamites ‘trunks’
Carboniferous

Calamites wood
Calamites stems

Carboniferous

Calamites stems
Carboniferous

Calamites wood
Cross section
Clubmosses: Modern Lycopodium
Clubmosses: Lepidodendron

Extinct

Reconstruction of Lepidodendron

Lepidodendron stumps excavated from Carboniferous rocks, Glasgow, Scotland
Carboniferous

Lepidodendron

Sigillaria

juvenile stumps growing upwards

Sigillaria and Lepidodendron
Miss/Penn Forests
(Ferns, Horsetails & Clubmoss)

Illustration by Mary Parrish
The trunk of a Sigillaria ‘tree’
Sigillaria bark

Carboniferous
Carboniferous

Sigillaria root
Carboniferous

Lepidodendron
Carboniferous

Lepidodendron ‘bark’
Carboniferous

The *strobilus* of *Lepidodendron*
Carboniferous

Stigmaria root
Cordaites

Carboniferous

Cordaites

A

B

subtending leaf

fertile shoot

C

subtending leaf

Mesoxylon
or
Pennsylvanioxylon

Amyelon
Cordaites stems

Carboniferous

Cordaites stems
Carboniferous

Cordaites leaves
Permian

Ginkgo leaves
Seed Ferns

Jurassic is the age of cycads

Neuropteris sp.

Modern cycad
Naked seed, but still a seed.

A protective capsule that remains dormant until the proper conditions are met.

This means that plants can invade drier environments.
Gymnosperms

‘naked seed’

Seed Cone (Female)

Larix decidua

Pollen (male)
Ginkos (Permian)

(b) Ginkgo biloba
Cretaceous

*Dammarites*

*Early gymnosperm*
Conifers

(d) Sequoiadendron giganteum
Angiosperms

These come much later
The “Not-So-Naked” Seed
Fossil Leaves and Flowers
Plant Evolution Summary

1. **Paleozoic** - Plants move to land
   - Dominated by bryophytes & seedless vascular Plants

2. **Mesozoic** - Dominated by gymnosperms
   - Angiosperms arise

3. **Cenozoic** - Dominated by angiosperms