Summary from last time

• We talked about?
The Tracheophytes

• A leaf is a flattened photosynthetic structure emerging laterally from a main axis or stem and possessing true vascular tissue.

• Two leaf types: microphylls and megaphylls.

• The microphyll has a single vascular strand that has departed from the stem without disturbing the stem’s vascular structure.
  – Club mosses have microphylls.
  – Microphylls may have evolved from sterile sporangia.
Figure 29.13a The Evolution of Leaves

(a)

Vascular tissue

Sporangia

Time

Sporangium

Microphyll
The Tracheophytes

• The megaphyll is larger, and more complex found in ferns and seed plants.
• May have arose from flattening of stems and development of overtopping
Introducing the Tracheophytes

• Plants that bear a single type of spore are said to be homosporous.
  – The most ancient tracheophytes were all homosporous.
  – Both the gametophyte and the sporophyte are independent and usually photosynthetic.
  – A single type of gametophyte bears both female and male reproductive organs.
Introducing the Tracheophytes

• Plants with two distinct types of spores evolved later, and are said to be heterosporous.
Figure 29.14a & b  Homospory and Heterospory

(a) Homospory
- Gametophyte
- Archegonium (♀)
- Antheridium (♂)
- Egg (♀)
- Spore (♂)
- Sperm (♂)
- Meiosis
- HAPLOID (♀)
- DIPLOID (♂)

(b) Heterospory
- Megagametophyte (♀)
- Microgametophyte (♂)
- Megaspore (♀)
- Microspore (♂)
- Spore mother cell (♂)
- Spore mother cell (♀)
- Meiosis
- HAPLOID (♀)
- DIPLOID (♂)
The Surviving Nonseed Tracheophytes

• The club mosses (phylum Lycophyta) have microphylls, exhibit apical growth, and have roots that branch dichotomously.

• Sporangia in many Lycophyta are contained within structures called strobili (clusters of spore-bearing leaves)
Figure 29.15 Club Mosses

(a) Lycopodium obscurum

(b)
The Surviving Nonseed Tracheophytes

• The horsetails, whisk ferns, and ferns form a clade, the phylum *Pteridophyta*.
• The leaves are reduced megaphylls and grow in whorls.
• Stem growth is from the base of the stem segments.
The Surviving Nonseed Tracheophytes

• The sporophytes of the ferns typically have true roots, stems, and leaves.

• The ferns first appeared during the Devonian.

• Ferns are characterized by fronds, large leaves with complex vasculature.

• Sporangia are found on the undersurfaces of the fronds, clustered in groups called sori.
Figure 29.19  *Fern Sori Are Clusters of Sporangia*

*Dryopteris intermedia*
Figure 29.10 *The Evolution of Today’s Plants*

- **Common ancestor**
  - Tracheids; branching, independent sporophyte
    - Multiflagellate sperm, complex leaves
      - Seeds
        - Flowers, carpels, triploid endosperm
          - Nontracheophytes
            - Club mosses
              - Horsetails
                - Whisk ferns
                  - Ferns
                    - Cycads
                      - Conifers
                        - Ginkgos
                          - Gnetophytes
                            - Angiosperms

- Nonseed tracheophytes
  - Pteridophytes
    - Gymnosperms
      - Seed plants

The Seed Plants

- Seed plants are the most derived tracheophytes.

- Big evolutionary innovations
Figure 30.2  The Relationship between Sporophyte and Gametophyte Has Evolved (Part 1)
The Seed Plants

- The seed plants are heterosporous
  - Separate **megasporangia** and **microsporangia**

- Megaspores produce a single, haploid, multicellular female gametophyte in megasporangia

- Microspores meiotically divide to produce **pollen grains** in microsporangia
  - Fertilization occurs through **pollen tube** elongation to the female gametophyte (which release two sperm)

- Resulting zygote divides until an embryonic stage is reached, when growth is halted (producing a **seed**).
The Seed Plants

• A seed may contain tissues from three generations.

• The possession of seeds is a major reason for the enormous evolutionary success of seed plants.
The Gymnosperms: Naked Seeds

- The **gymnosperms** do not produce flowers, and their ovules and seeds are not protected by flower or fruit tissue.

- There are four clades of living gymnosperms today.
The Gymnosperms: Naked Seeds

- Fir, cedar, spruce, and pine all belong to **Pinophyta**
  - Megaspores are
  - Microspores are
Figure 30.6 The Life Cycle of a Pine Tree
The Gymnosperms: Naked Seeds

• Gymnosperms exhibit secondary growth

• Recall types of types of growth (animals versus plants)
  – **Determinate**
  – **Indeterminate**

• Meristematic regions are localized regions of cell division.
  – They produce new cells indefinitely

• Two meristem types:
  – **Apical meristems**
  – **Lateral meristems**
Figure 35.13 Apical and Lateral Meristems

- Leaf primordia
- Lateral bud primordia
- Cork cambium
- Vascular cambium
- Root apical meristem
- Root hairs
- Root apical meristem
- Root cap

100 μm

50 μm
Forming the Plant Body

• Secondary tissues derive from two lateral meristems: vascular and cork cambium.
  – Vascular cambium -
  – Cork cambium -

• Growth in the diameter of the stems and roots, produced by these meristematic regions is called
  – Wood is
  – Bark is
Gymnosperms: Naked Seeds

- Gymnosperms (except Gnetophyta) have only tracheids, and simple phloem.

- Tracheids are

- Phloem are
The Angiosperms: Flowering Plants

• Phylum Angiospermae ~

• The angiosperms are the most derived form of the tracheophytes
The Angiosperms: Flowering Plants

- A number of **synapomorphies**, or shared derived traits, characterize the angiosperms:
  - They have
  - They produce
  - Their ovules and seeds are
  - They have
  - They produce
  - Their xylem contains
  - Their phloem contains
The Angiosperms: Flowering Plants

• **Double fertilization** - two male gametes participate in fertilization events within the megagametophyte.
Figure 30.11 The Life Cycle of an Angiosperm
The Angiosperms: Flowering Plants

- All the parts of a flower are modified leaves.

- **Stamens - filament** bearing **anthers** containing pollen-producing microsporangia.

- **Pistil** – one or more carpels with a swollen base (**ovary**) containing megasporangia.

- **Style** is the apical stalk of the pistil (terminal surface receiving pollen is called the **stigma**).
The Angiosperms: Flowering Plants

• Specialized leaves (petals and sepals) are

• Evolutionarily ancient angiosperms have a large and variable number of floral structures (petals, sepals, carpels, and stamens)
  – Evolutionary trend within the group:
Figure 30.8 Inflorescences

(a) *Daucus carota*  
Compound umbel

(b) *Echinacea purpurea*
Disk flowers
Ray flowers

(c) *Pennisetum setaceum*
The Angiosperms: Flowering Plants

• **Perfect** flowers have both

• **Imperfect flowers**
  – **Monoecious** species produce
  – In **dioecious** species,

• Developing embryos consists of an embryonic axis and one or two **cotyledons** (seed leaves), which
Figure 35.1 Monocots versus Eudicots

Monocots

Cotyledons

Eudicots

Veins in leaves

Flower parts

Arrangement of primary vascular bundles in stem
Organs of the Angiosperms

- Two main types of root system:
  - Many eudicots have a
  - Monocots and some eudicots have a

- Some plants have **adventitious roots**, which arise from points along the stem where roots would not usually occur.
Figure 35.3 Root Systems

(a) Carrots

(b) Grass Roots
Angiosperm vascular systems

• **Xylem** in angiosperms consists of **vessel elements** in addition to tracheids
  – **Vessel elements** also

  – **Vessel elements** are generally

• Sieve tube elements (Phloem) in Angiosperms are stacked, similar to xylem
  – Have adjacent **companion cells** that

  – **Companion cells** may regulate the performance of the sieve tube members through their effects on active transport of solutes
Why is a greater diameter a big deal for the evolution of plants?
Figure 35.11 Sieve Tubes

- Pores of sieve plate
- Sieve plate
- Sieve tube element
- Companion cell
- Sieve tube element

Scale: 10 μm
Angiosperms: Flowering Plants

- **Monocots** - a single embryonic cotyledon (grasses, cattails, lilies, orchids, and palms)

- **Eudicots** - two cotyledons, and include the majority of familiar seed plants

- Additional clades - water lilies, star anise, and the magnoliid complex

- Big question in plant evolution – what is the basal angiosperm?