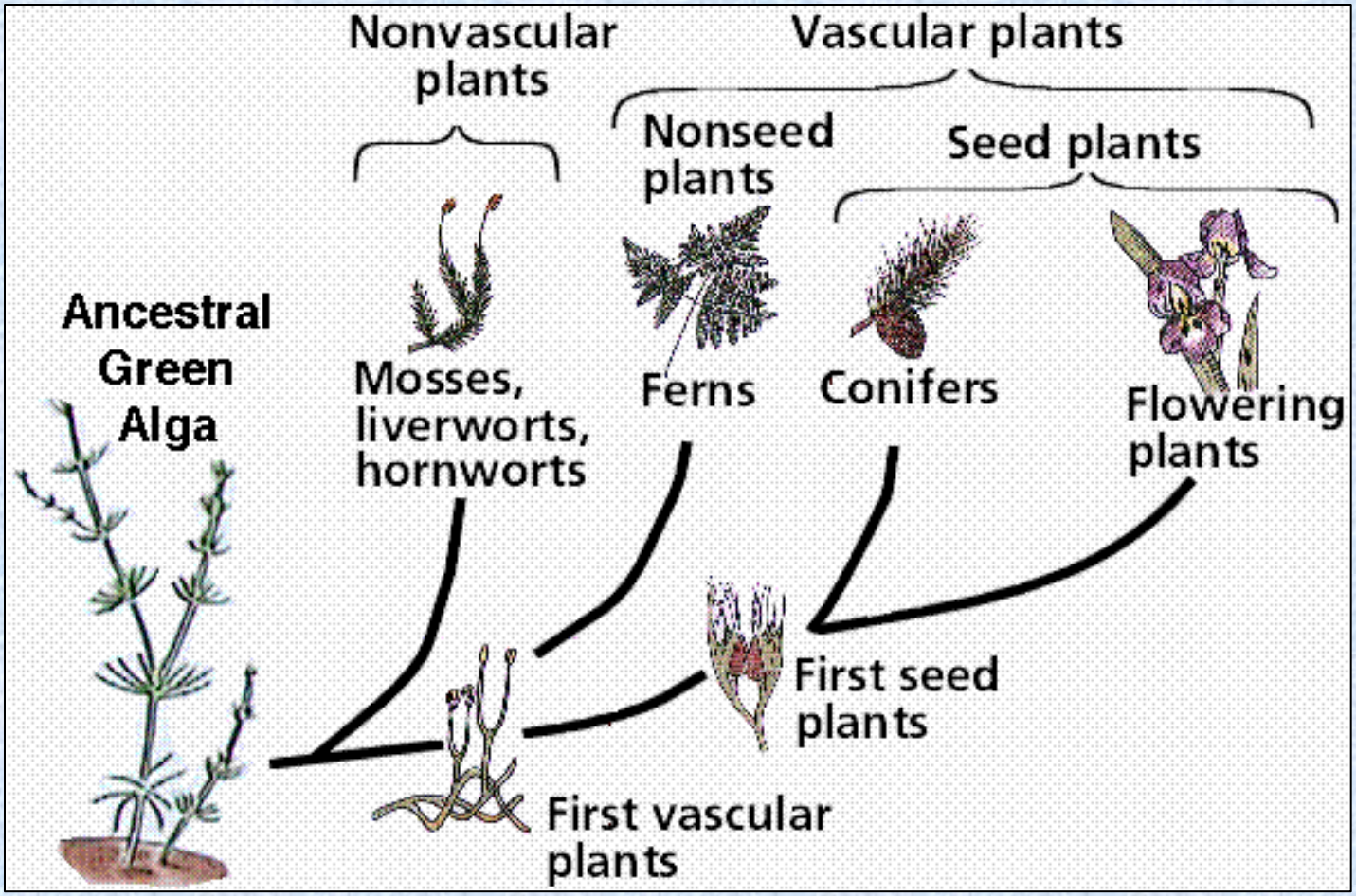
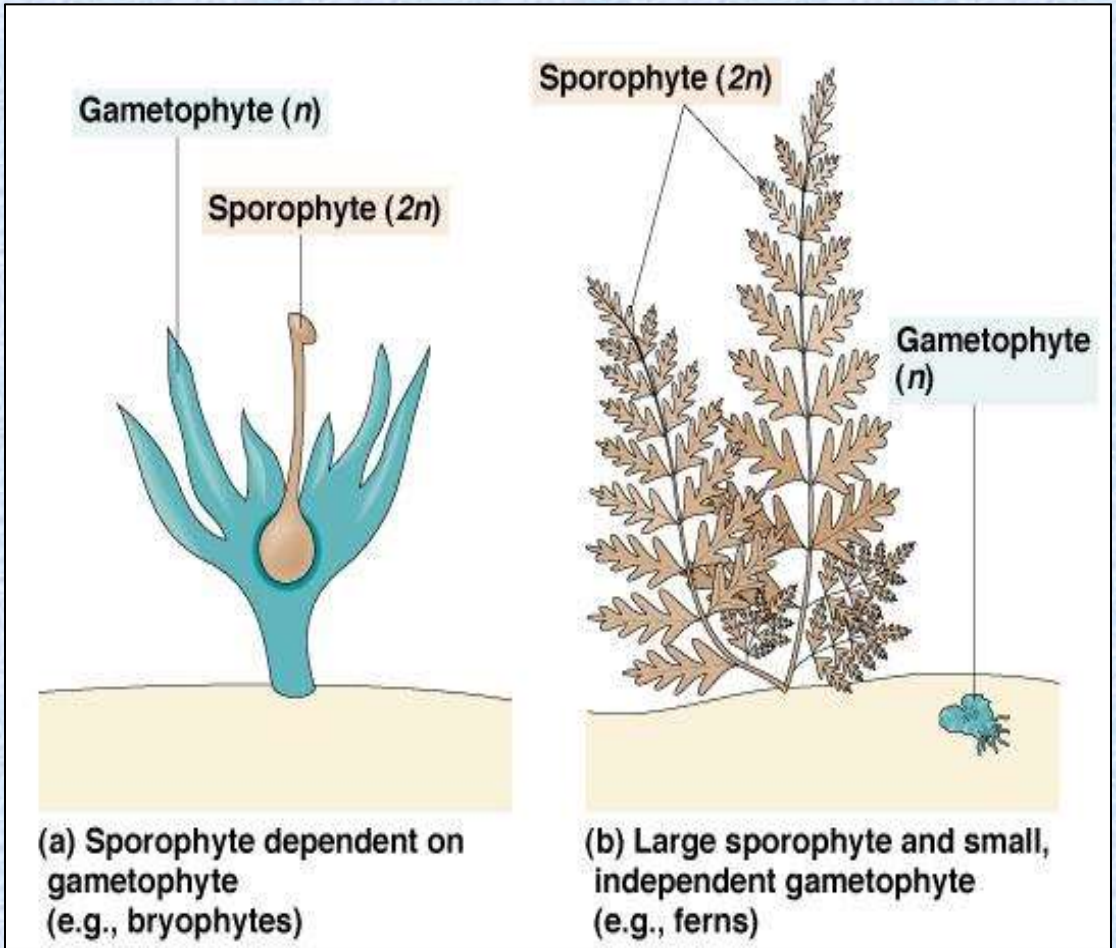
Angiosperm Reproduction, Evolution and Diversity



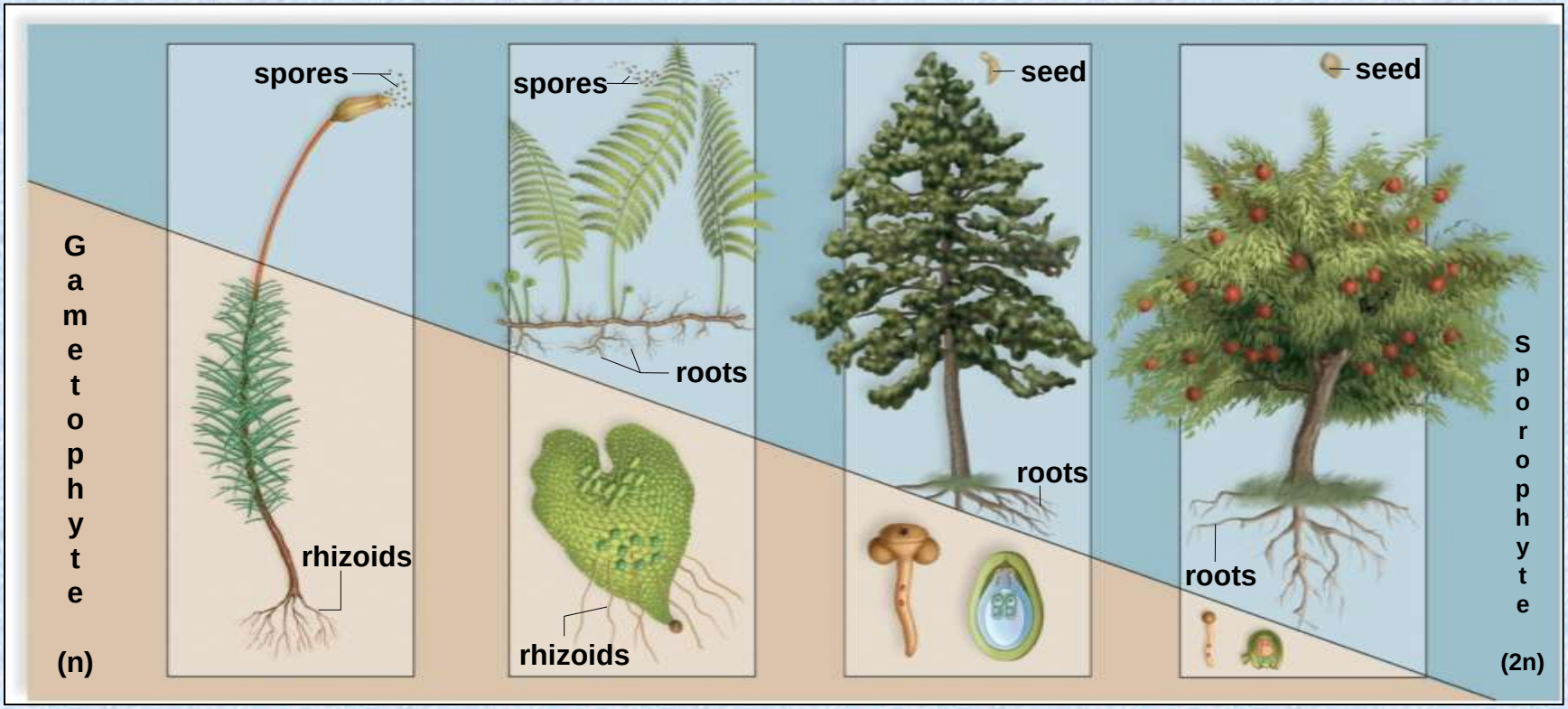
Non-vascular Plants – the Bryophytes

Evolutionary Trends in Plant Life Cycles

- Both mosses and ferns require water for fertilization.
- However, the presence of vascular (water-conducting) tissue in ferns has allowed the sporophyte to become independent of the gametophyte, to grow taller, and to exploit drier habitats.

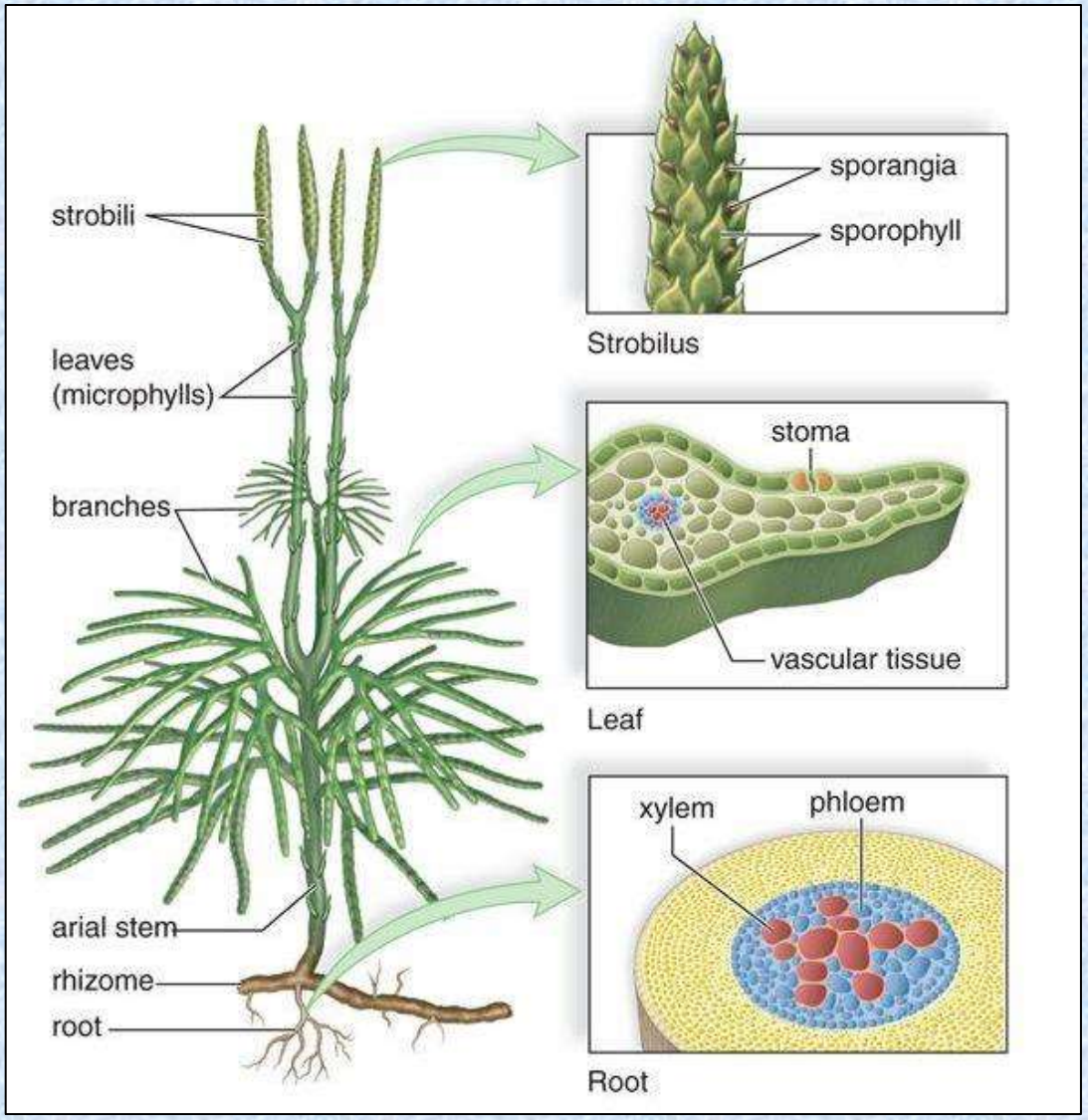


Reduction in the Size of the Gametophyte

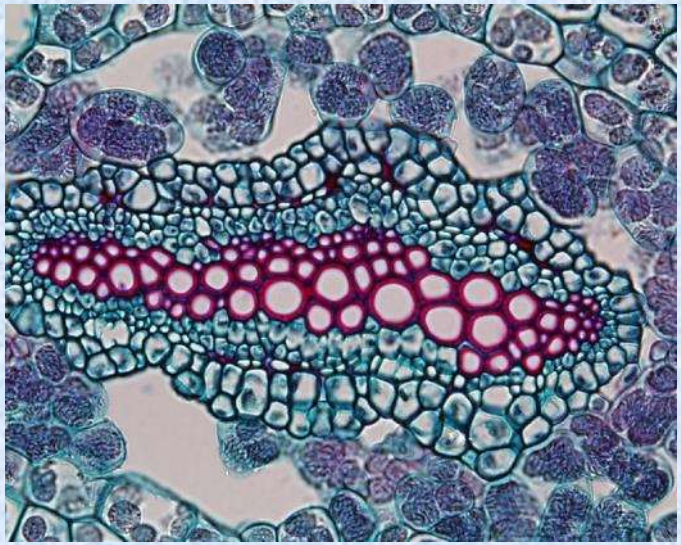


Vascular Seedless Plants – Ferns and Fern Allies

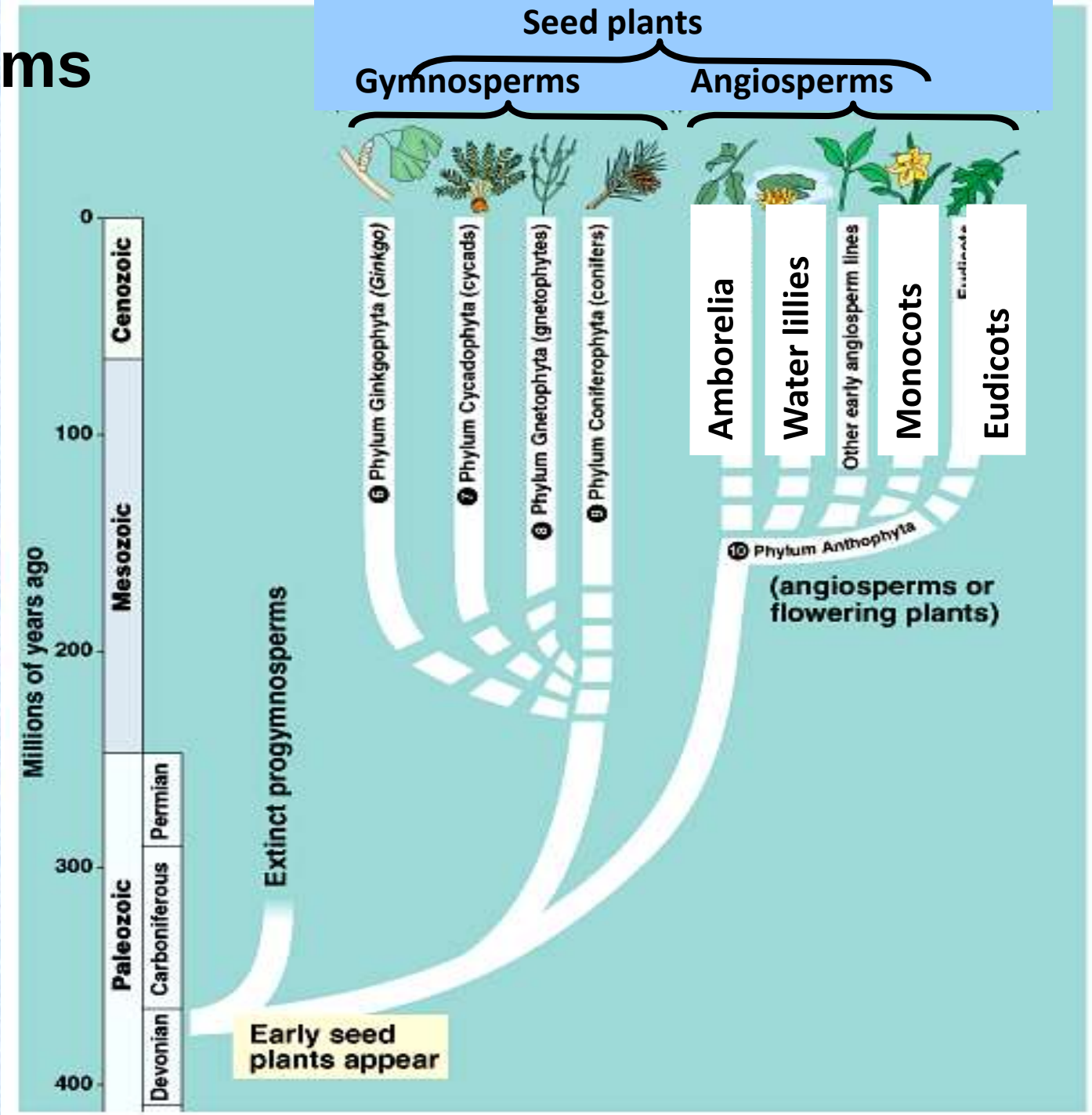
Adaptations for Life on Land



Vascular tissue (xylem and phloem)



Gymnosperms



Gymnosperm Diversity

Douglas fir

Sequoia

Common juniper

Wollemi pine

Bristlecone pine

European larch

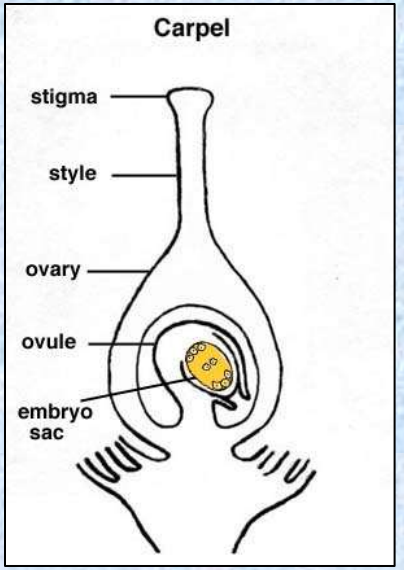
Gymnosperms – “naked seed” plants

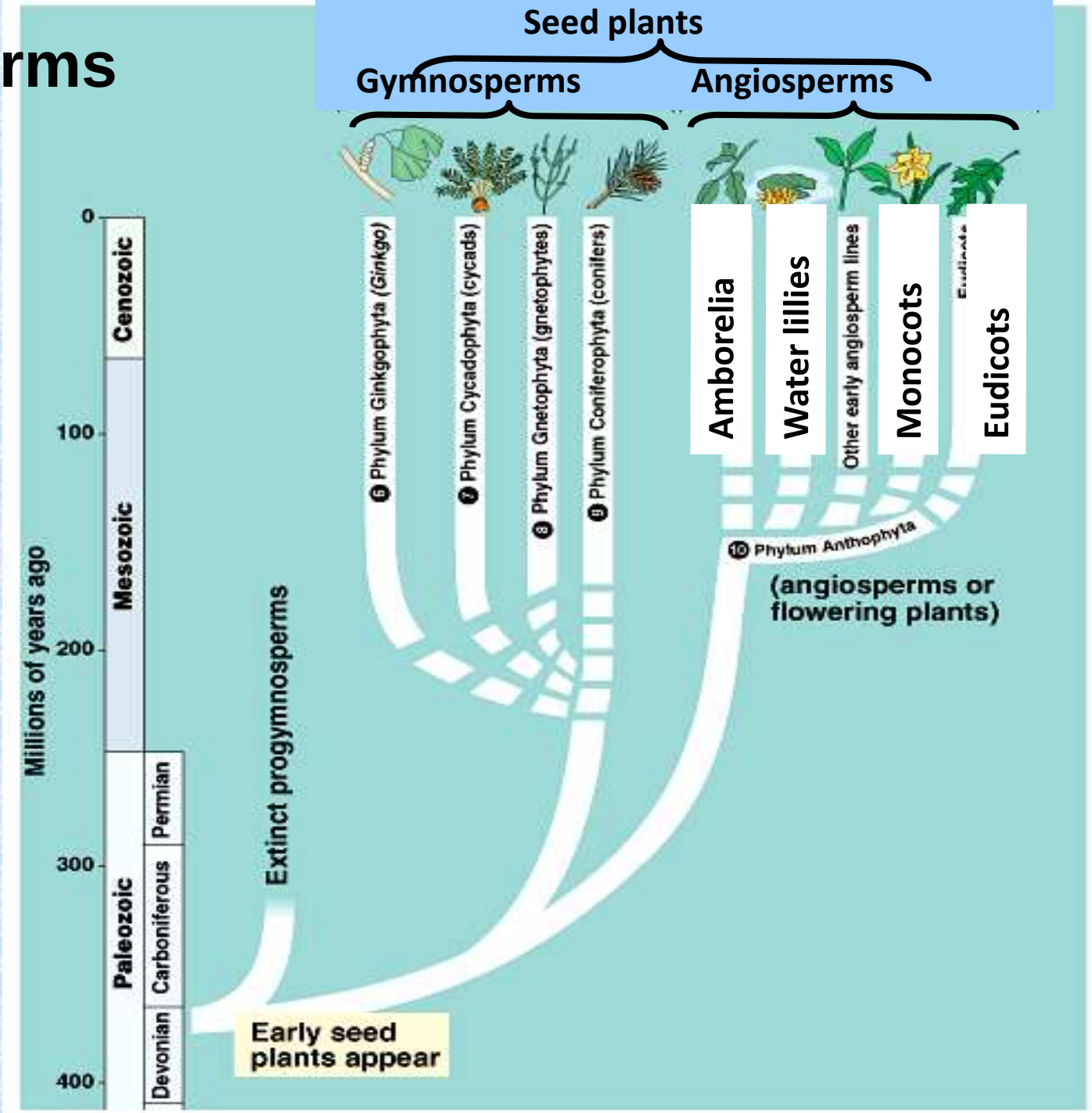
Have no flowers or fruit, seeds borne naked in cones

Gymnosperms were the dominant plants during the Age of Dinosaurs (Mesozoic 245-65 mya).

Angiosperms - Anthophyta

Angiosperms

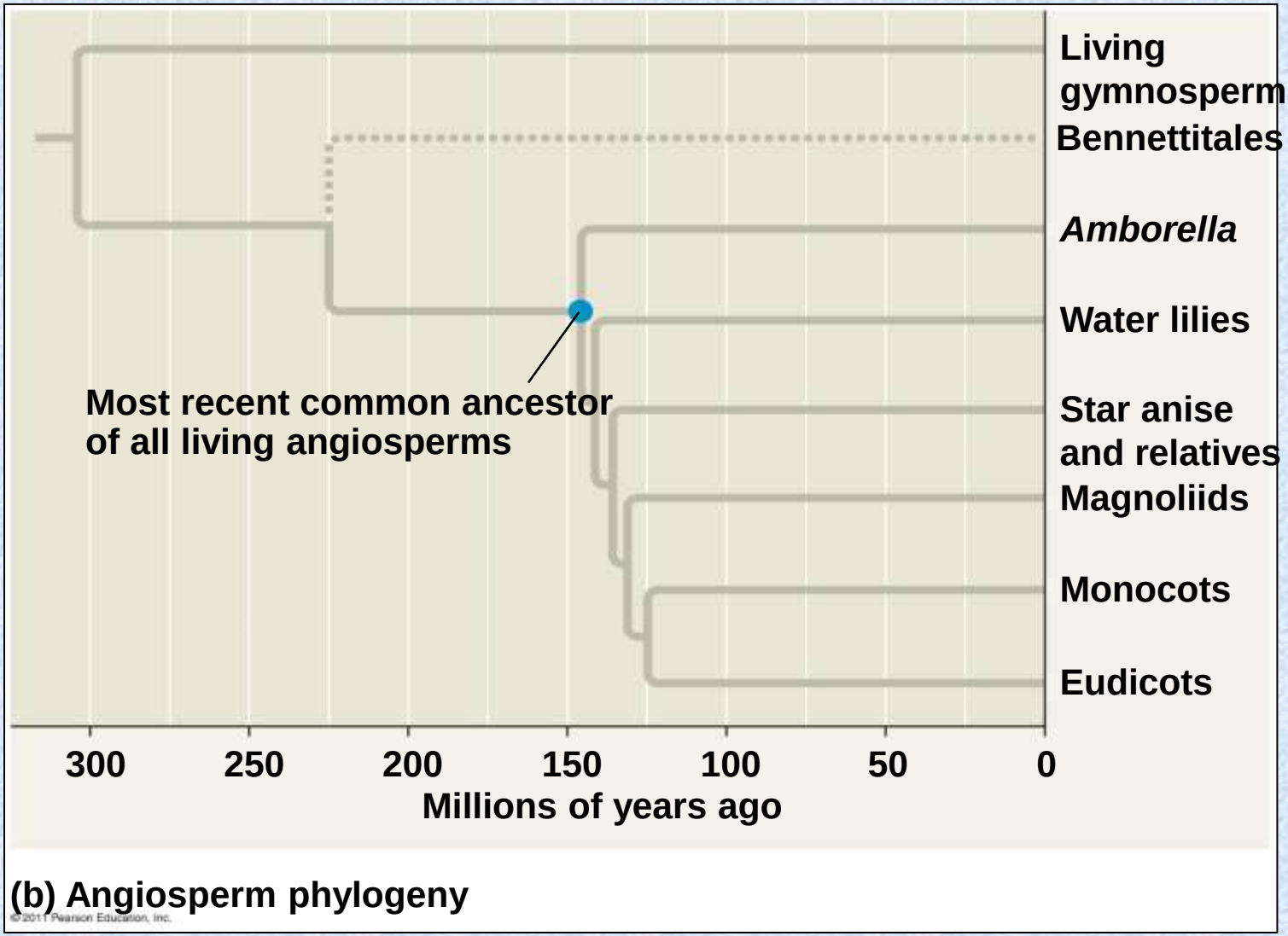




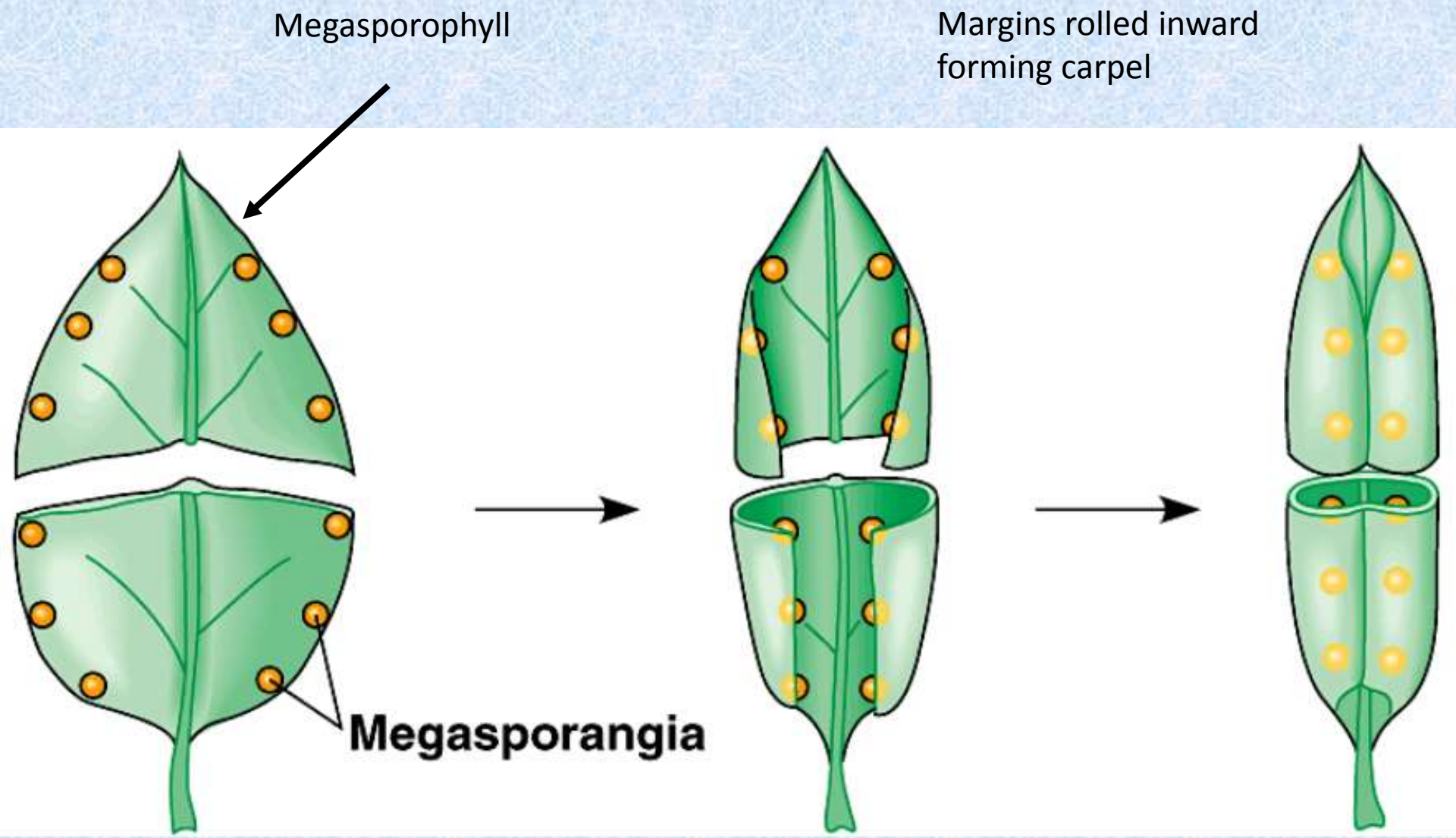
Angiosperms

- Reproductive organs within a flower
- Gametophytes greatly reduced
- Ovules embedded within sporophyte tissue (ovary)
- Seeds within a fruit (ovary wall)
- Most pollinated by insects and birds

The key to the success of the Angiosperms has been that they have evolved flowers and fruit.



Evolution of the Carpel



Origin of Angiosperms

Darwin's "Abominable Mystery"

- Long thought to be Cretaceous
- Probably older

Archaefructus

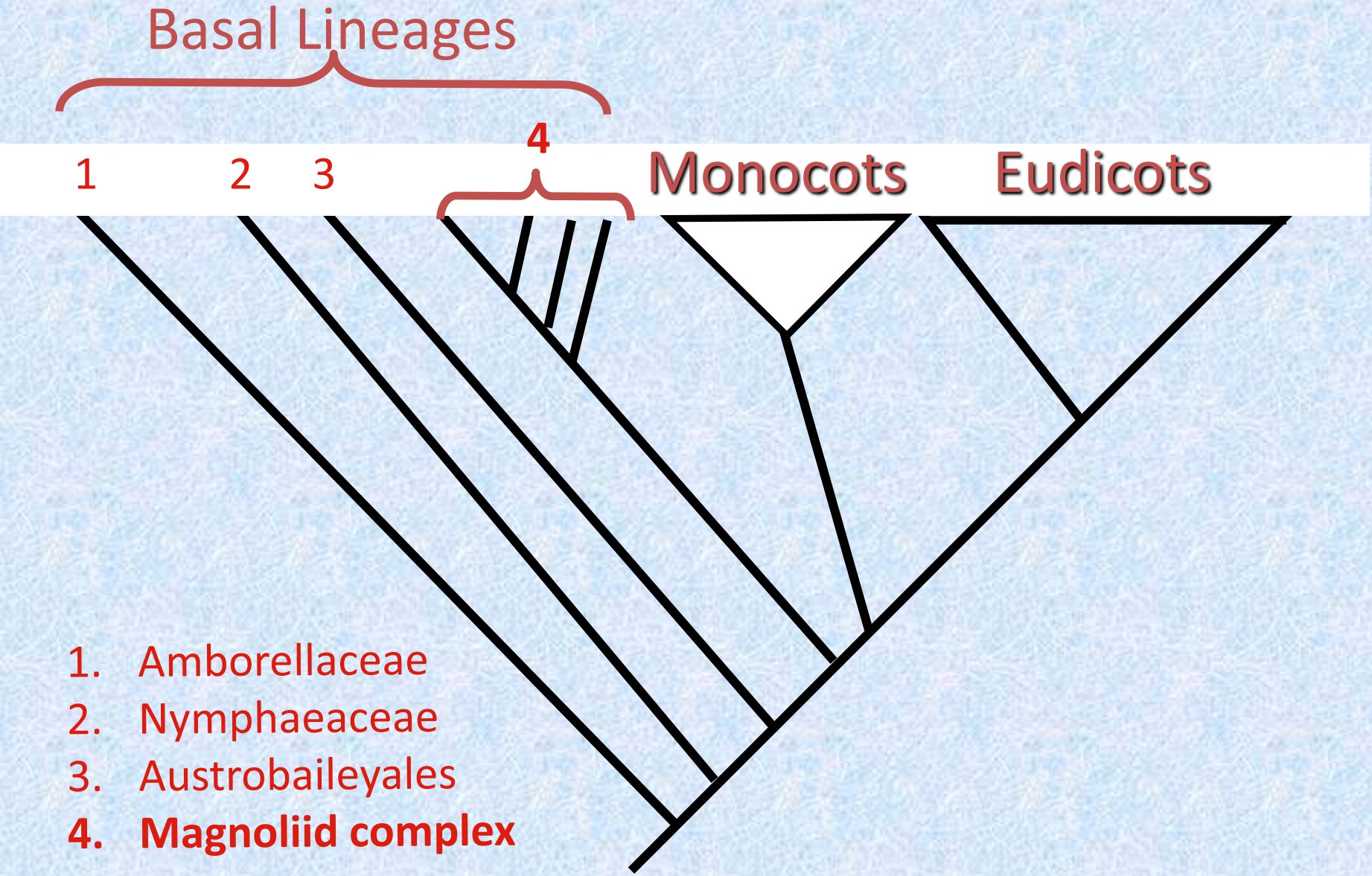
- About 125 MYA
- No sepals or petals, just stamens and carpels.
- Stamens thought to have attracted pollinators
- Share some traits with living angiosperms but lack others

Angiosperm Diversification

Angiosperm Diversity

- Angiosperms comprise more than 250,000 living species
- Previously, angiosperms were divided into two main groups
  - **Monocots** (one cotyledon)
  - **Dicots** (two cotyledons)
- DNA studies suggest that monocots form a clade, but dicots are polyphyletic

Modern angiosperm relationships



1. Amborellaceae
2. Nymphaeaceae
3. Austrobaileyales
4. **Magnoliid complex**

Angiosperm Diversity

- Non Monocot Paleoherbs
  - Nymphales (water lilies), Aristolociales (pipe vine)
- Magnoliids
  - Magnoliales (Magnolia) Laurales (Red Bay)
- Monocotyledons (monocots)
  - Grasses, lilies, irises, orchids, cattails, palms
- Eudicotyledons (eudicots)
  - most familiar trees and shrubs (other than conifers and palms) and many herbs

- The clade **eudicot** (“true” dicots) includes most dicots
- The rest of the former dicots form several small lineages
- **Basal angiosperms** are less derived and include the flowering plants belonging to the oldest lineages
- **Magnoliids** share some traits with basal angiosperms but evolved later

Basal Angiosperms

- Three small lineages constitute the basal angiosperms
- These include *Amborella trichopoda*, water lilies, and star anise

Basal Angiosperms

Water lily

Star anise

Amborella trichopoda

Basal angiosperms

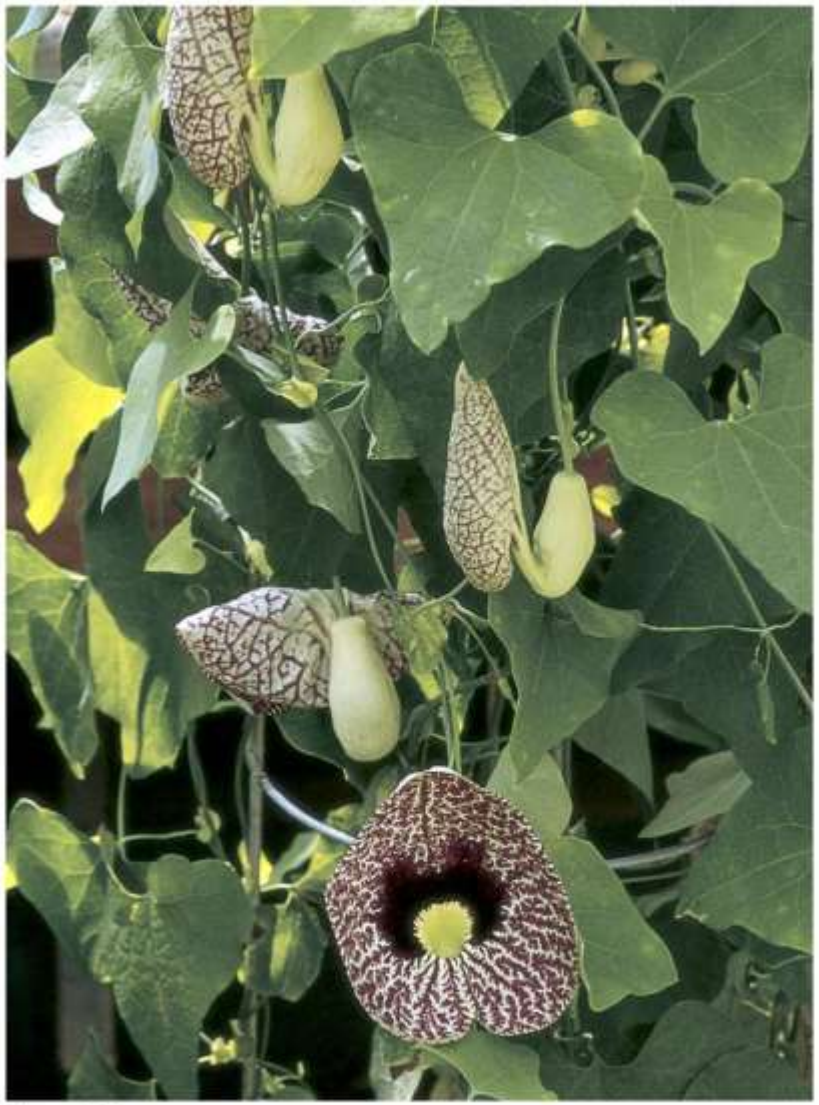


Figure 20-4
Biology of Plants, Seventh Edition

Aristolochia gigantea-
Dutchman's pipe

Magnoliids

- Magnoliids include magnolias, laurels, and black pepper plants
- Magnoliids are more closely related to monocots and eudicots than basal angiosperms

Magnoliids: Magnoliaceae – *Magnolia grandiflora*

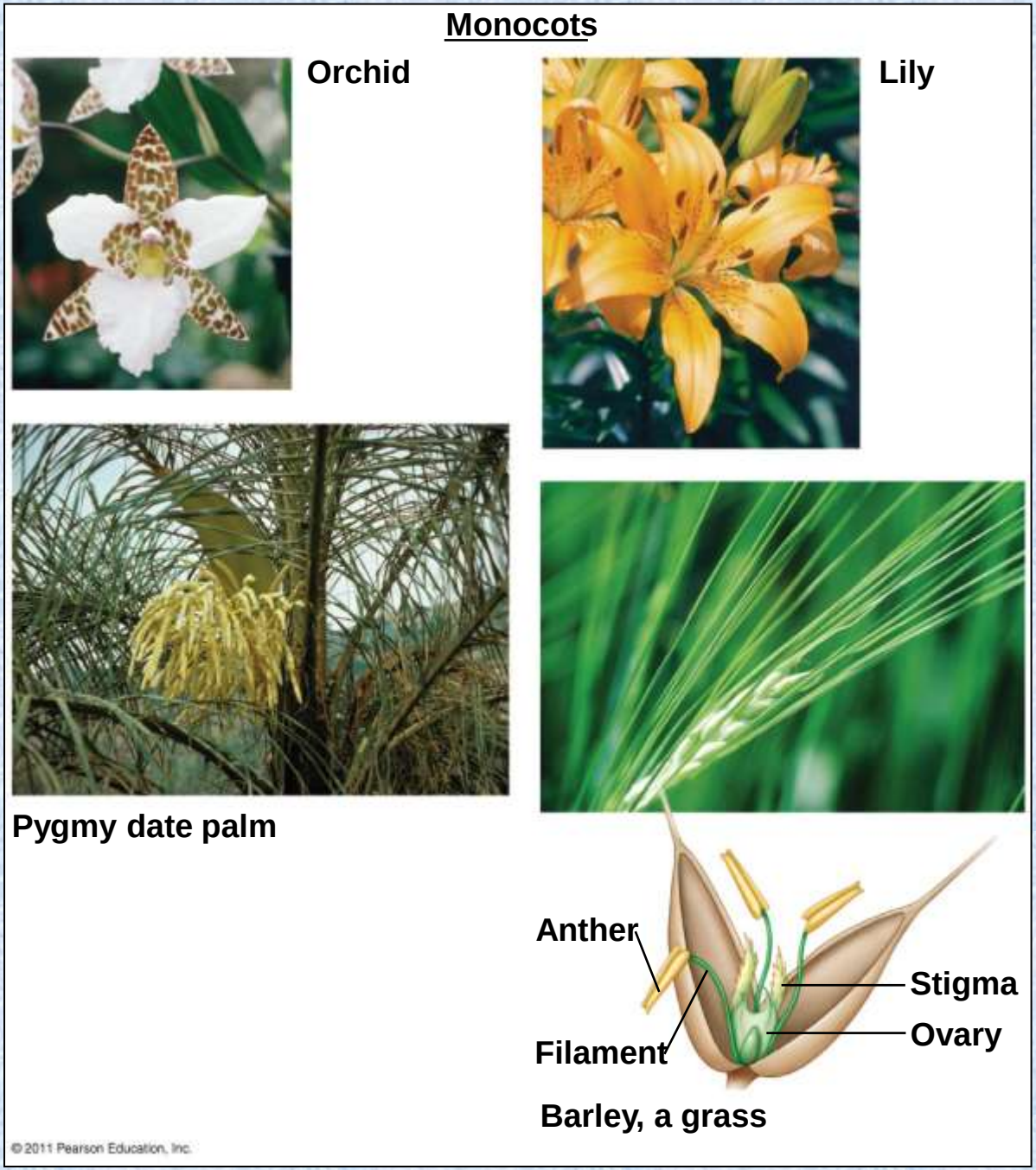
Monocots

More than one-quarter of angiosperm species are monocots

Poaceae – Grasses

Orchidaceae - Orchids

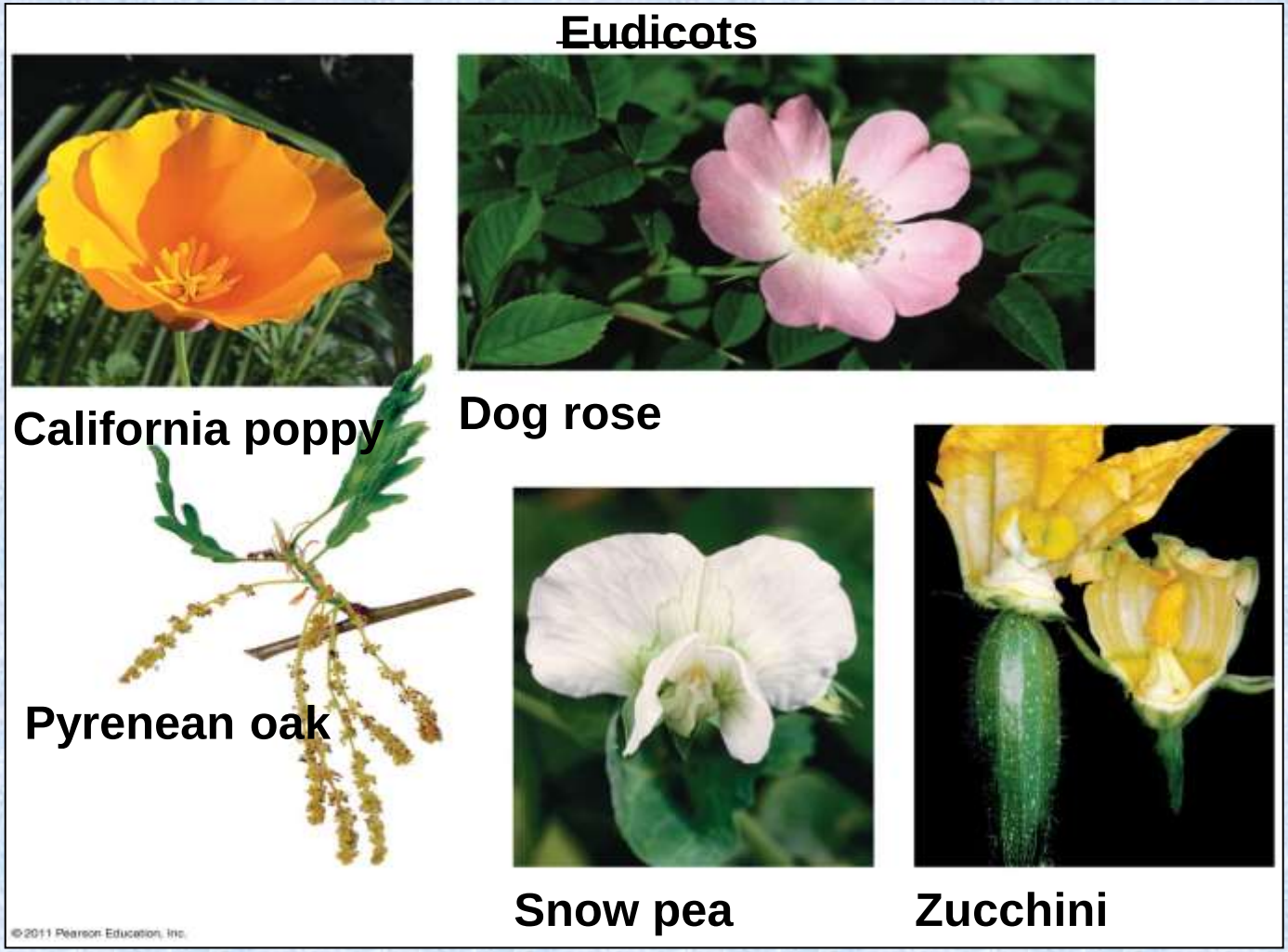
Arecaceae - Palms



Eudicots

More than two-thirds of angiosperm species are eudicots

Fabaceae – Beans
Asteraceae - Sunflowers
Papaveraceae – Poppies
Cucurbitaceae – Squash
Fagaceae – Oaks
Rosaceae - Roses



Trends of Specialization in Flowering Plants

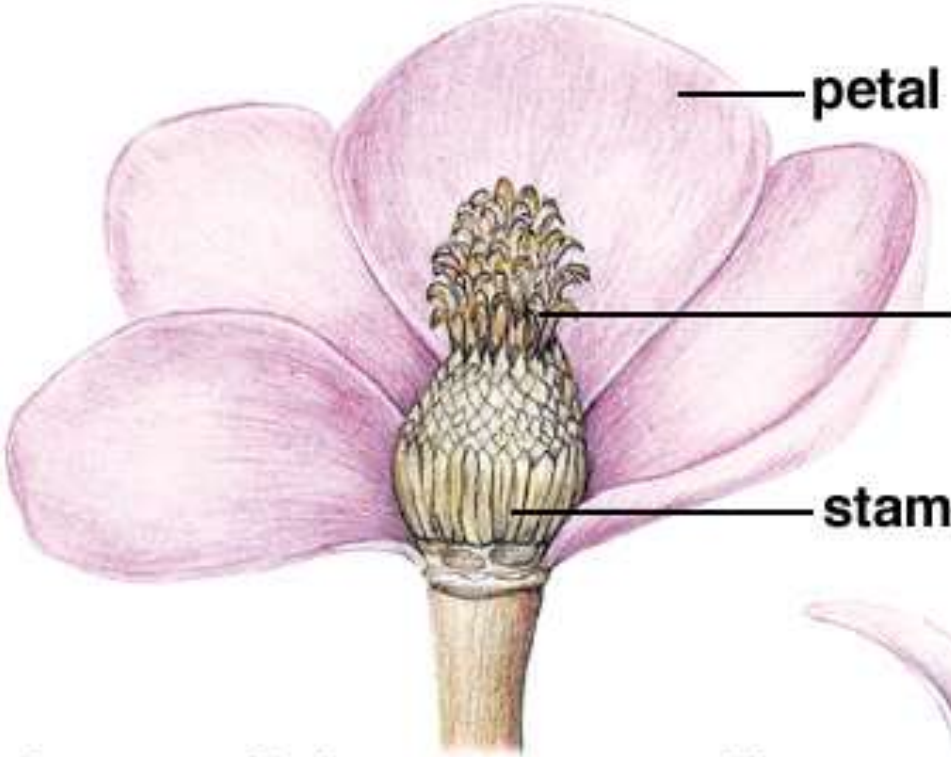
Features of a Primitive Flowering Plant

1. Simple leaves
2. Flowers with numerous spirally arranged parts
3. Flowers radially symmetrical and have both stamens and pistils

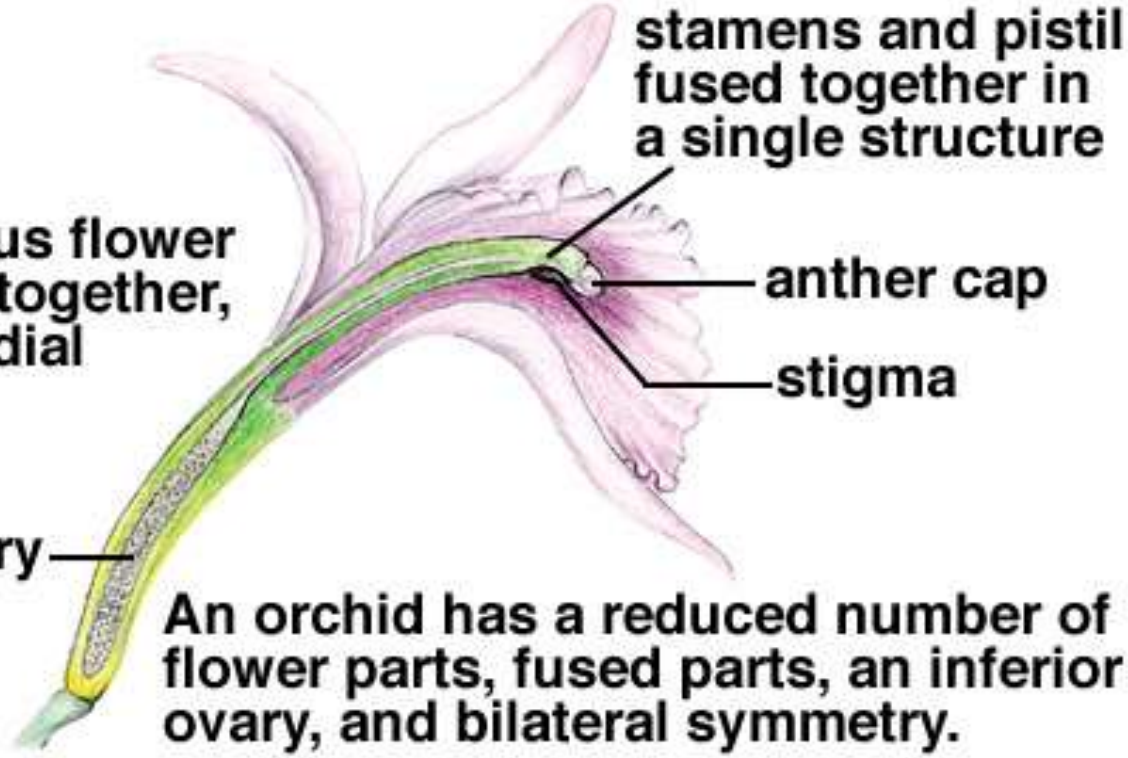
Specializations and Modifications of Flowers

1. Reduction in number of flower parts
2. Fused flower parts (compound pistil)
3. Monoecious - both male and female imperfect flowers occur on the same plant such as members of the pumpkin family (squashes and watermelons)
4. Dioecious - male and female imperfect flowers occur on different plants such as willows.

Primitive and Advanced Flowers

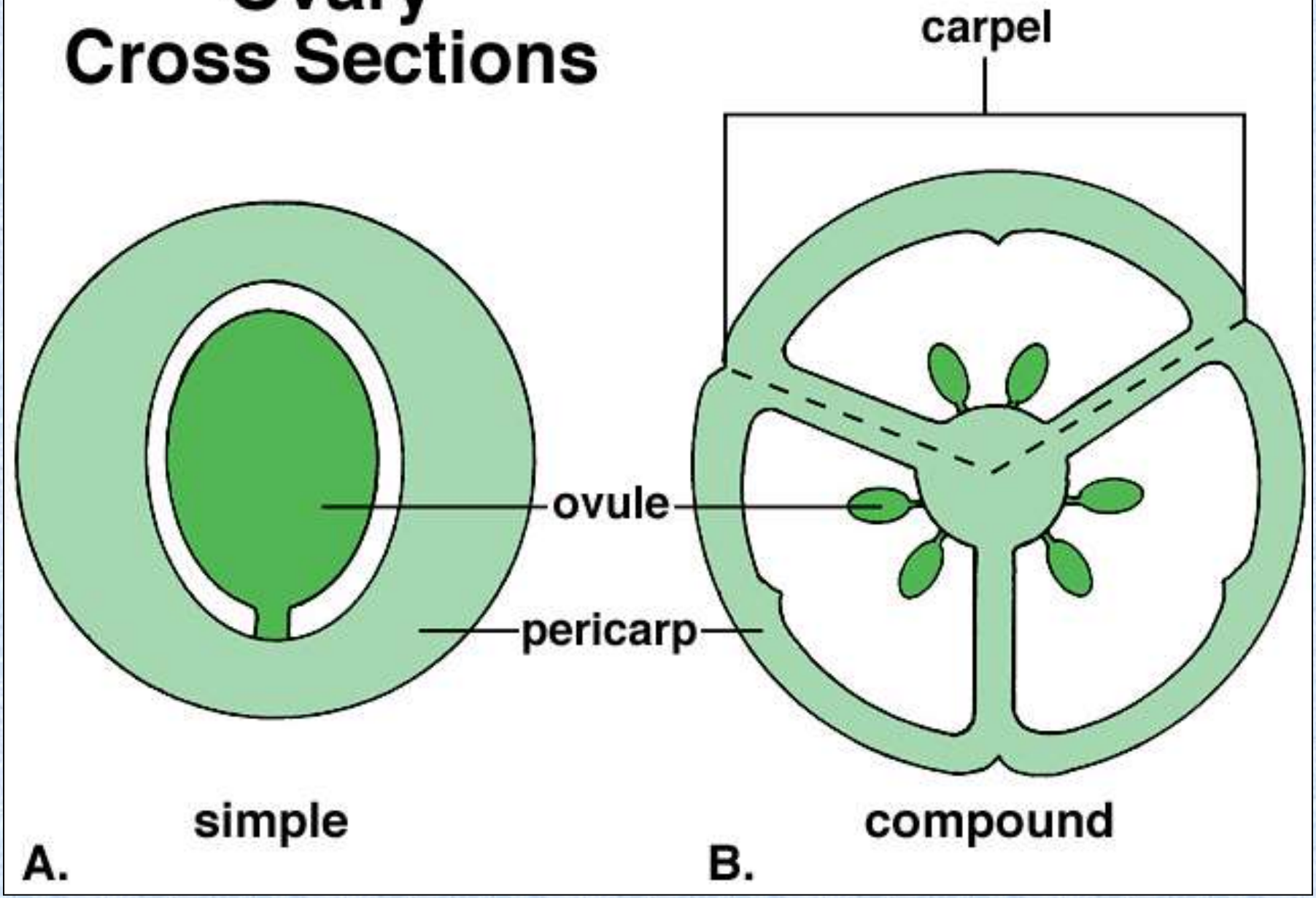


A magnolia has numerous flower parts that are not fused together, superior ovaries, and radial symmetry.

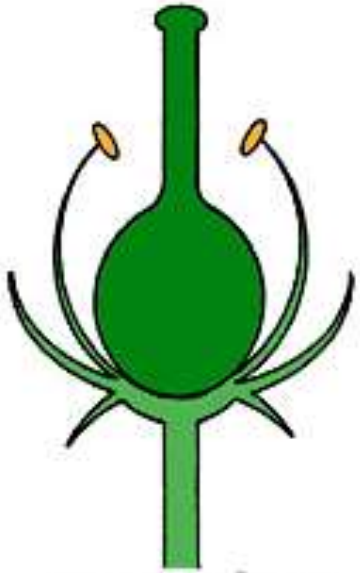


An orchid has a reduced number of flower parts, fused parts, an inferior ovary, and bilateral symmetry.

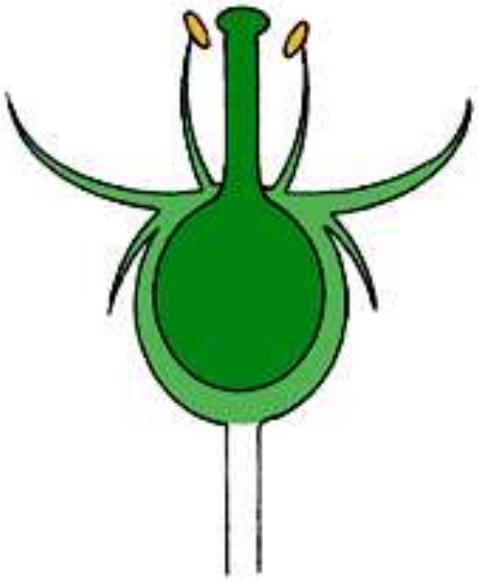
Ovary Cross Sections



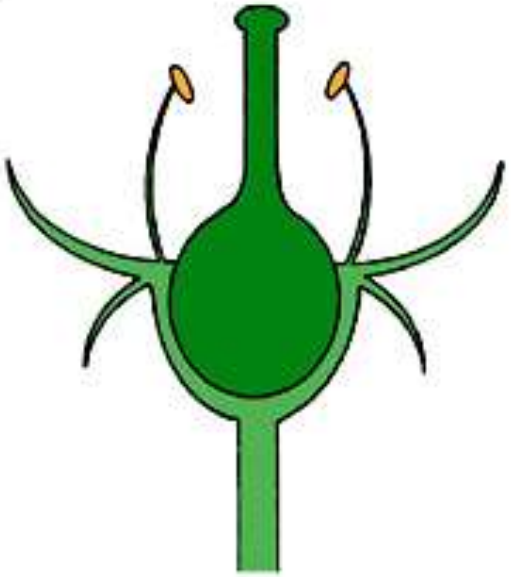
Ovary Positions



superior
(parts hypogynous)



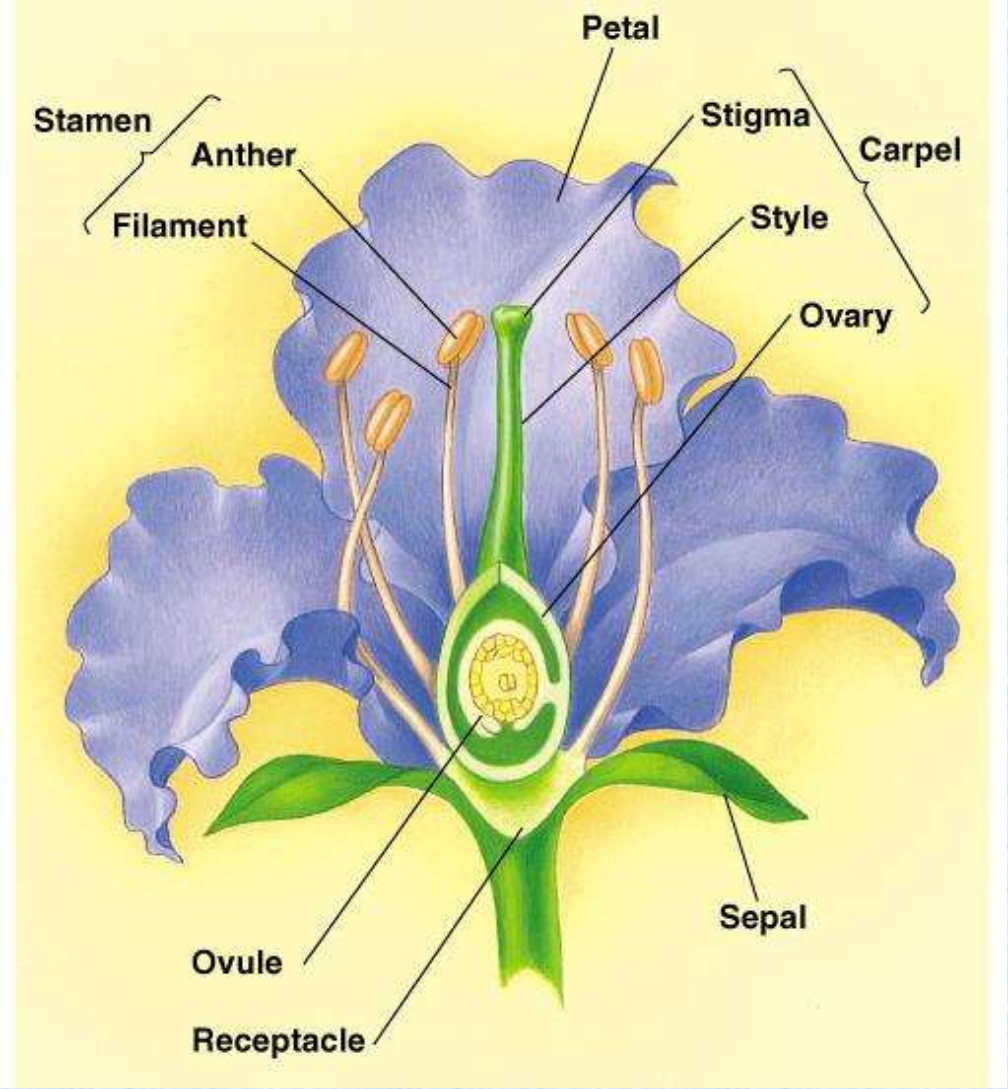
inferior
(parts epigynous)



half-inferior
(parts perigynous)

Reproductive Strategies

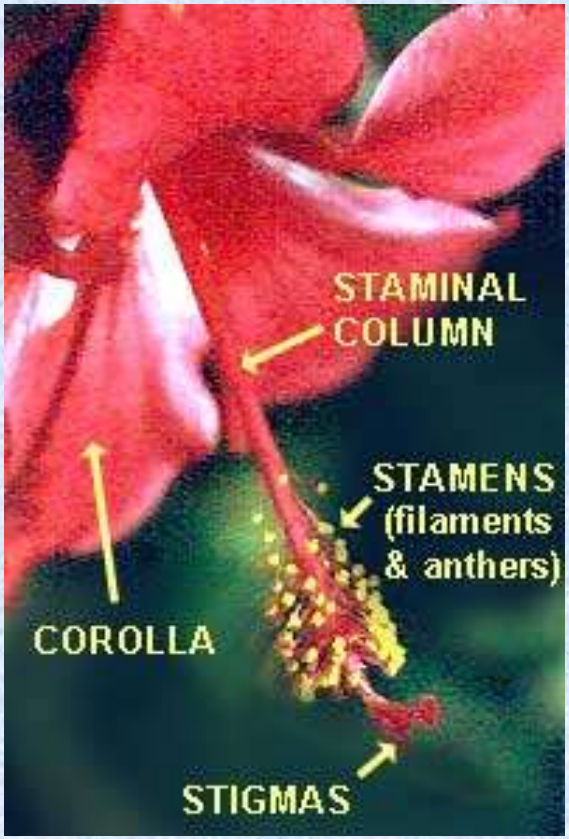
- A flower is a specialized shoot with four circles of modified leaves: sepals, petals, stamens, and carpals.
- Whorls can be absent in some groups of plants
  - -Staminate flowers
  - -Pistillate flowers.
- Part of breeding system



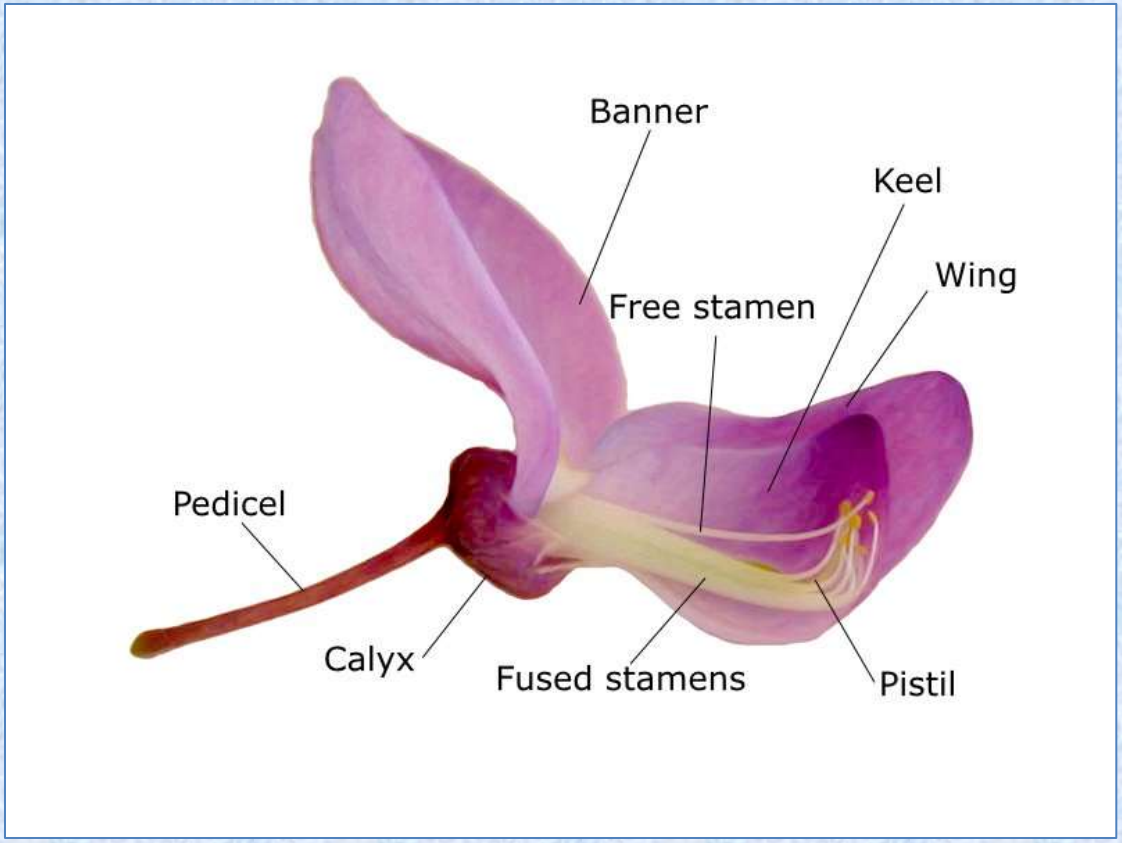
Malus – crab apple – typical flower structure (inferior ovary)

Helleborus – five separate carpels

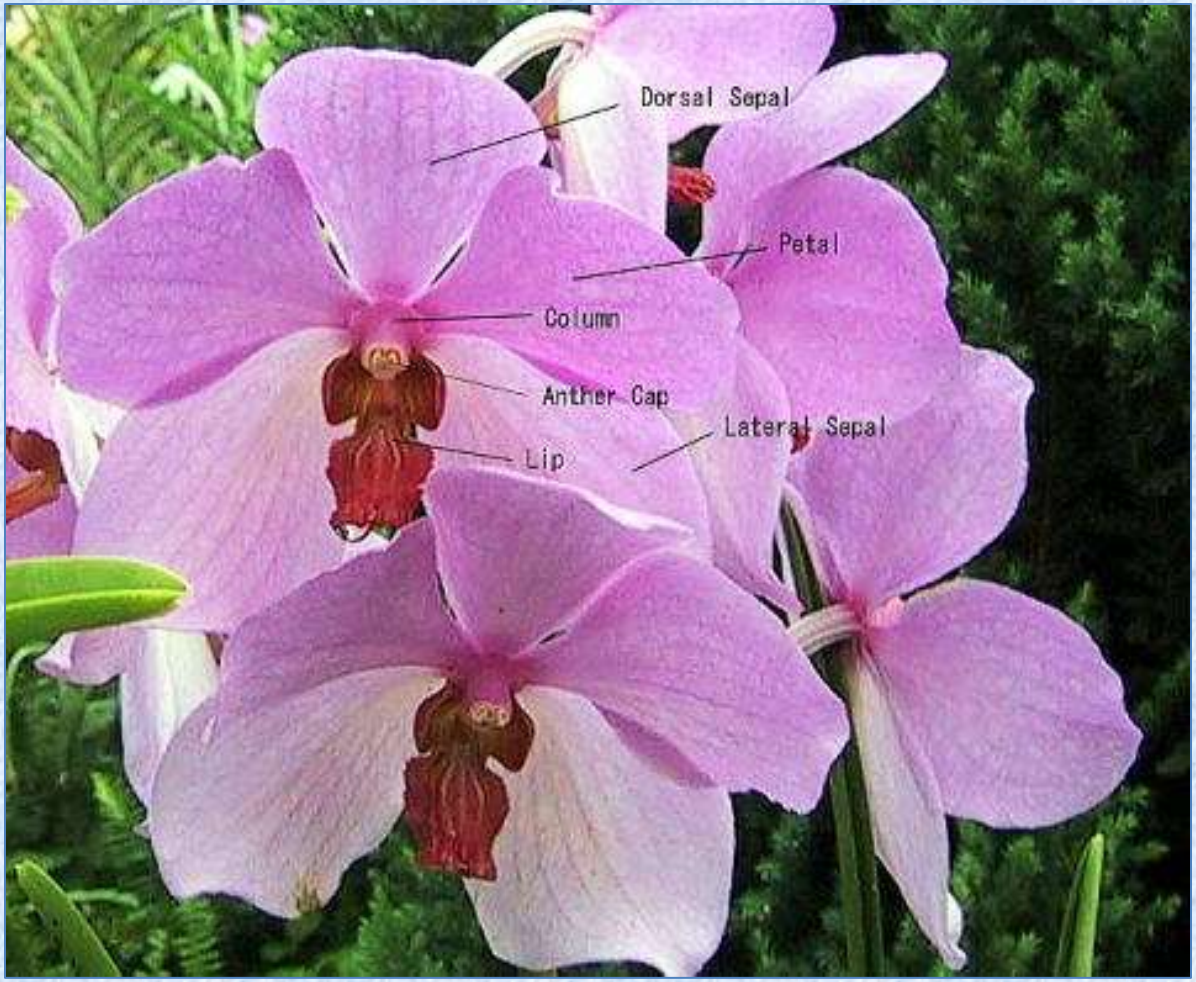
Hibiscus – Mallow Family
Filaments fused, monadelphous



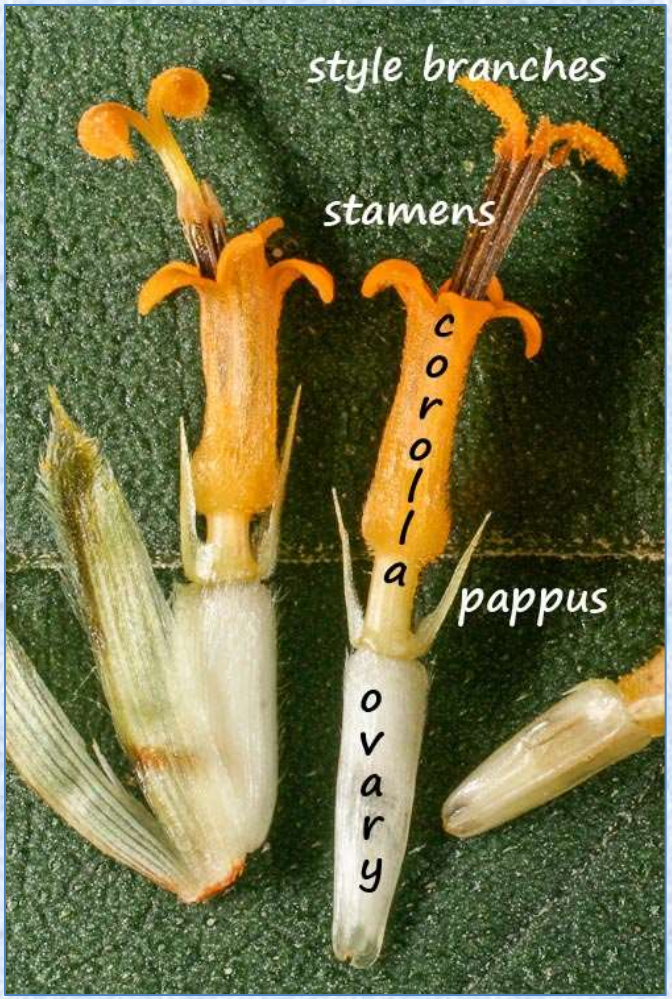
Flower Structure – Wisteria, a dicot, legume family
Papilionoid - wings



Orchid Flowers – zygomorphic, stamens fused in column



Asteraceae (Compositae) – Sunflower Family
Flowers in a Head



Poaceae – Grass Family, flowers reduced, wind pollinated

Oat flower – close up

Oats – Whole plant

Plant Sexuality

- **Monoecious** - separate flowers for male and female both on one plant - corn
- **Dioecious** - male and female plants are separate - separate sexes - gingko
- **Perfect flower** - flower has stamens and carpels – bisexual flowers
- **Imperfect flower** - lacks either stamens or carpels - will be staminate or carpellate (pistillate)
- **Complete** - has sepals, petals, stamens and carpels
- **Incomplete** - lacking one of the 4 main flower parts

Jatropha – monoecious but insect pollinated
Female left, male right

Dioecious – Holly
Separate male and female plants

Female flower

Male flower

Berries on female

Basic Inflorescence Types

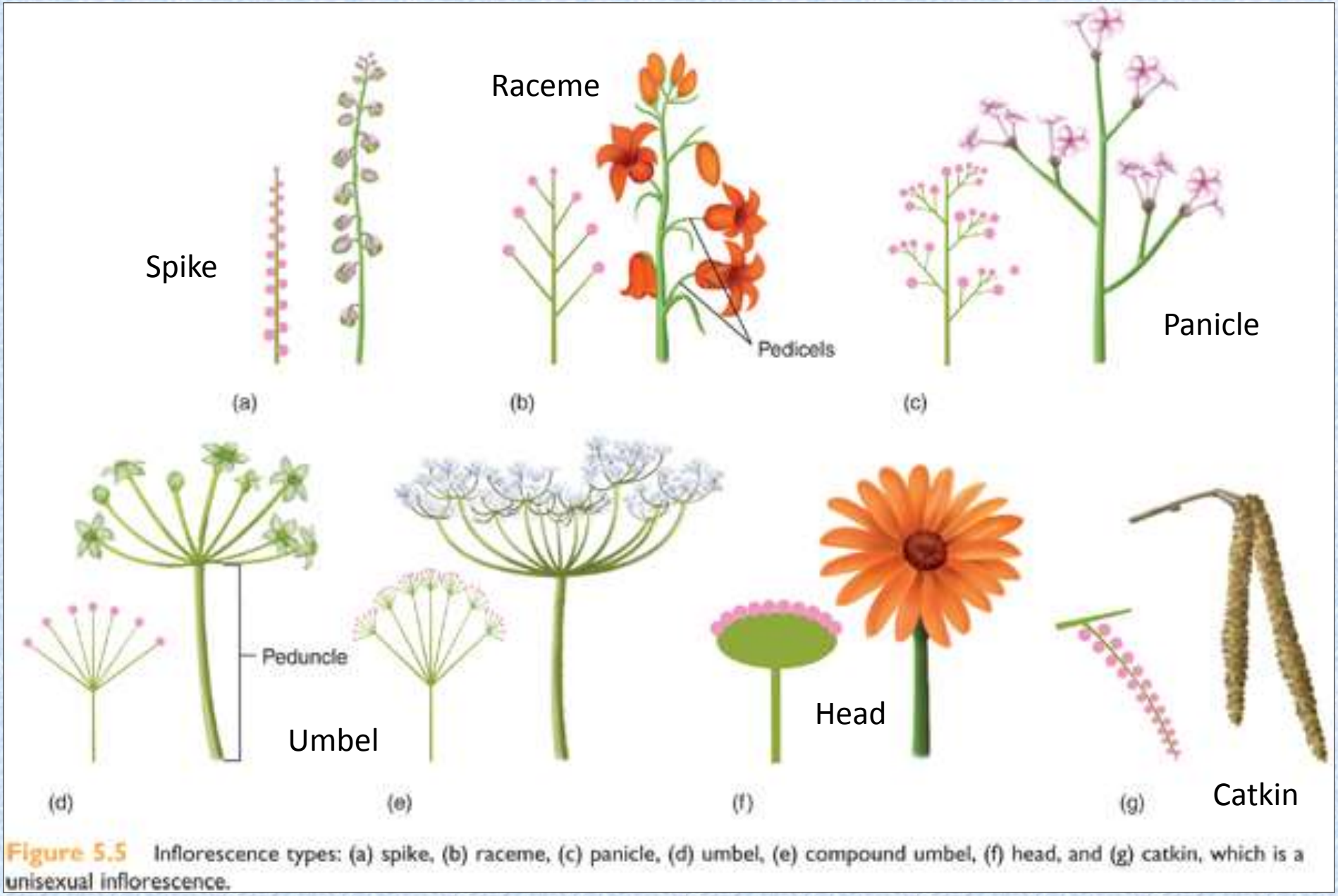


Figure 5.5 Inflorescence types: (a) spike, (b) raceme, (c) panicle, (d) umbel, (e) compound umbel, (f) head, and (g) catkin, which is a unisexual inflorescence.

- **Pollination -** The transfer of pollen from an anther to the stigma of a carpel
  - Self-pollination occurs if the pollen is from the same plant.
  - Cross-pollination occurs if the pollen is from a different plant of the same species.
- Agents of pollination
  - -Wind
  - -Water
  - -Insects
  - -Birds
  - -Bats

Wind Pollination

Gymnosperms rely on wind to move pollen from male to female cones

The ovule exudes sap to trap pollen

Catkin - an elongated inflorescence of unisexual flowers on a woody plant, willow, oak, walnut, birch

Alder catkin

Box elder – wind pollinated – female left, male right

Origins of Insect Pollination?

Around 150 m.y.a. some insects fed on both protein-rich pollen of male cones and sugar-rich secretions of female cones…

May have led to the origin of Angiosperms and animal-mediated pollination

Flowers and pollination

- A major advantage of flowers is that they have allowed angiosperms to use other organisms to move their pollen about.

- Bees, bats, birds and others all transport pollen. They are attracted to flowers by the nectar and pollen [bribes] provided by the plant and when they visit multiple flowers they move pollen from one to the next

Bee Pollination

Bee Hives and Orchard Crops

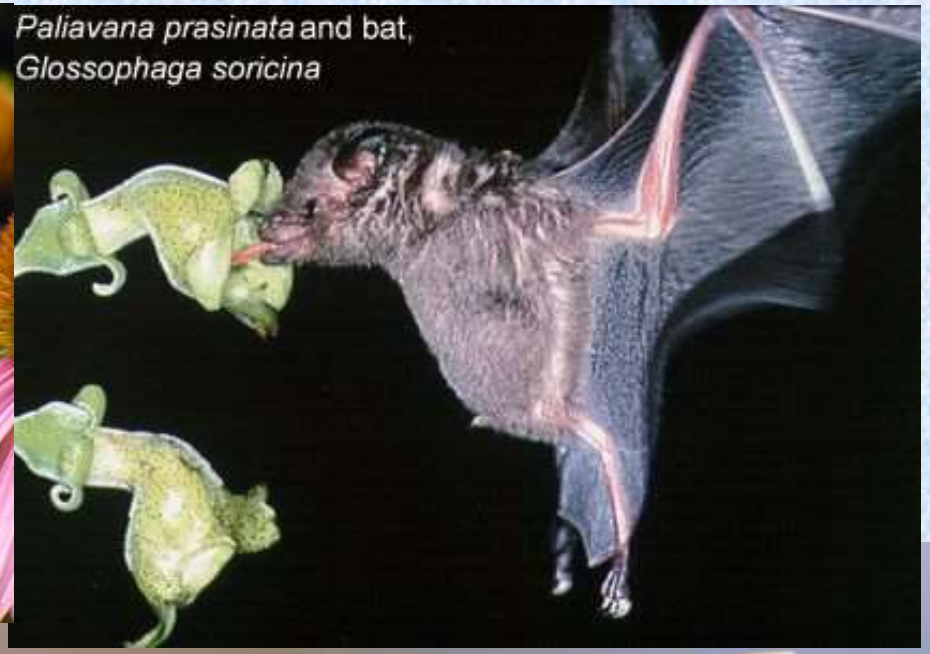
Pollination Vectors

1. Bees
- Nectar of flower their chief source of nourishment
- Prefer blue and yellow flowers
- Honey guides - lines on flower petals that lead bees to the nectar
- Ultraviolet patterns on flowers visible to bees

2. Beetles
- Flowers generally white or dull in color
- Strong yeasty, spicy, or fruity odors

3. Flies
    - Flowers dull red or brown
    - Foul odors (like rotting meat)
    - Flowers called "carrion flowers"
4. Moths and Butterflies
    - White or yellow in color
    - Sweet fragrances
5. Birds
    - Flowers bright red or yellow and large inflorescences
    - Produce copious quantities of nectar in long floral tubes
6. Bats
    - Generally tropical flowers that open at night
    - Large flowers or ball-like inflorescences

Animals are attracted to flowers for a reward



Wild Native bees and Bumblebees

Pollinating beebalm – Monarda sp.

Petals sometimes exploit the sensory capabilities of pollinators

Bees can see Ultraviolet patterns on flowers

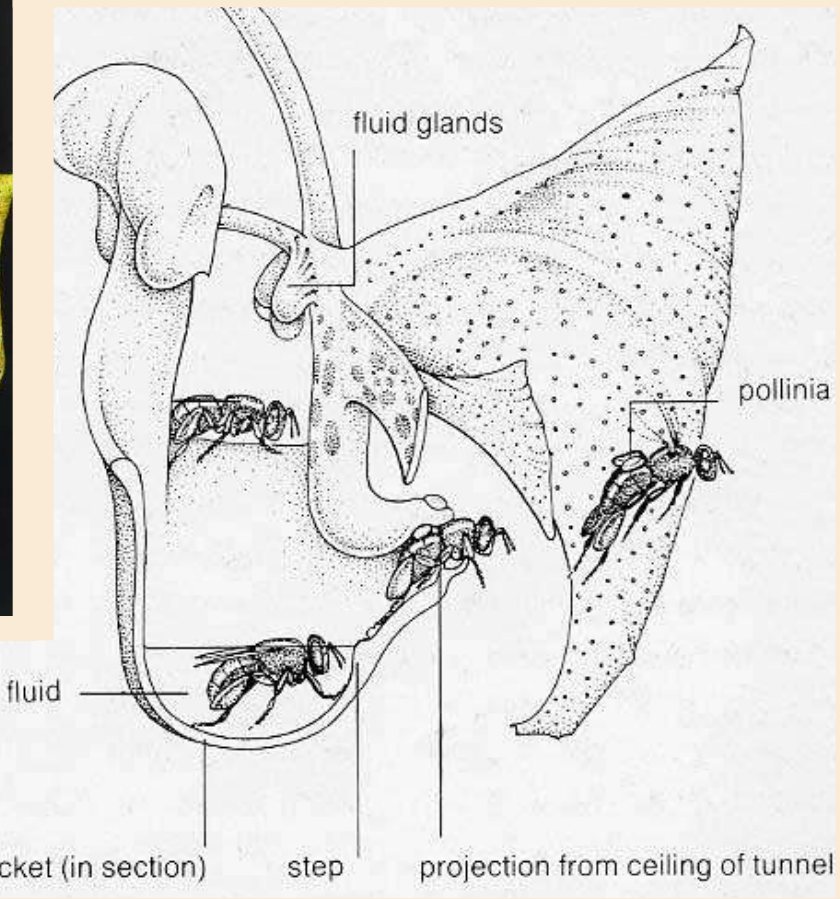
Nectar Guides – signpost to nectar reward

Angiosperms have formed many partnerships with many kinds of animals to move their pollen

Pollinator-plant relationships are partly responsible for the diversity of flowers.

Passiflora species – adaptations for many pollinators

Some flowers trick their pollinators



Bucket Orchid – bee crawls in, falls into water, only one way out, picks up pollinia on way out

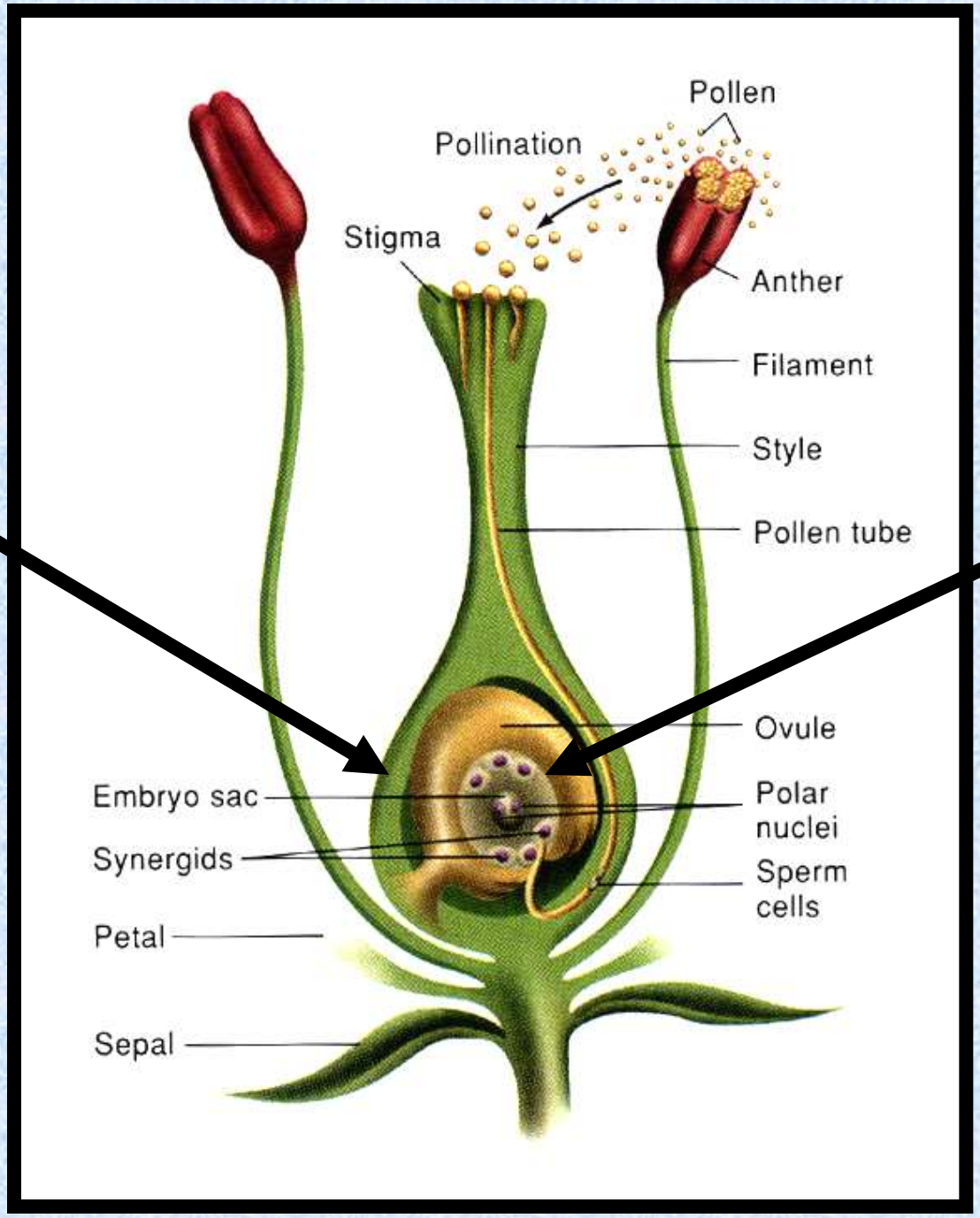
Some flowers trick their pollinators

Bee Orchids – resembles female bees, emits odors, male bee tries to mate with it, getting pollinia attached to head.

From ovary to fruit

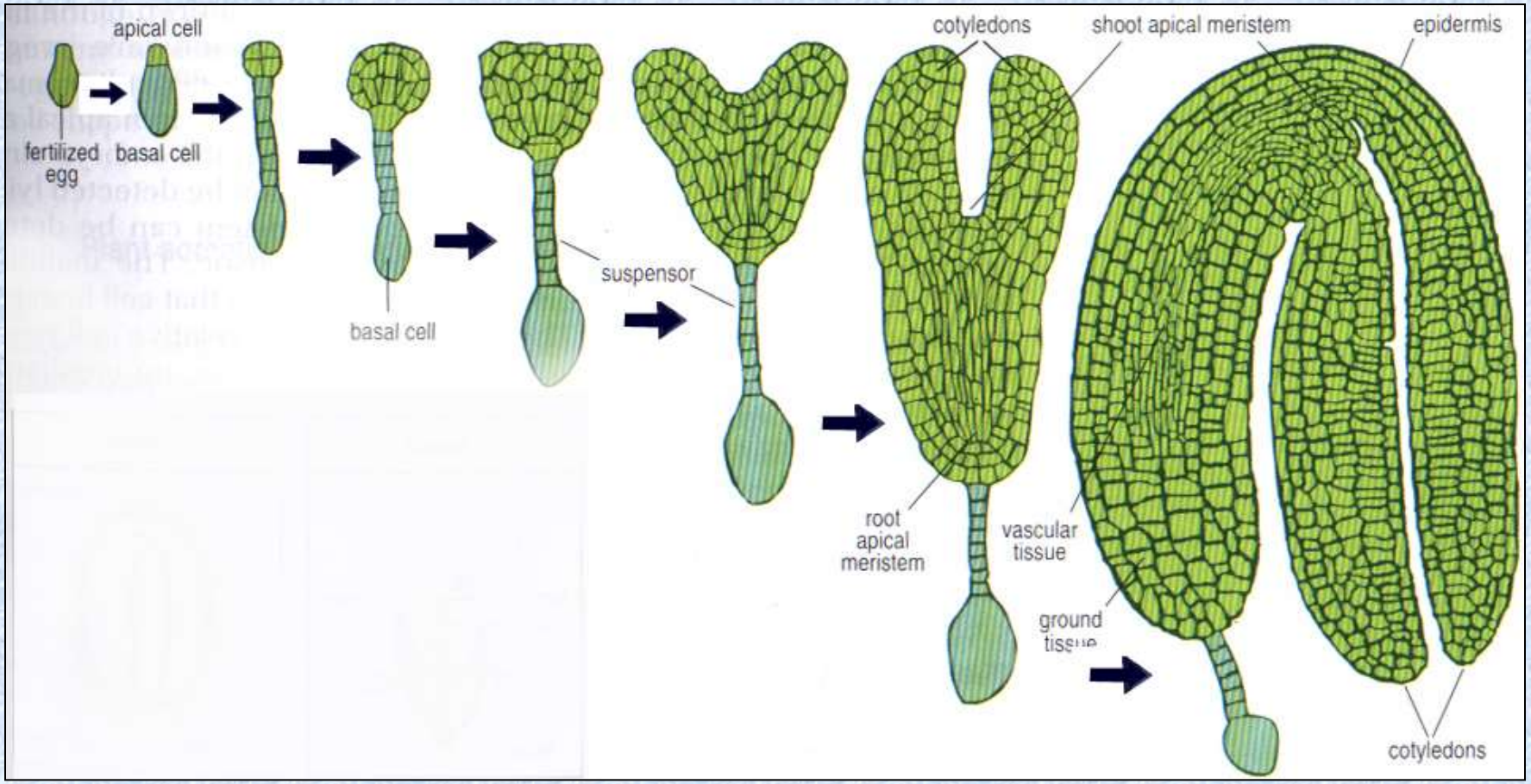
- The ovary of the flower contains the ovules.
- As fertilized ovules develop into seeds, the ovary wall develops into the fruit.
- In science, the term “fruit” refers to a mature ovary that contains seeds.

A fruit develops from the ovary wall after fertilization of the egg in the ovule

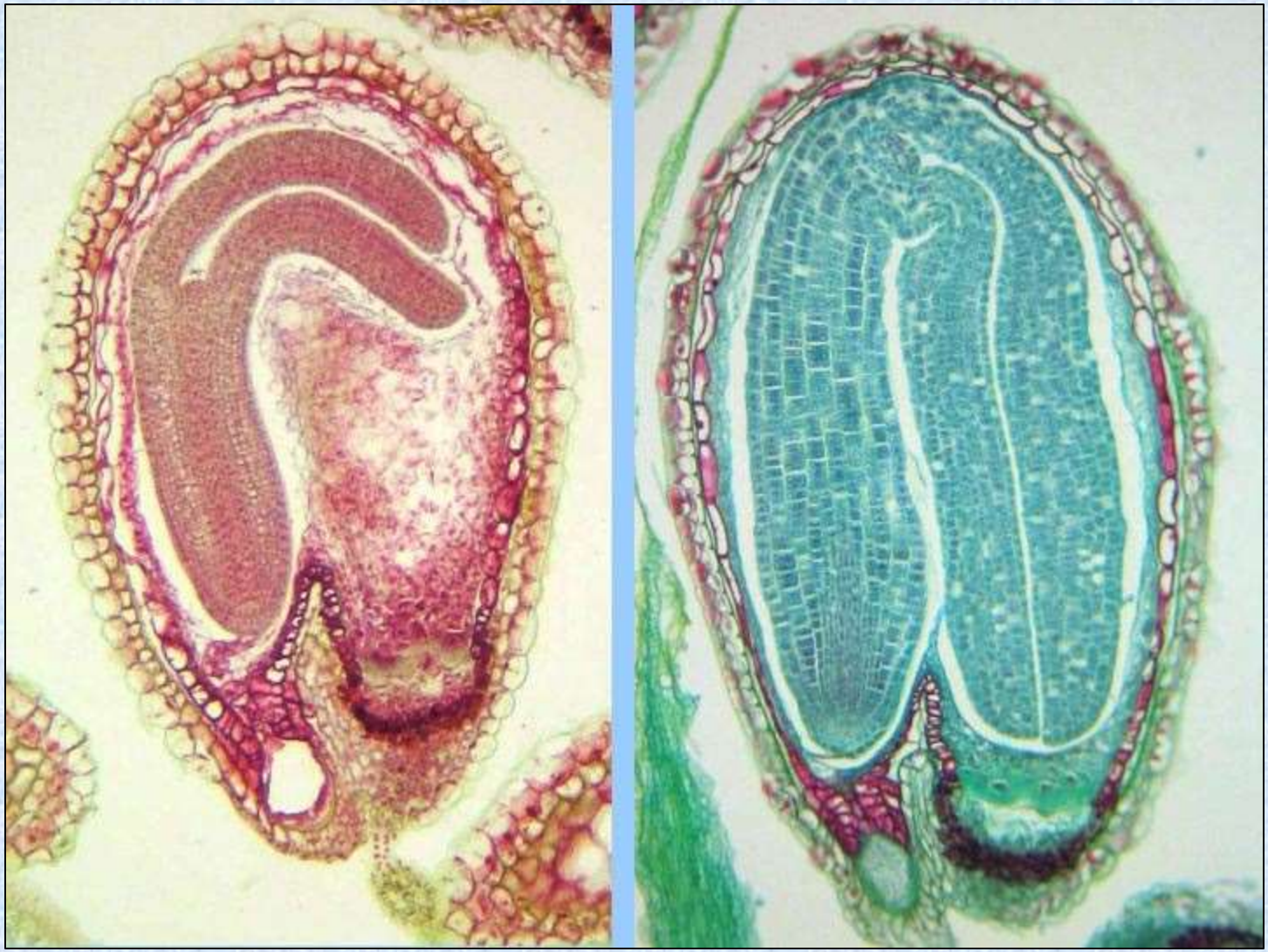


A seed develops from the ovule after fertilization of the egg in the ovule

Following Pollination and Fertilization Growth and Development of Embryo

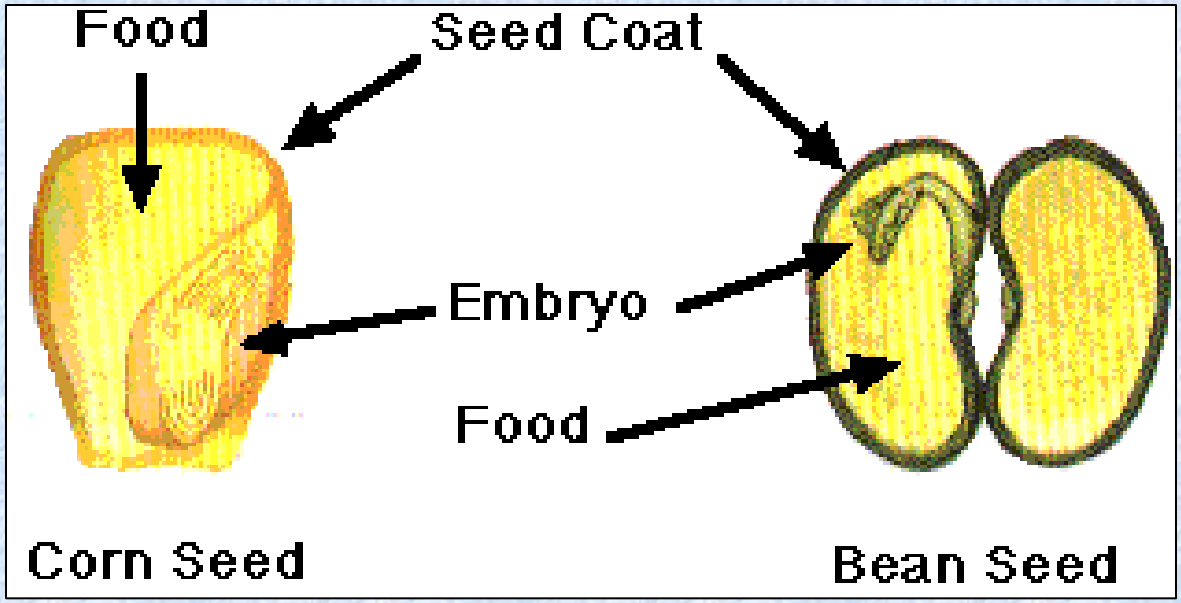


Maturation of Seed



Description of Seed

- Seed: A reproductive structure consisting of an embryo enclosed in its food supply and protected with a seed coat (integument).



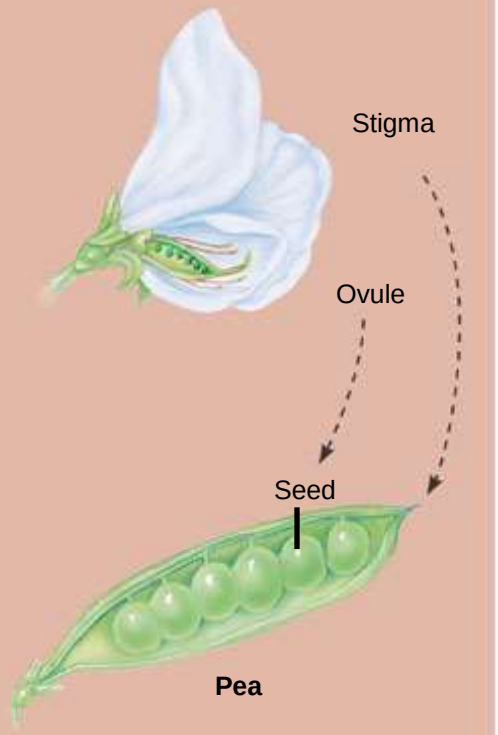
Fruits

- Just as flowers evolve for pollination, fruit evolves for dispersal
- Fruit is a mature ovary
- Types
  - Simple: one (or united) carpels
  - Aggregate: many separate carpels from one ovary (magnolia, raspberry, strawberry)
  - Multiple fruits: ovaries of >1 flower (pineapple)

Development of the seed and fruit

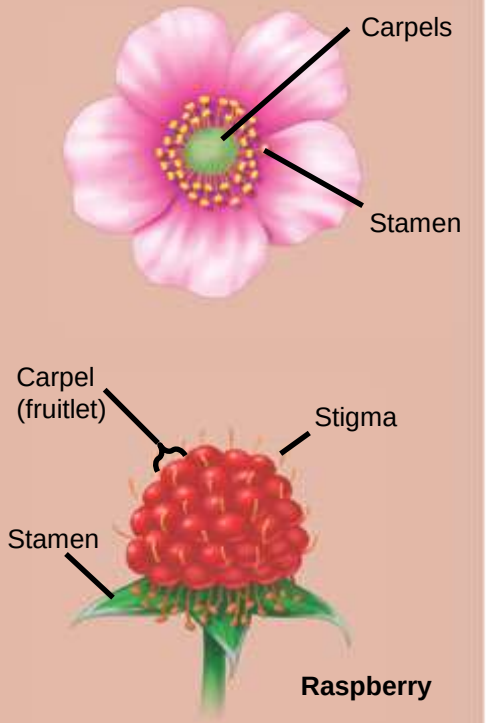
There are many kinds of fruits

Simple



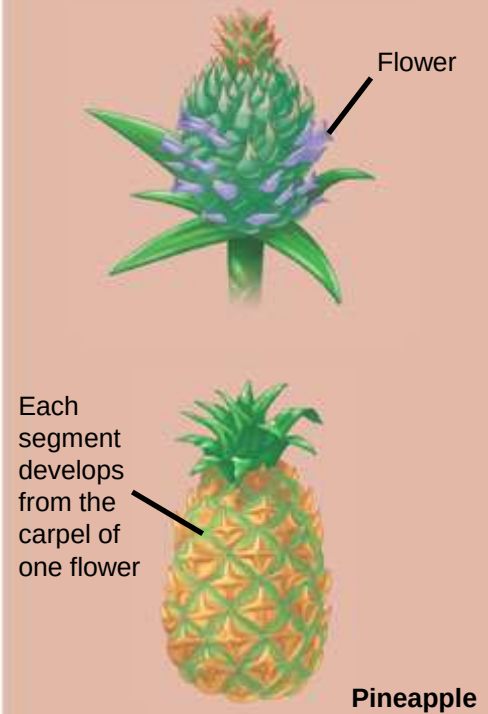
Simple fruit - single carpel of one flower

Aggregate



Aggregate fruit - many separate carpels of one flower

Multiple



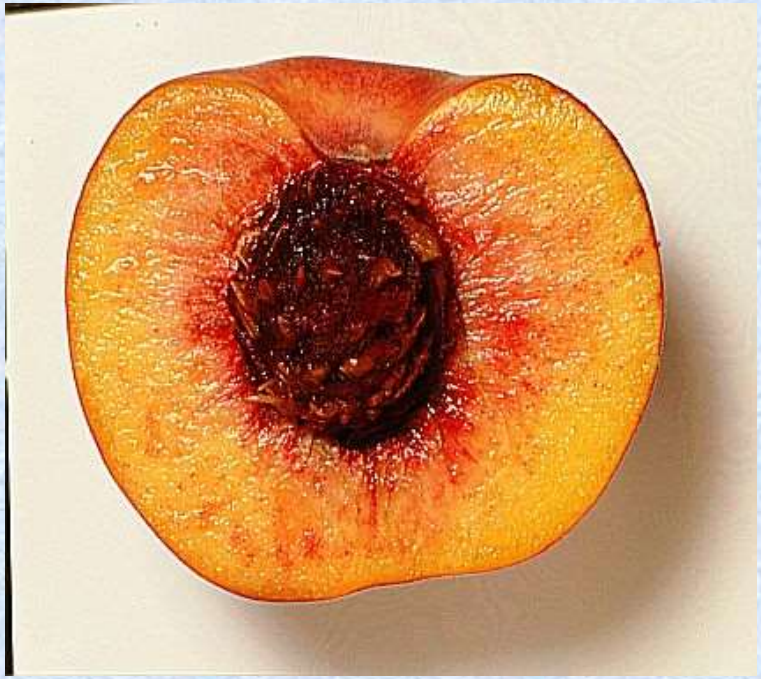
Multiple fruit - many carpels of many flowers

Types of Fleshy Fruits

- Berry - 1-many carpels, each often many-seeded, inner layer of wall fleshy (tomato, date, grape)
- Drupes- 1-many carpels with only 1 seed each, inner layer of fruit stony (peach, cherry, olive)
- Pomes- subfamily in Rosaceae- inferior ovary with large fleshy part from the base of the perianth- also an accessory fruit (apple, pear)

Fleshy Fruits

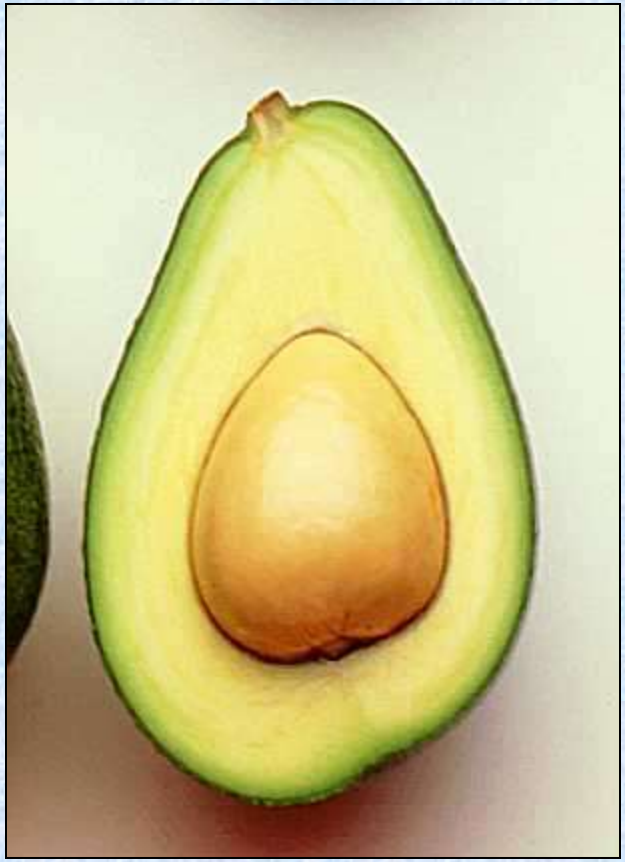
Berry



Drupe

Pome

Fleshy Fruits



Types of dry fruits

Legume
(Bean pod)

Capsule
(Poppy)

Achene
(Sunflower)

Silique
(Money Plant)

Follicle
(Columbine)

Nut
(Hazelnut)

Seed Dispersal

Angiosperms have a number of different mechanisms for seed dispersal.

Gymnosperms only had wind dispersal.

- Fleshy fruits ripen when seeds mature. This signals animals that fruit is edible.
- Barbs on fruits attach to fur of animals.
- Wings - wind dispersal mechanisms.

Wings

Seeds within berries

Barbs

How are these fruits dispersed?

Dandelion

Coconut

Maple

Cocklebur

Jewelweed

Seed dormancy

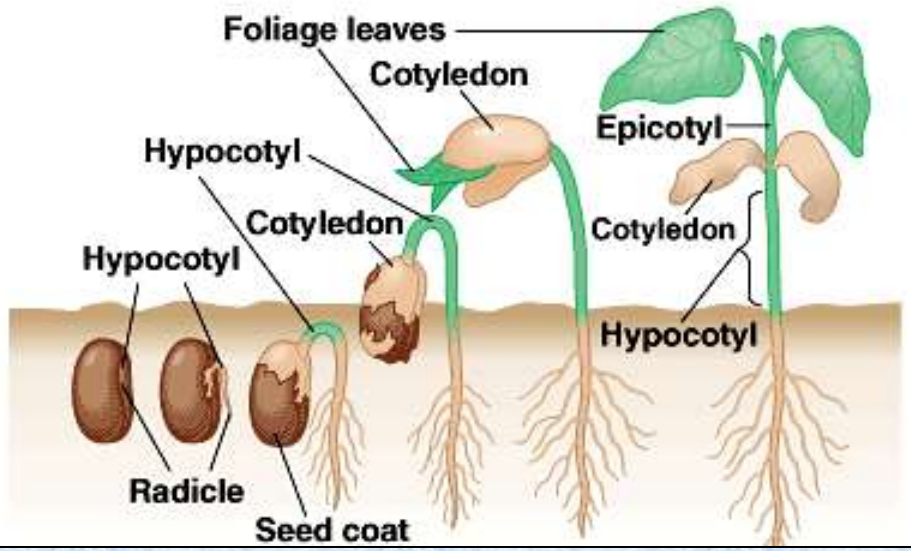
- Most seeds become dormant as they mature, *i.e.*, they will not germinate without the appropriate environmental stimuli
- The stimuli are species-specific, and include:

  -Drying, which avoids germination in the fruit

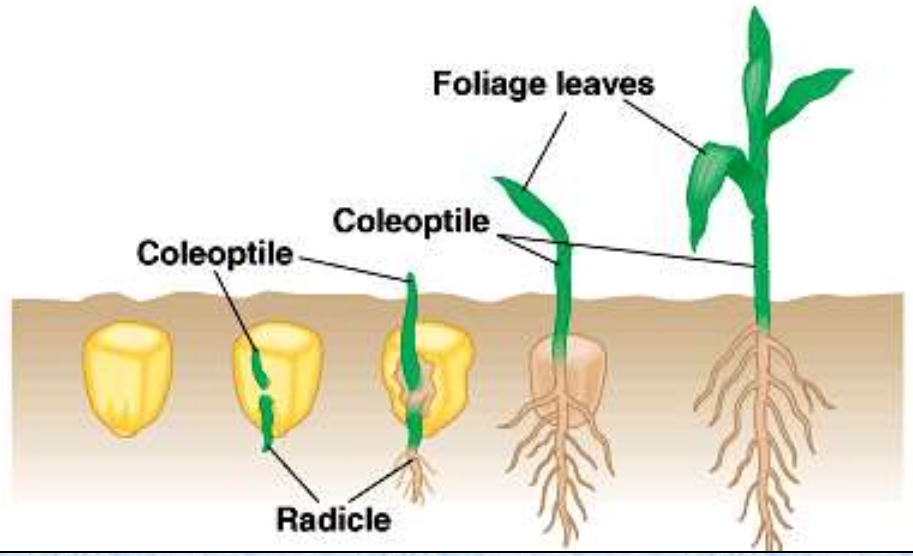
  -Cold, which may prevent germination in the wrong season

  -Disruption of the seed coat, *e.g.*, by acids or soaking in water

Seed Germination



Dicot



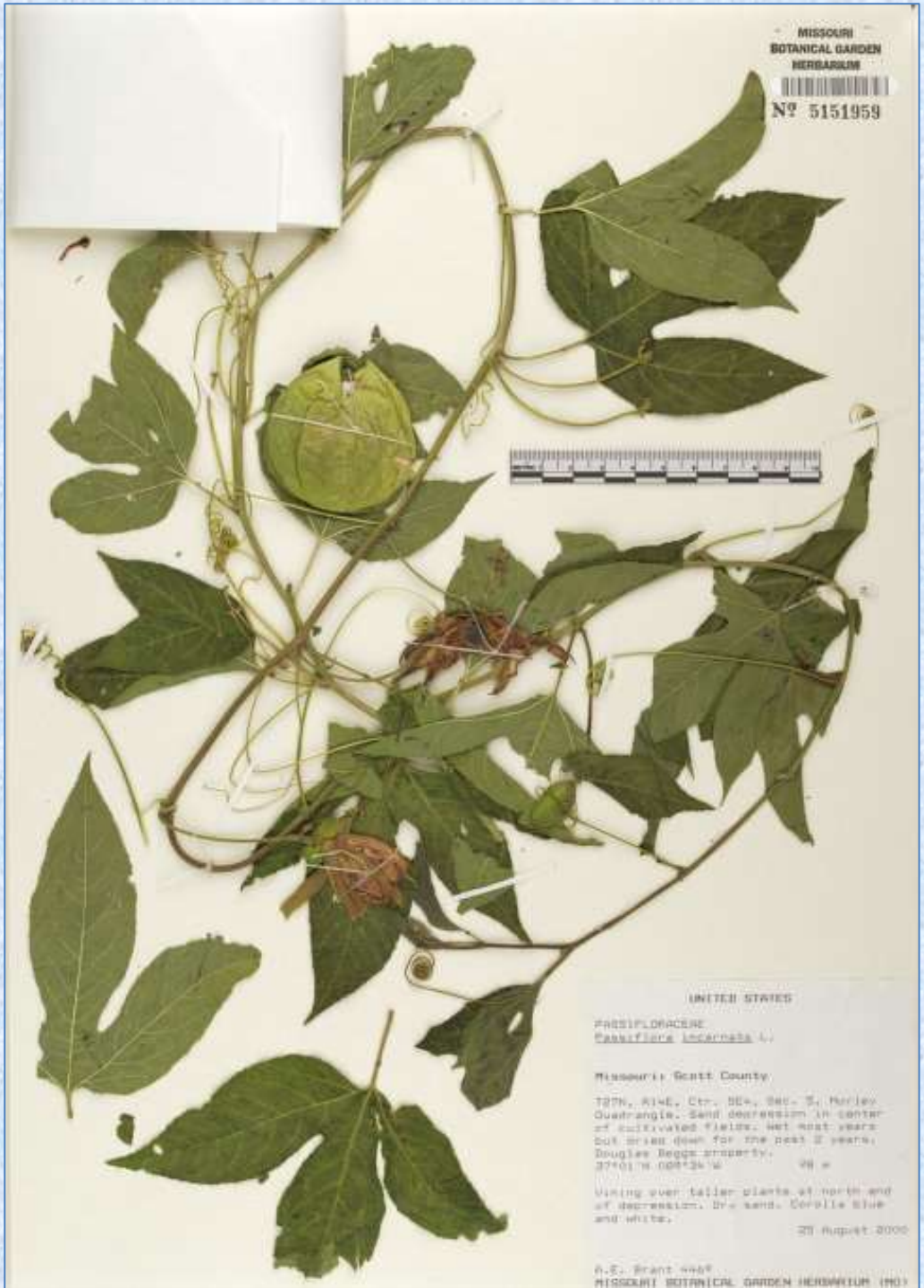
Monocot

Plant Collecting

- Fieldwork involves plant presses, careful note-taking, insect nets and hard work getting from place to place, just as it did in the past.
- Specimens are placed in a plant press to dry. The plant is trimmed and placed between sheets of newspaper and corrugated cardboard. The whole press goes into a drying oven.

Pressing a Plant for a Voucher Specimen in Herbarium Collection

Tighten straps, place on heater



Mounting Plant Specimens at MBG

Chelsea Pretz
Joseph Bradley
REU 2014


copyright reserved
ORYZA SATIVA L.
Cultivated land - solid stand


copyright reserved
PLANTS OF MISSOURI
no. 78153
Echinacea purpurea f. Liggettii Steyermark
rays white
ravine slopes

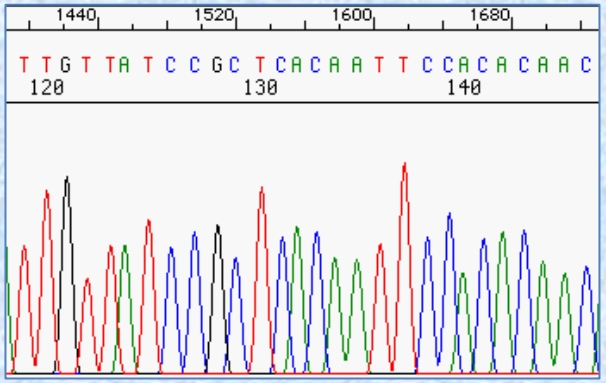
Taxonomists house their collected specimens in museums (called a herbarium), for their use and for that of future generations of scientists.

Morphology is still important in the study of evolutionary patterns, so specimens continue to have a critical role in taxonomy.

But today's researchers have at their disposal an armory of ways of looking at the relationships between species--from electron microscopes for examining the tiniest organisms to DNA sequencers for looking at genes.

Extracting DNA

PCR



DNA Sequence

Human welfare depends greatly on seed plants

- No group of plants is more important to human survival than seed plants
- Plants are key sources of food, fuel, wood products, and medicine
- Our reliance on seed plants makes preservation of plant diversity critical

End