

# Plants

## now with seeds!

### Learning Objectives

- By the end of this unit, a student should be able to...
  - Describe the characteristics and distinguish among the major groups of seed plants
  - Compare the features of gymnosperms and angiosperms
  - Summarize the features that distinguish seed plants from non-seed plants
  - Name and briefly describe the features of the four phyla of gymnosperms
  - Summarize the features that distinguish flowering plants from other plants
  - Explain the modification of the plant life cycle seen in flowering plants
  - Contrast the features of monocots and dicots
  - Discuss the adaptations in flowering plants that led to their diversity and abundance
  - Explain the structure of fruits and seeds and their origins from floral structures

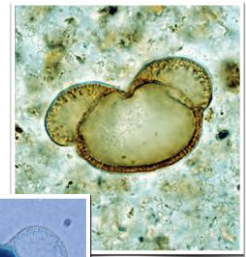
## Seed Plants

### THE GYMNOSPERMS



## Gymnosperms

- Produce **Pollen**
  - unlike bryophytes & ferns
  - contains male gametophyte
  - dispersed primarily by wind



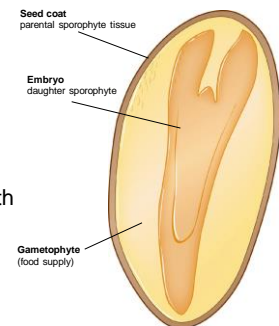
## Gymnosperms

- Produce **Seeds**
  - unlike bryophytes & ferns
  - precursor "contains" the female gametophyte
    - and then the sporophyte embryo



## Gymnosperms

- Advantages of Seeds (over spores)
  - Further along in development before release
  - Contain abundant food supply for growth of embryo
  - Protected by multicellular **seed coat**



## Gymnosperms

- Seeds found in “cones” and other structures
  - (not fruits)
- Seeds are exposed
  - Ovary wall does not surround ovules/seeds

## Gymnosperms

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## Gymnosperms

• What are the types of gymnosperms?

Four phyla or divisions of seed bearing lineages leading up to flowers

## THE GYMNASPERMS

• What are the four phyla/divisions of gymnosperms?

## CYCADOPHYTA

## CYCADOPHYTA

- Often mistaken for
  - ferns
  - palms

“Sago Palm”  
*Cycas revoluta*

## CYCADOPHYTA

- Are **dioecious**
- male and female reproductive structures on separate plants
- reproduce with pollen and ovules in cone-like strobili



Female strobilus (seed cone)

## THE GYMNASPERMS

Cycads



Ginkgoes



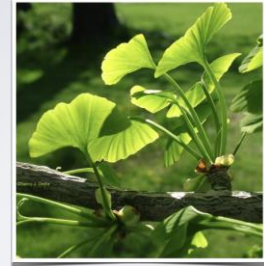
Conifers



Gnetophytes



Gymnosperms



**Ginkgophyta**  
**Ginkgo biloba**

## GINKGOPHYTA

- *Ginkgo biloba*
- only surviving species in division
- "living fossil"
- deciduous, dioecious tree



## GINKGOPHYTA

Female ginkgo produces fleshy seeds from ovules directly on branches



## GINKGOPHYTA

Planted extensively as a landscape tree

Mainly males because seeds stink like rancid butter



## THE GYMNASPERMS

Cycads



Ginkgoes



Conifers



Gnetophytes



Gymnosperms



**Pinophyta**  
**or Coniferophyta**



## PINOPHYTA

## Pinophyta (Coniferophyta)

- Largest division of gymnosperms
- Most diverse, most numerous
- Woody plants
- Bear needles (b) or scales (c)
- Usually evergreen
- Produce seeds in cones

## PINOPHYTA

- Most are **monoecious**
- male and female parts in separate cones on same plant

(a)  
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## THE GYMNOSPERMS

Cycads

Ginkgoes

Conifers

Gnetophytes

Gymnosperms

**Gnetophyta**

## Gymnosperms

- Gnetophyta
- Share traits with Angiosperms
- "Cones" are flower-like

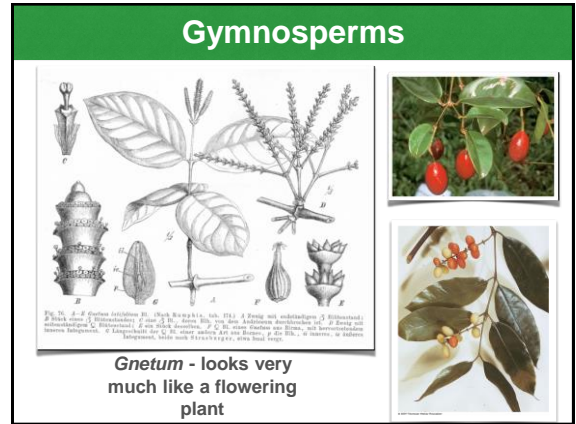
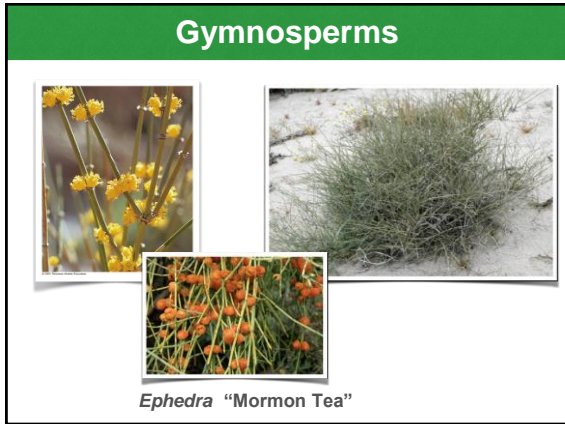
*Welwitschia*

*Ephedra*

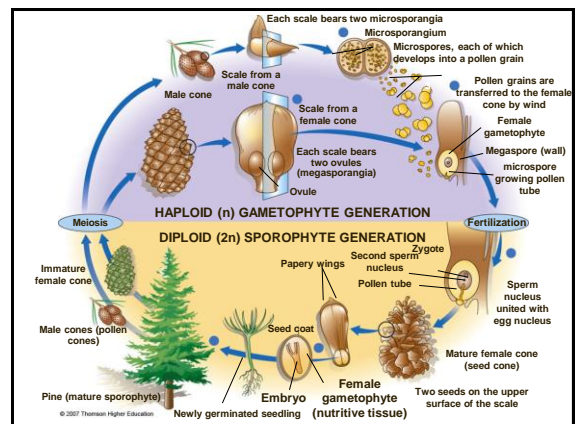
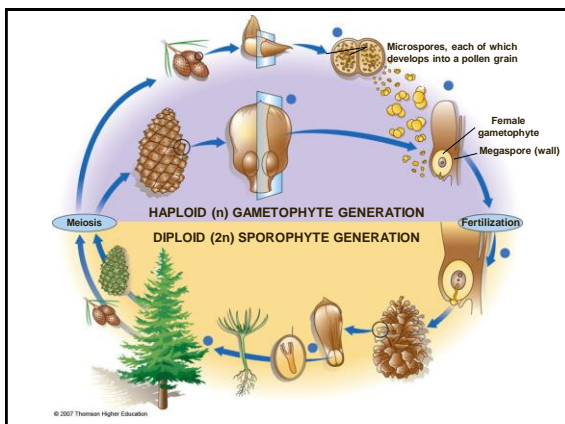
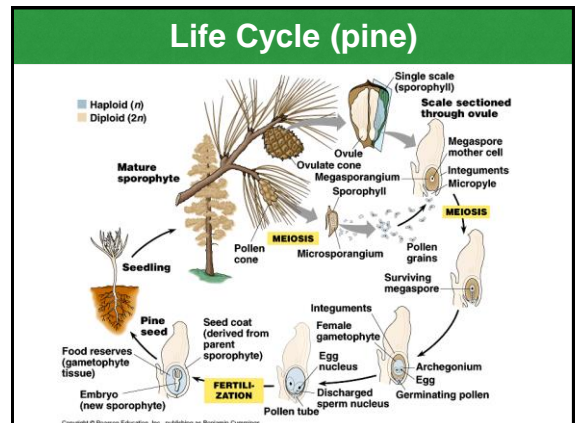
*Gnetum*

## Gymnosperms

- *Welwitschia mirabilis*
- only 2 leaves
- short, heart shaped, woody "trunk"
- long taproot



- ### Life Cycle (pine)
- Pollination
    - transfer of pollen to female cones
  - Pollen tube
    - grows through megasporangium to egg within archegonium
    - can take up to a year in pines!
  - Fertilization
    - sperm nucleus fuses with egg nucleus
  - After fertilization
    - zygote develops into embryo encased inside seed
    - adapted for wind dispersal







### Flowering Plants

- Angiosperms
- Anthophyta
- Magnoliophyta


Gymnosperms




Cycads




Ginkgoes



Conifers



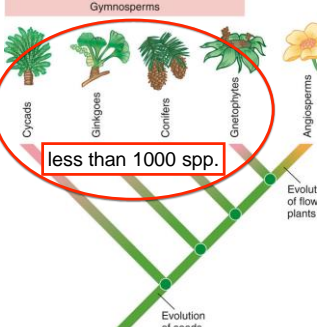
Gnetophytes



Angiosperms


### Flowering Plants

Gymnosperms



less than 1000 spp.

Angiosperms



200,000 - 400,000 spp.

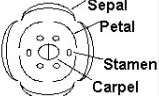
Evolution of flowering plants


Evolution of seeds


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### Flowers

- **Flower**
  - Complex sexual organ
  - whorls of modified leaves
    - **sepals**
    - **petals**
    - **stamens**
    - **carpels**



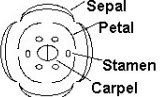


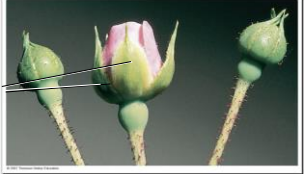


- Attached to a **receptacle** on a flower stalk called a **peduncle**

### Flowers

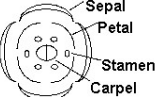
- **Floral Structure**
  - **Sepals**
    - Lowest and outermost whorl
    - Cover & protect other parts in buds
    - All sepals of a flower make up the calyx







### Flowers

- **Floral Structure**
  - **Petals**
    - whorl(s) inside of sepals
    - all petals together make up the corolla



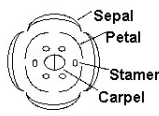







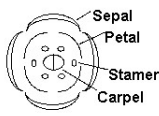

### Flowers

- Floral Structure
  - **Petals**
    - bright petals attract pollinators
    - **conspicuous flowers**
    - wind pollinated flowers do not need bright petals
    - **inconspicuous flowers**

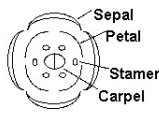
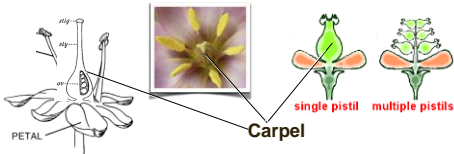
### Flowers

- Floral Structure
  - **Stamens**
    - whorl inside the petals
    - consist of anthers and filaments
    - where microspores develop into pollen grains

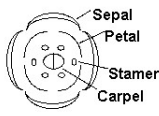
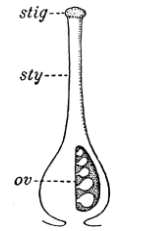
### Flowers

- Floral Structure
  - **Carpels**
    - Center whorl
    - “female” reproductive organs
      - contains ovary, ovules
    - one or more carpels called the “**pistil**”

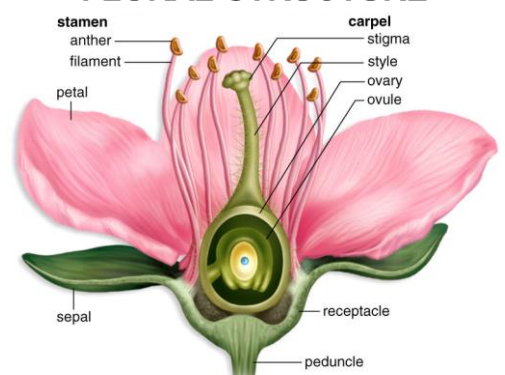



### Flowers

- Floral Structure
  - **Carpels**
    - Each pistil has three sections:
      - A **stigma** on which the pollen grain lands
      - A **style** through which the pollen tube grows
      - An **ovary** that contains one or more ovules


## FLORAL STRUCTURE




### Flowers

- Floral Structure
  - A flower with all four parts is **complete**
  - A flower missing one or more part is **incomplete**
  - A flower with both stamens and carpels is **perfect**
  - A flower with either stamens or carpels but not both is **imperfect**

Incomplete, imperfect flowers of the cucumber family (Cucurbitaceae)



Pistillate (female) flowers (cucumber)



Staminate (male) flowers (cucumber)



# Wait! it gets even more exciting!



**these aren't flowers!**

## Flowers


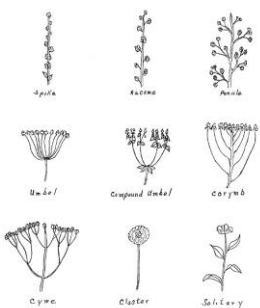
- **Composite flowers**
  - **Inflorescence** or group of small, specialized flowers
  - ray flowers - petals
  - disk flowers - reproductive

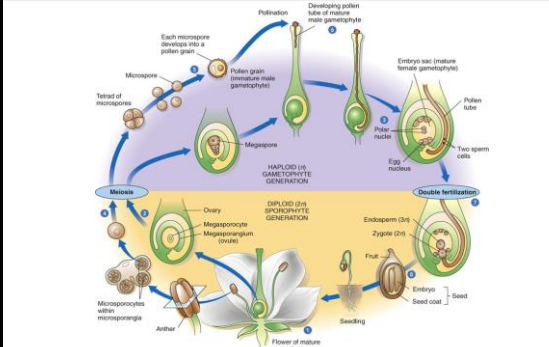
## Flowers

- **Inflorescences**

*Types of Inflorescences*

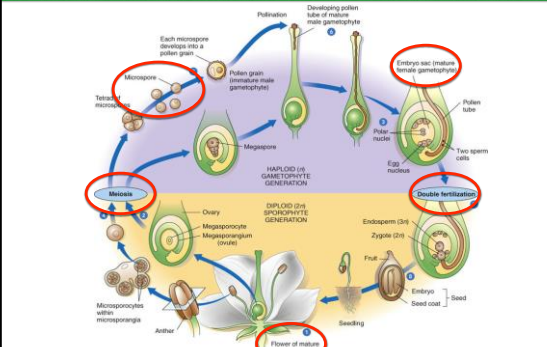



## Flowering Plant Life Cycle



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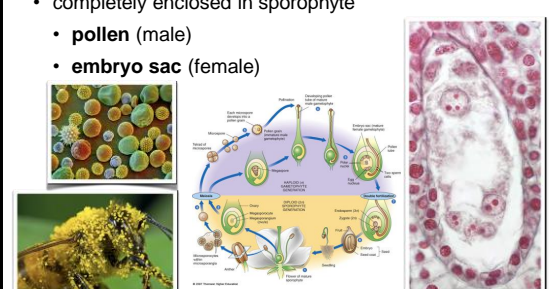
## Flowering Plant Life Cycle



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## Flowering Plant Life Cycle

- Gametophytes extremely reduced in size
- completely enclosed in sporophyte
  - **pollen** (male)
  - **embryo sac** (female)





**Embryo sac (mature female gametophyte)**

- **Embryo sac**
  - gametophyte consists of eight nuclei
- **Double Fertilization**
  - Egg cell and two polar nuclei participate in fertilization
  - Results in
    - diploid zygote (2n)
    - triploid endosperm (3n)

Labels in diagram: Embryo sac (mature female gametophyte), Pollen tube, Polar nuclei, Egg nucleus, Two sperm cells, Double fertilization, Endosperm (3n), Zygote (2n), Fruit.

## Fruits and Seeds

- Following fertilization
  - ovary develops into **fruit**
  - ovules become **seeds**

Labels: stigma, ovary wall, ovule, fruit wall (pericarp), seed, pea flower, pea pod.

## Fruits and Seeds

- All fruits come from flowers

**FRUITS**

## Fruits and Seeds

- All fruits come from flowers

**FRUITS**

**Mangos from the Big Island of Hawaii**

## Fruits and Seeds

- All fruits come from flowers

**DRY DEHISCENT FRUITS**

**DRY INDEHISCENT FRUITS**

## Fruits and Seeds

- A lot of vegetables are fruits (botanically)

### Fruits and Seeds

- A lot of vegetables are fruits (botanically)

All of these are fruits

### Fruits and Seeds

- A lot of vegetables are fruits (botanically)

unopened inflorescences

sunflower "seeds" are really fruits

strawberry "seeds" are really little fruits

not even a plant!

### Flowering Plants

Gymnosperms

Cycads, Ginkgoes, Conifers, Gnetales

Angiosperms

200,000 - 400,000 spp.

Evolution of seeds

Evolution of flowering plants

Basal Angiosperms

Core Angiosperms

Amborella, Water lilies, Star anise, Magnoliids, Monocots, Eudicots

Evolution of vessel elements

Evolution of flowering plants

Basal Angiosperms

Core Angiosperms

(b) *Amborella trichopoda*, a basal angiosperm.

(c) Water lily (*Nymphaea*), a basal angiosperm.

(d) Star anise (*Illicium verum*), a basal angiosperm.

(e) *Magnolia grandiflora*, a core angiosperm.

Monocots

Eudicots

Evolution of flowering plants

### Monocots vs. Dicots

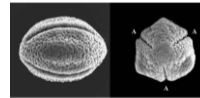
### Monocots vs. Eudicots



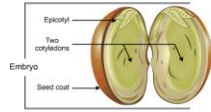
- two largest classes of flowering plants

### Eudicots (Class Eudicotyledones)

- Floral part multiples of four or five (usually)
- Seeds contain 2 cotyledons
  - nutritive organs in seeds
- Pollen are tricolpate
  - have 3 pores



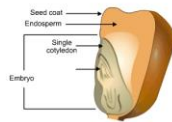
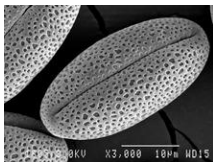
Pollen tricolpate - 3 apertures



Bean Seed

### Monocots (Class Monocotyledones)

- Floral parts in threes (tri-merous)
- Seeds usually contain one cotyledon
  - Endosperm
    - nutritive tissue in seeds
- One pore in pollen (monosulcate)



Corn Seed

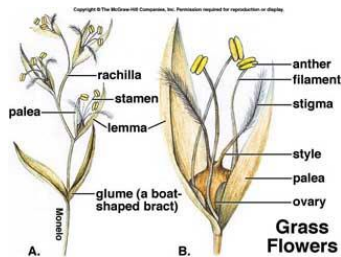
### Monocots (Class Monocotyledones)

- Grasses (Family Poaceae)
  - one of the 4 largest (most diverse) plant families
  - Over 50% of our calories come from just a few species of grass
  - Sugar Cane
  - Maize/Corn
  - Wheat



### Monocots (Class Monocotyledones)

- Grasses (Family Poaceae)
  - Highly specialized flowers
  - Highly divergent (evolved)

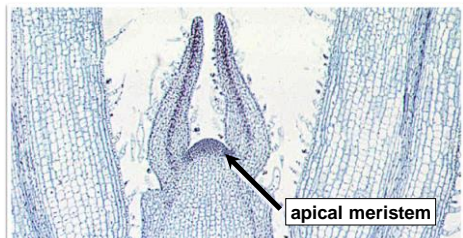


Grass Flowers

### Plant Growth

#### • Indeterminate growth

- Parts of plant grow with no pre-determined body plan
- Some tissue remains **embryonic** (meristems, buds)
  - can become roots, stems, or leaves

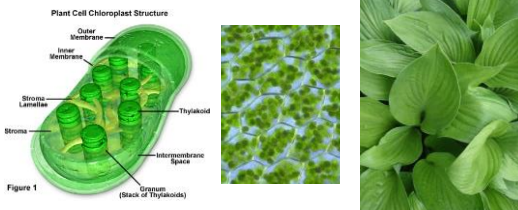


apical meristem



## Photosynthesis

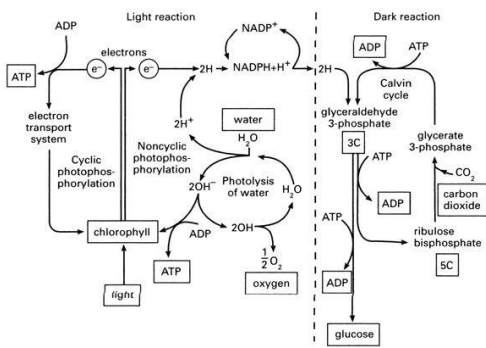
- Use chlorophyll to capture sun's energy
  - a green pigment
  - Found in subcellular organelles called Chloroplasts



## Photosynthesis

- Carbon dioxide + water + light → Sugars & Oxygen
- $6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$
- $6 \text{ CO}_2 + 12 \text{ H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 + 6 \text{ H}_2\text{O}$

## Photosynthesis



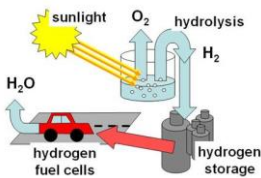
## Photosynthesis

- Plants take in Carbon dioxide
- Removes CO<sub>2</sub> from the air
- carbon and oxygen split and used to build larger molecules for energy storage and growth.



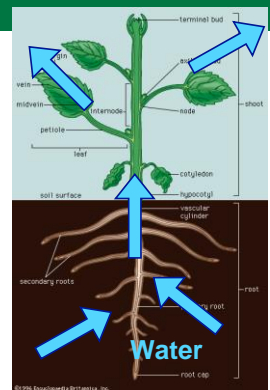
## Photosynthesis

- Plants need water
  - Water molecules are split apart by the plant
- The oxygen released by plants doesn't come from the carbon dioxide they take in, it comes from water!



## Transpiration

- Water moves from roots through stem and out of leaves
- 90% of water taken in is lost
- <10% of water is used for photosynthesis
- Plants act as natural filters for air and water



## Photosynthesis

- Non-photosynthetic plants
  - non-functional chloroplasts
  - a derived characteristic (lost the ability to be photosynthetic)
  - convergent evolution with fungi

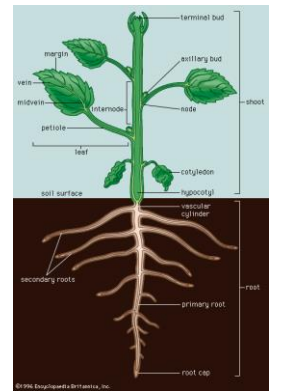


Photo: Jeremiah Bennett, Morley Michigan

*Orobanche fasciculata*

## Plants

- Structure
  - Roots
  - Stems
  - Leaves
- Growth
  - Indeterminate - no set body plan
    - parts remain embryonic (**meristems, buds**)
  - constrained by environment



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- Groves of aspen trees (*Populus tremuloides*) are often clones of a single organism, connected by an extensive root system



- The root system of "Pando", an aspen grove in Utah is estimated to be among the [oldest known living organisms](#) in existence at 80,000 years of age.



- King Clone creosote bush (*Larrea divaricata*) in the Mojave Desert, California. The oldest known clonal ring, estimated to be 11,700 years old, with a diameter of 15.6m