Chapter 30:
Plant Diversity II –
The Evolution of Seed Plants

1. General Features of Seed-Bearing Plants
2. Survey of the Plant Kingdom II
    A. Gymnosperms
    B. Angiosperms

The 10 Phyla of Existing Plants

Chapter 29

Chapter 30

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

1. General Features of Seed-bearing Plants

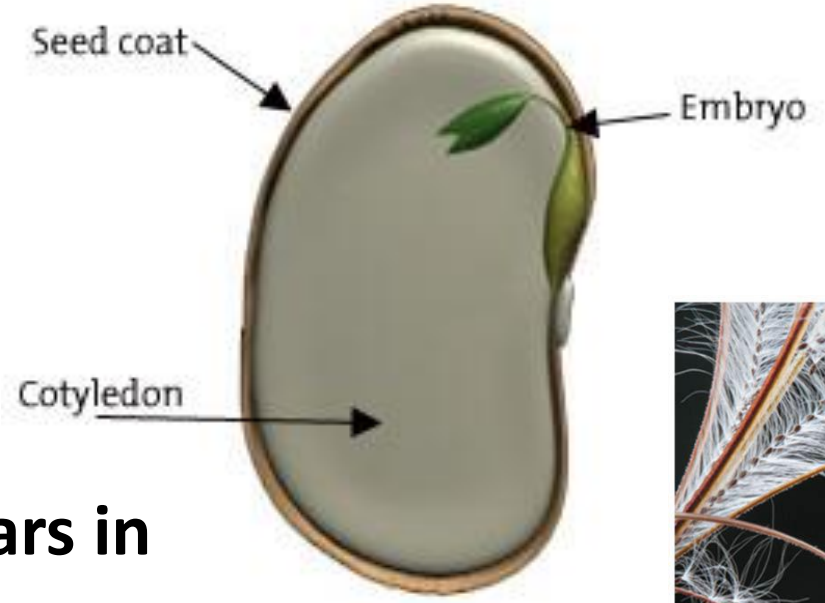
Key Adaptations for Life on Land

Plant life on land is dominated by seed plants due to the following 5 derived characters:

1. **SEEDS**
2. **REDUCED GAMETOPHYTES**
3. **HETEROSPORY**
4. **OVULES**
5. **POLLEN**

Advantages of Seeds

A seed is a sporophyte embryo surrounded by nutrients packaged in a protective seed coat which provides the following advantages for the embryo:



- **the fruit surrounding the seed can facilitate its dispersal over long distances**

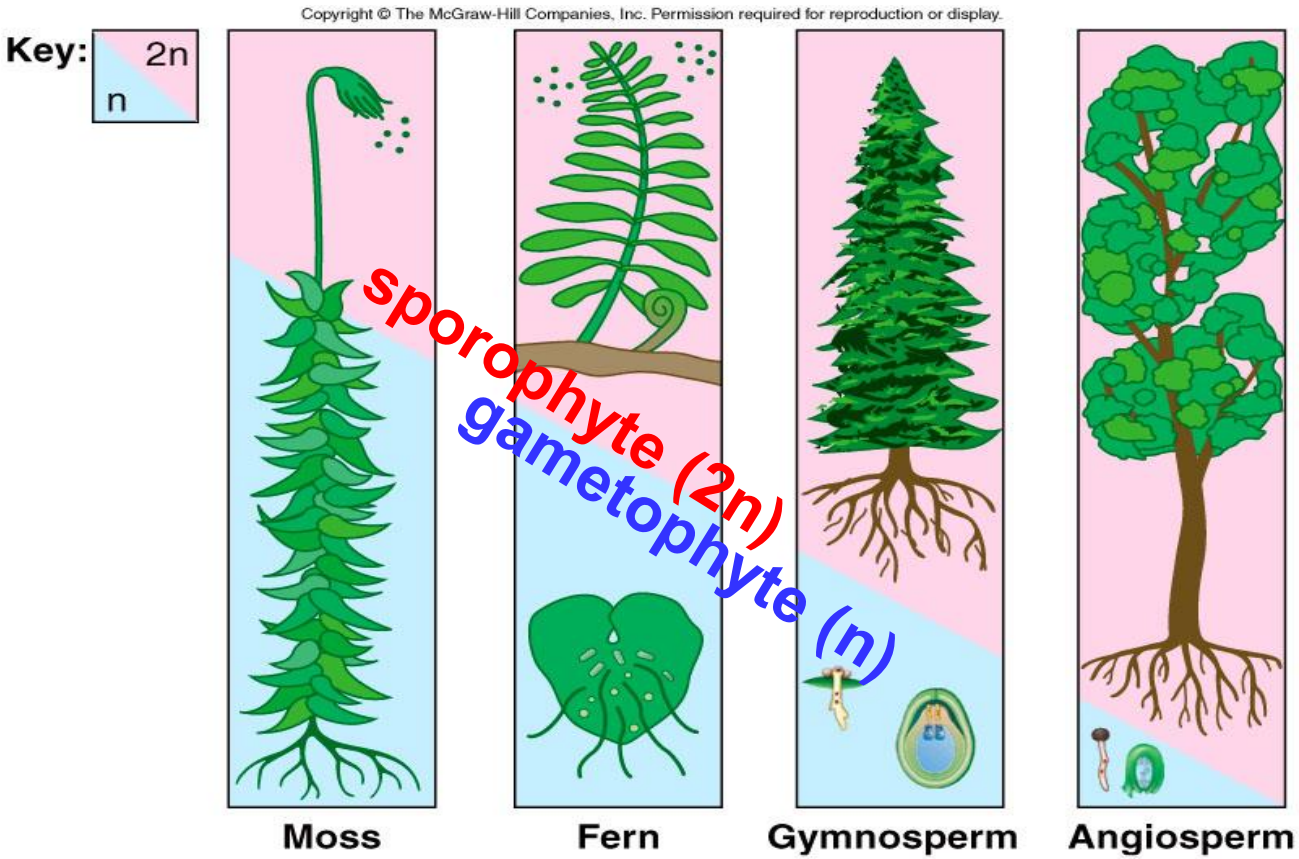
- **the embryo can survive for years in a dormant state until conditions are favorable for germination**

Fireweed seed

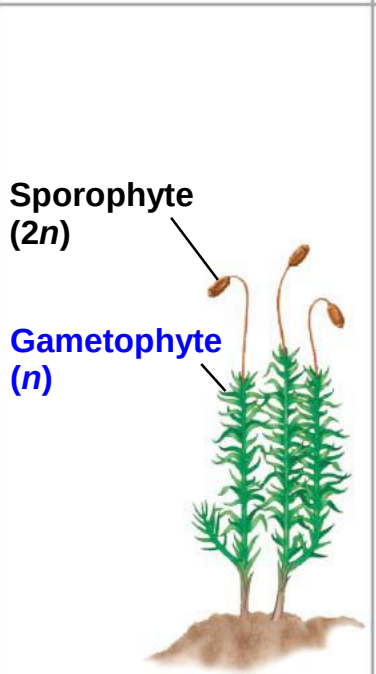
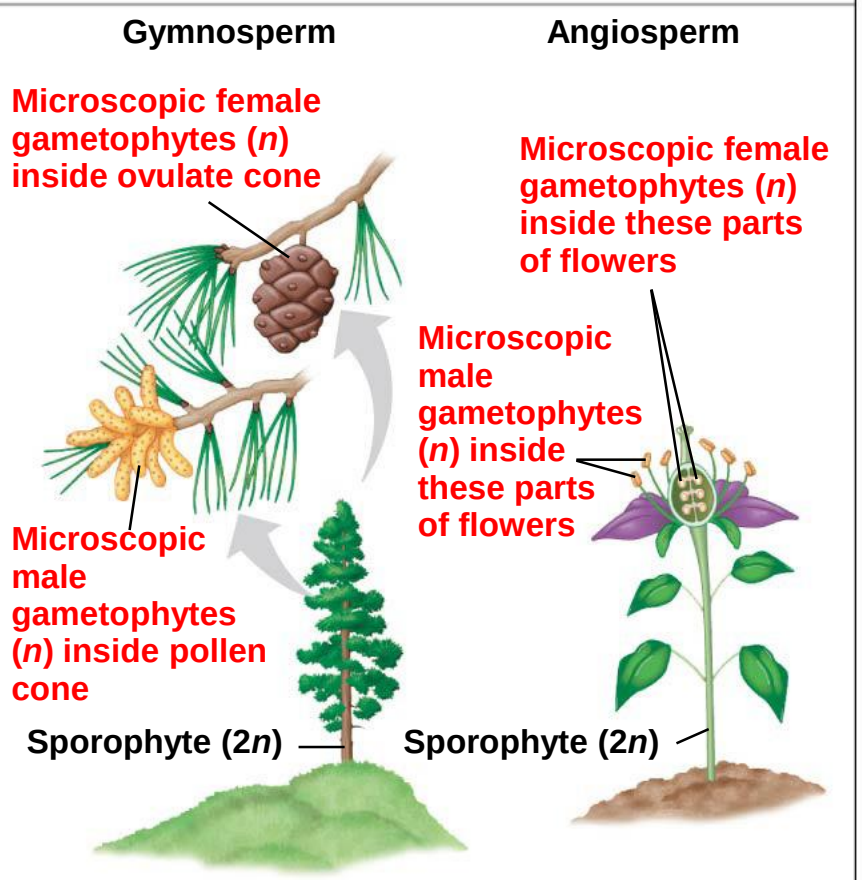
- **nutrients to sustain the embryo during early growth**

Advantages of Reduced Gametophytes

Seed plants have microscopic gametophytes that are fully contained within the sporangium of the sporophyte. This provides the following advantages:



- **the reproductive tissues of the sporangium protect the gametophyte from environmental stresses (e.g., UV exposure, loss of moisture, extreme temperature)**
- **the sporophyte can provide nourishment to sustain the gametophyte**

	PLANT GROUP		
	Mosses and other nonvascular plants	Ferns and other seedless vascular plants	Seed plants (gymnosperms and angiosperms)
Gametophyte	Dominant	Reduced, Independent (photosynthetic and free-living)	Reduced (usually microscopic), dependent on surrounding sporophyte tissue for nutrition
Sporophyte	Reduced, dependent on gametophyte for nutrition	Dominant	Dominant
Example			

Advantages of Heterospory

Most seedless plants are homosporous – produce one type of spore that develops into a bisexual gametophyte. Seed plants are heterosporous and produce 2 types of spores:

Megasporangium on megasporophyll → Megaspore → Female gametophyte → Eggs

Microsporangium on microsporophyll → Microspore → Male gametophyte → Sperm

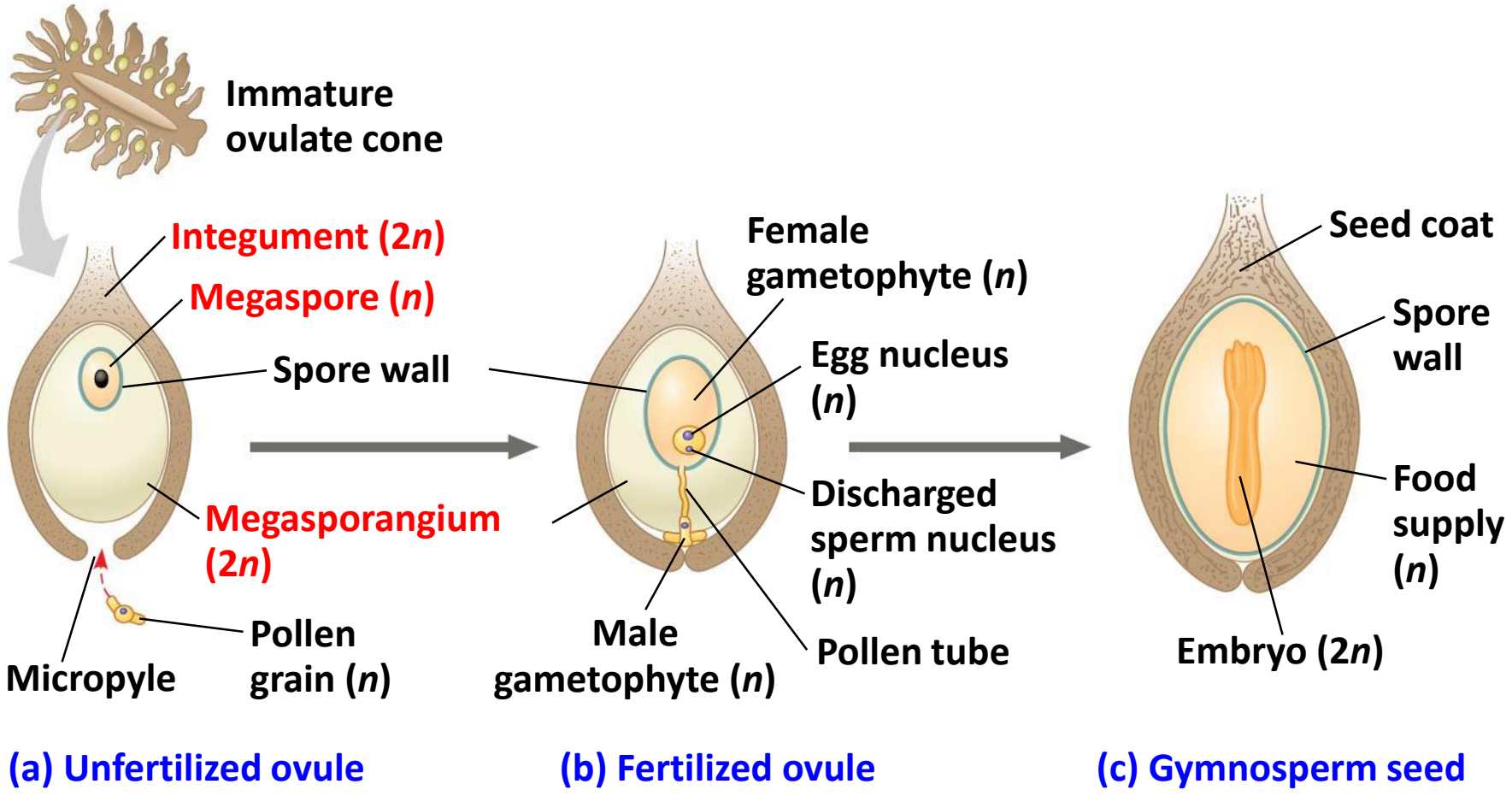
This provides 2 key advantages:

1. **male & female gametophytes can mature at different times avoiding self fertilization and increasing genetic diversity**
2. **a separate female gametophyte can better support a developing embryo**

Egg Production in Ovules

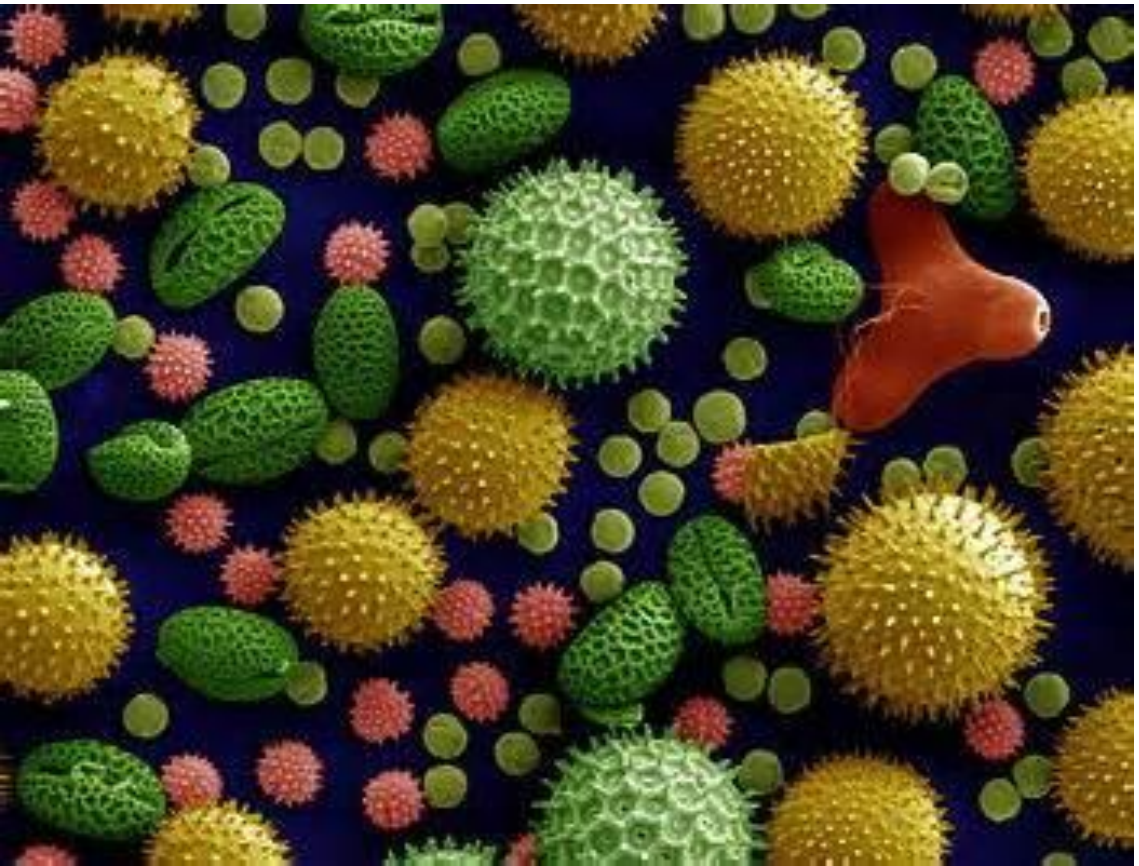
Seed plants are unique in containing the megasporangium within the parent sporophyte surrounded by a protective integument.

The complete structure – megaspore within megasporangium within the integument – is called an ovule.



Pollen and Sperm Production

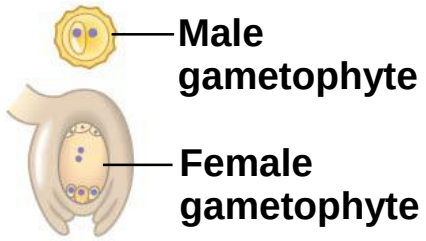
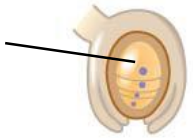
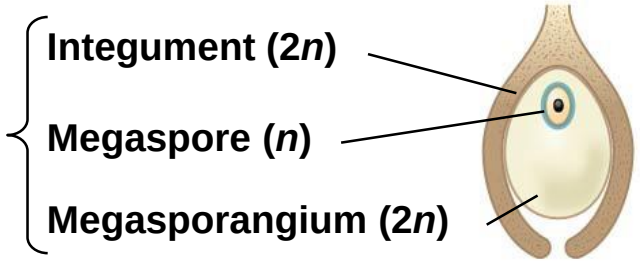
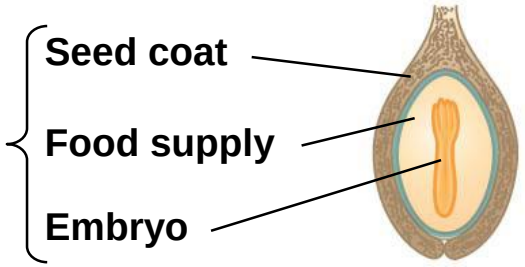
Microspores develop into multicellular pollen grains – a male gametophyte surrounded by a protective outer layer containing sporopollenin produced by the sporophyte.



- **pollen grains protect the male gametes – sperm – and facilitate their dispersal without the requirement for water**
- **unlike seedless plants, the sperm contained in pollen grain are not flagellated and gain access to an egg at pollination through a pollen tube**

Summary of the Key Derived Traits of Seed Plants

Five Derived Traits of Seed Plants

Reduced gametophytes	Microscopic male and female gametophytes (*n*) are nourished and protected by the sporophyte (2*n*) 
Heterospory	Microspore (gives rise to a male gametophyte)  Megaspore (gives rise to a female gametophyte) 
Ovules	Ovule (gymnosperm) 
Pollen	Pollen grains make water unnecessary for fertilization 
Seeds	Seeds: survive better than unprotected spores, can be transported long distances 

2A. Survey of the Plant Kingdom II

Gymnosperms

Nonvascular plants (bryophytes)

Seedless vascular plants

Gymnosperms

Angiosperms

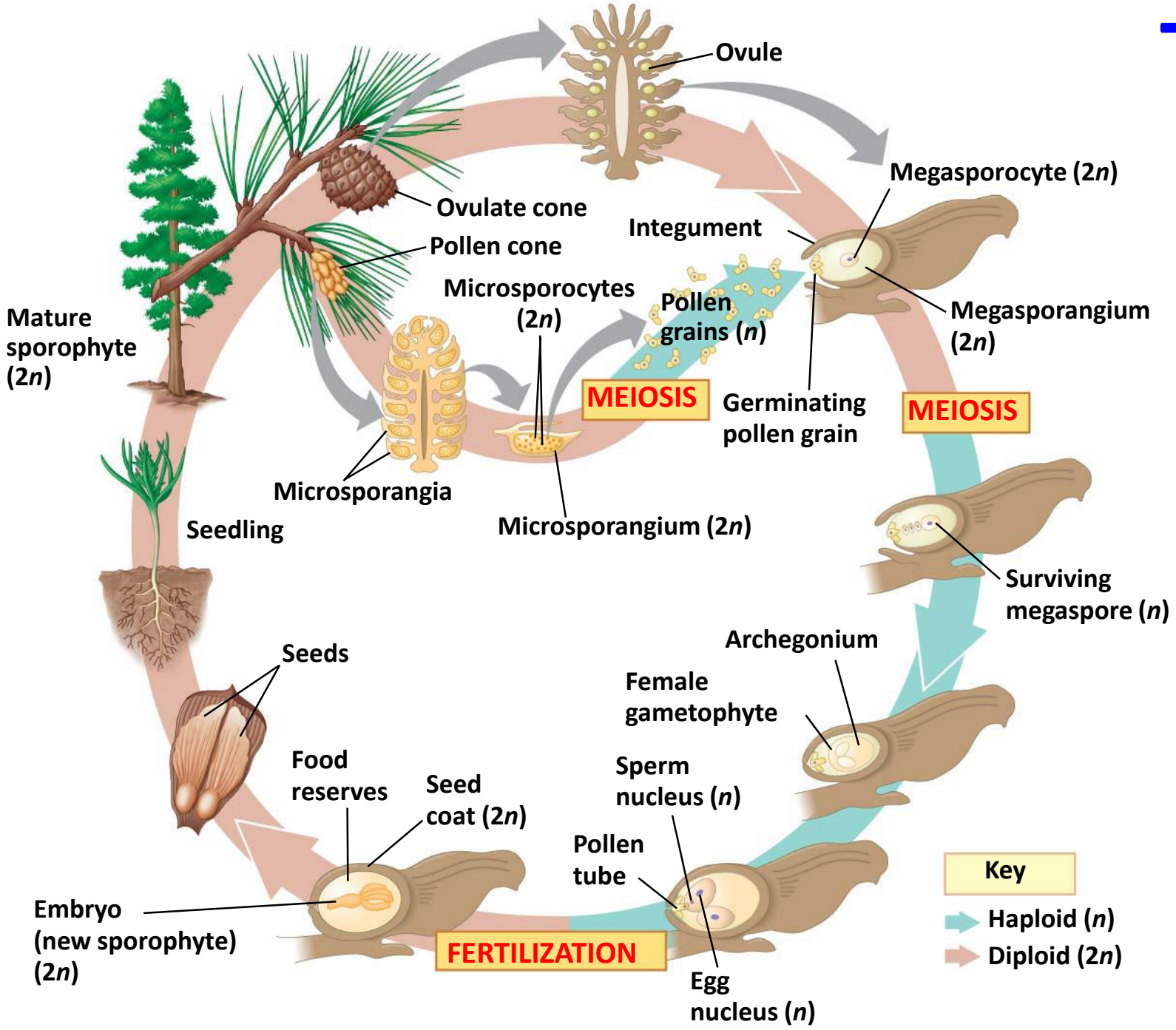
Gymnosperm Characteristics

Gymnosperms are at least 300 million years old according to the fossil record and were the dominant group of land plants in the Mesozoic era, with many still existing today.

- **gymnosperm means “naked seed” which refers to the exposed seeds produced on modified leaves (sporophylls) of cones**
- **cones are a type of strobilus, a collection of sporophylls**

It takes approximately 3 years for an ovulate cone to produce mature seeds!

The Life Cycle of a Pine



- most conifers such as pines produce both ovulate (female) cones and pollen (male) cones
- conifer pollen grains have an aerodynamic morphology and reach megasporangia through the air

Gymnosperm Phyla

4 of the 10 plant phyla are gymnosperms:

- **CYCADOPHYTA**
- **GINGKOPHYTA**
- **GNETOPHYTA**
- **CONIFEROPHYTA**

Phylum Cycadophyta

Cycads have large cones and palm-like leaves.

Cycas revoluta

- produce flagellated sperm unlike most seed plants
- widespread during the Mesozoic period, most modern species are endangered

Phylum Ginkgophyta

There is only one living species in this phylum:
Gingko biloba

- **produces flagellated sperm like the cycads**
- **a popular ornamental tree in southern California**

Ginkgo biloba

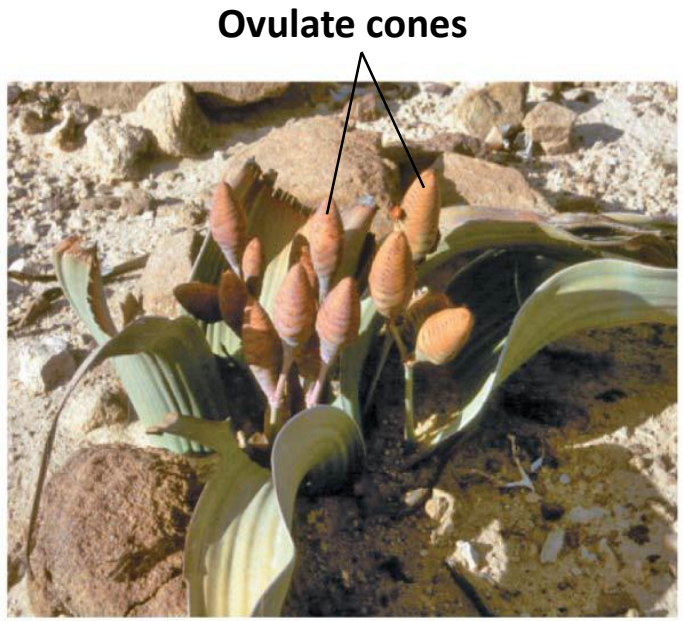
Phylum Gnetophyta

This phylum contains only 3 genera: *Gnetum*, *Ephedra*, and *Welwitschia*

- **some species are tropical and others thrive in deserts**

Welwitschia

Gnetum

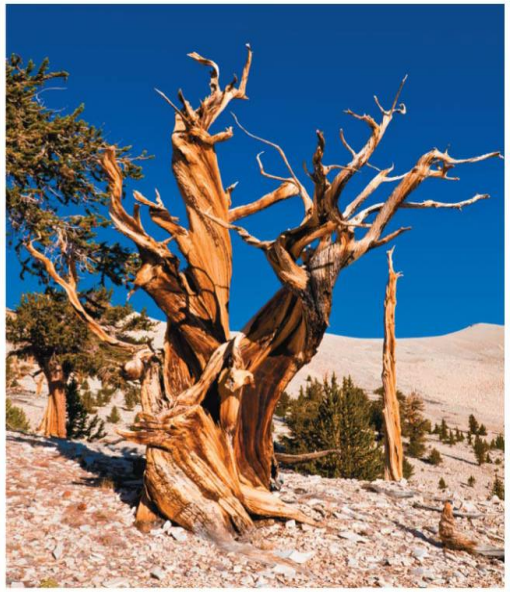


Welwitschia

Ephedra

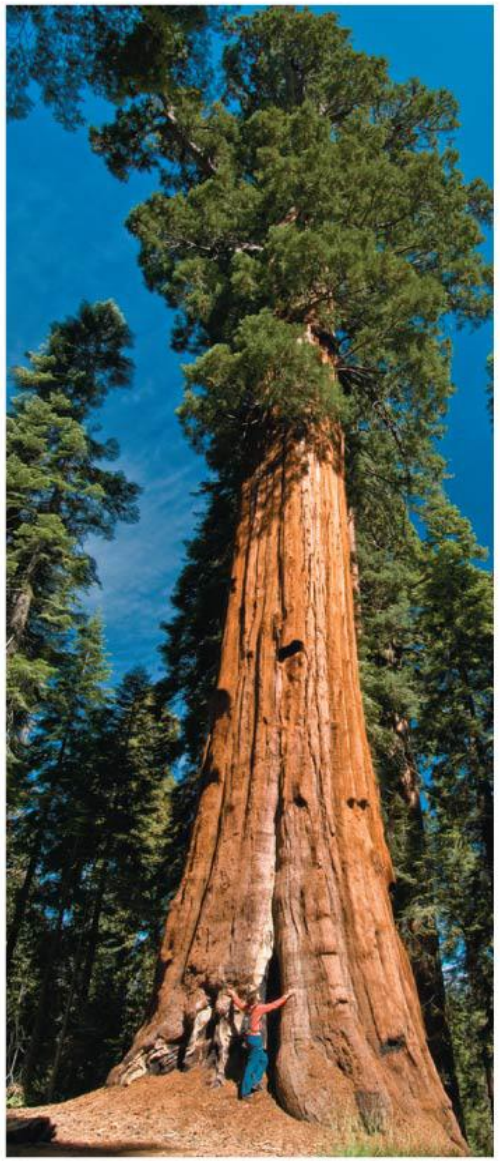
Phylum Coniferophyta

- this is the largest gymnosperm phylum with ~600 known species
- most conifers are evergreens that carry out photosynthesis year round



Bristlecone pine

Common juniper



Sequoia

Douglas fir

European larch

2B. Survey of the Plant Kingdom

Angiosperms

Nonvascular plants (bryophytes)

Seedless vascular plants

Gymnosperms

Angiosperms

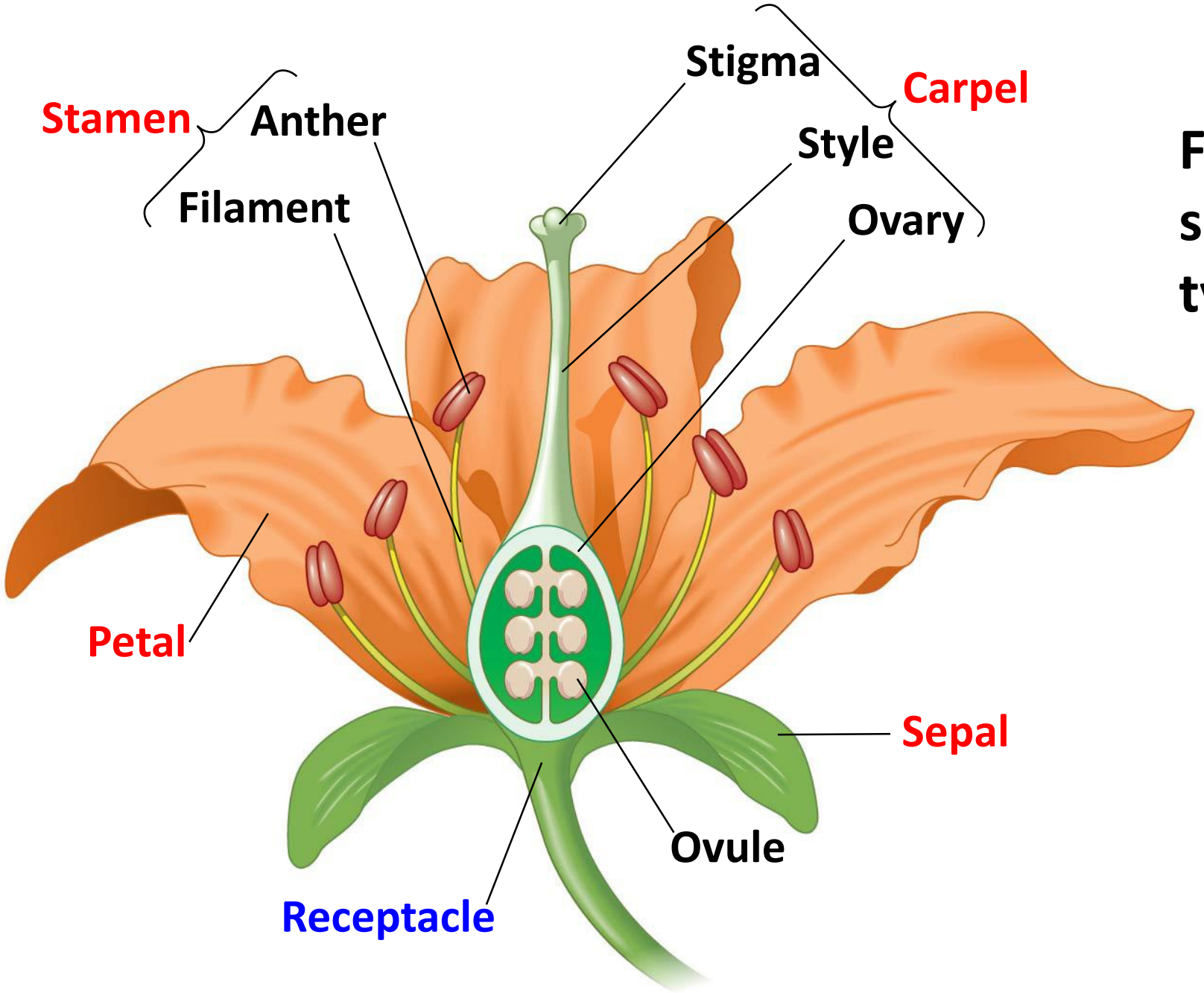
Characteristics of Angiosperms

All angiosperms (literally "enclosed seeds") or flowering plants belong to the phylum Anthophyta and have 2 key adaptations:

1. **Flowers as sexual reproductive structures**

2. **Seeds enclosed in fruits which aid in seed dispersal**

Flowers

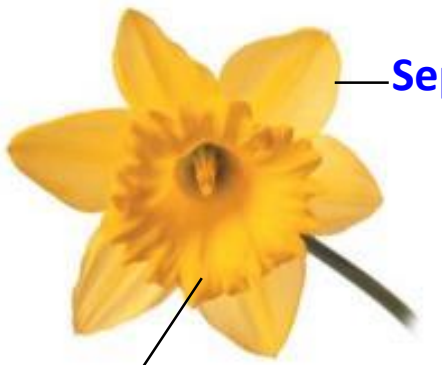


Flowers are modified shoots containing up to 4 types of modified leaves:

- **<u>sepals</u> that enclose and protect the flower**
- **<u>petals</u> to attract pollinators**
- **<u>stamens</u> – the male reproductive organs**
- **<u>carpels</u> – the female reproductive organs**

Variations in Flower Structure

Flower Symmetry



Radial symmetry (daffodil)

Bilateral symmetry (orchid)

Location of Stamens and Carpels

Common holly flowers with stamens

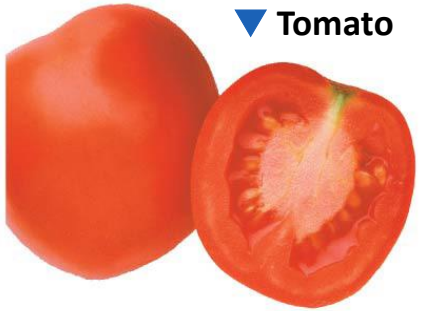
Common holly flowers with carpels

- flowers of any given species of angiosperm may have radial or bilateral symmetry
- flowers of any given species may also be complete (have all 4 flower organs) or incomplete (lacking at least one flower organ

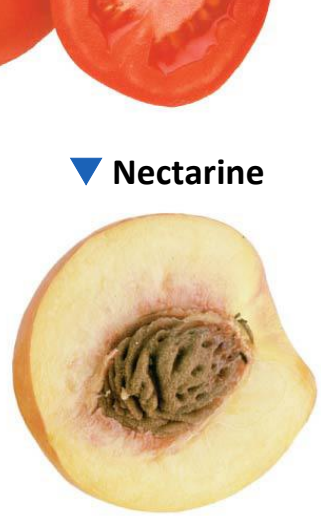
Fruits

Fruits develop from the ovary wall and aid in the dispersal of seeds by a variety of methods:

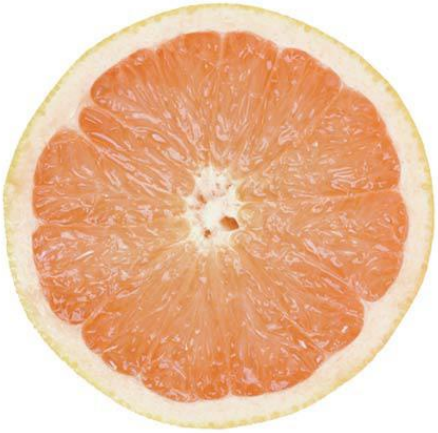
- animals disperse seeds in edible fruits
- wind disperses some seeds (e.g., dandelion)
- hitchhiker fruits act as barbs to stick to animals passersby
- some fruits burst open when dry to disperse seeds
- (e.g., peas)



Tomato



Nectarine



Ruby grapefruit

Hazelnut

Milkweed

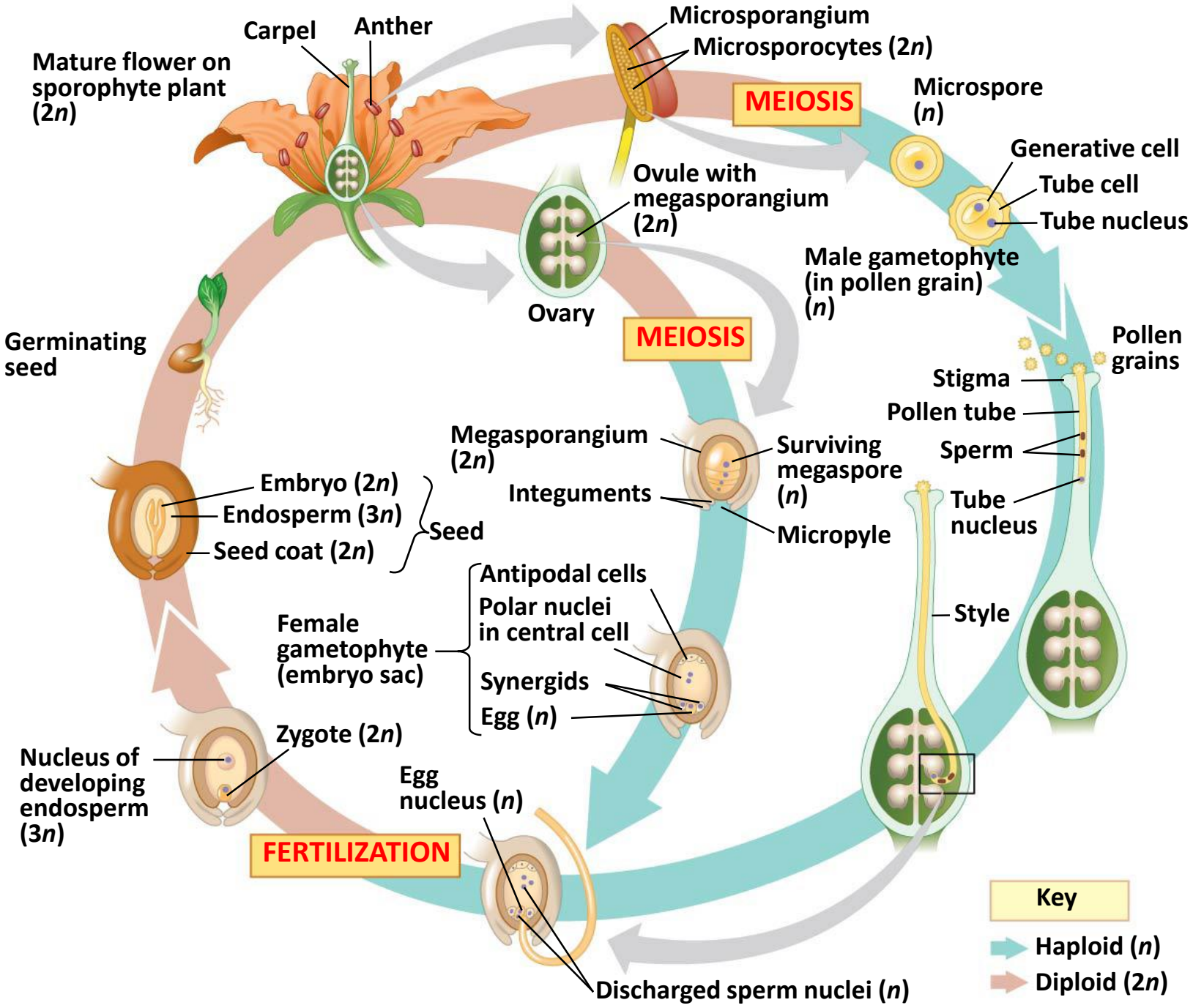
Mechanisms that disperse seeds by explosive action

Wings

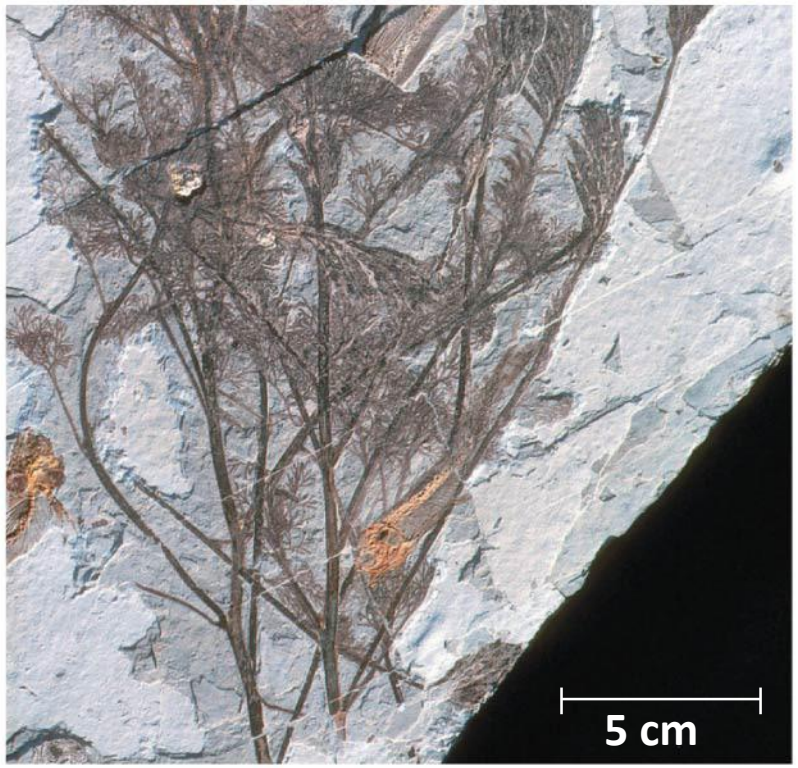
Seeds within berries and other edible fruits

Barbs

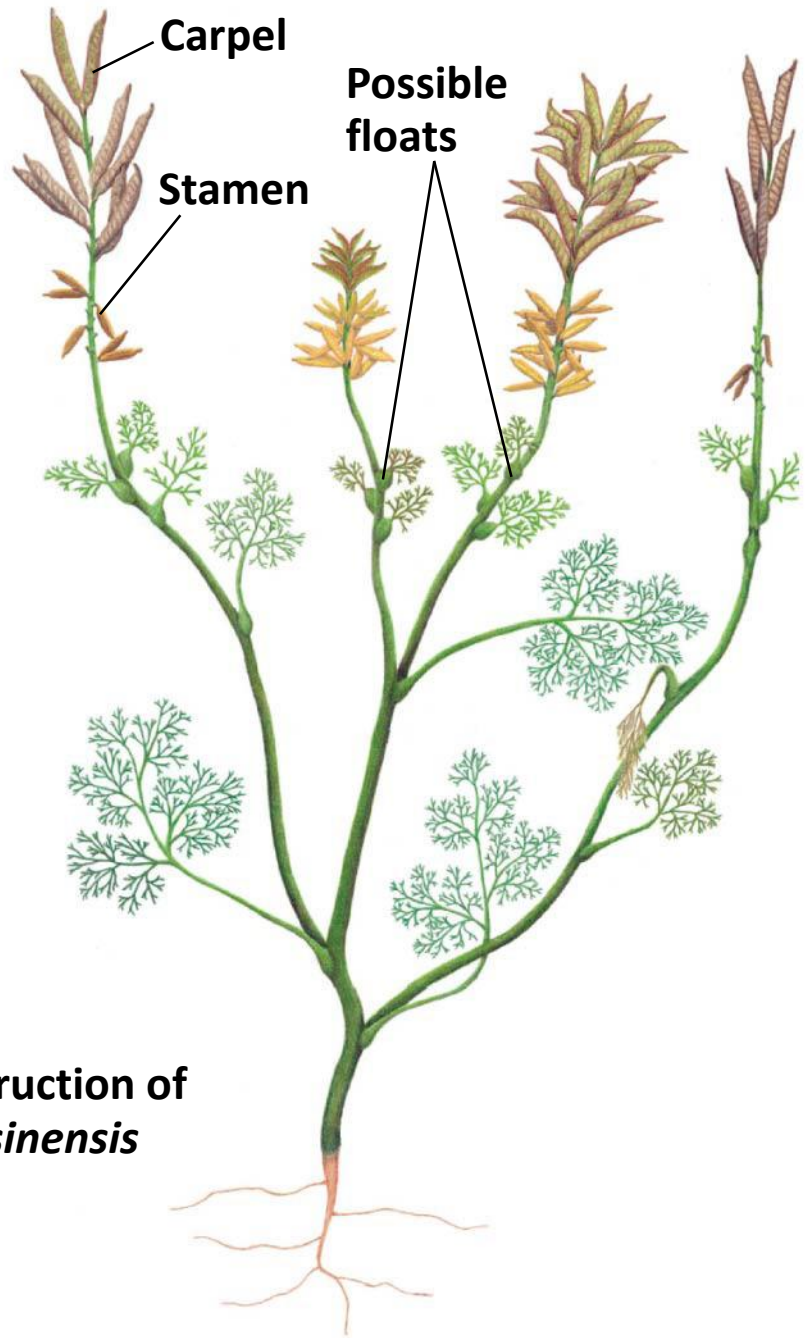
Angiosperm Life Cycle



Angiosperm History



(a) *Archaefructus sinensis*, a 125-million-year-old fossil



(b) Artist's reconstruction of *Archaefructus sinensis*

- the oldest angiosperm fossil dates to ~140 million years ago
- angiosperms dominate the fossil record as of ~100 million years ago and still dominate the world today

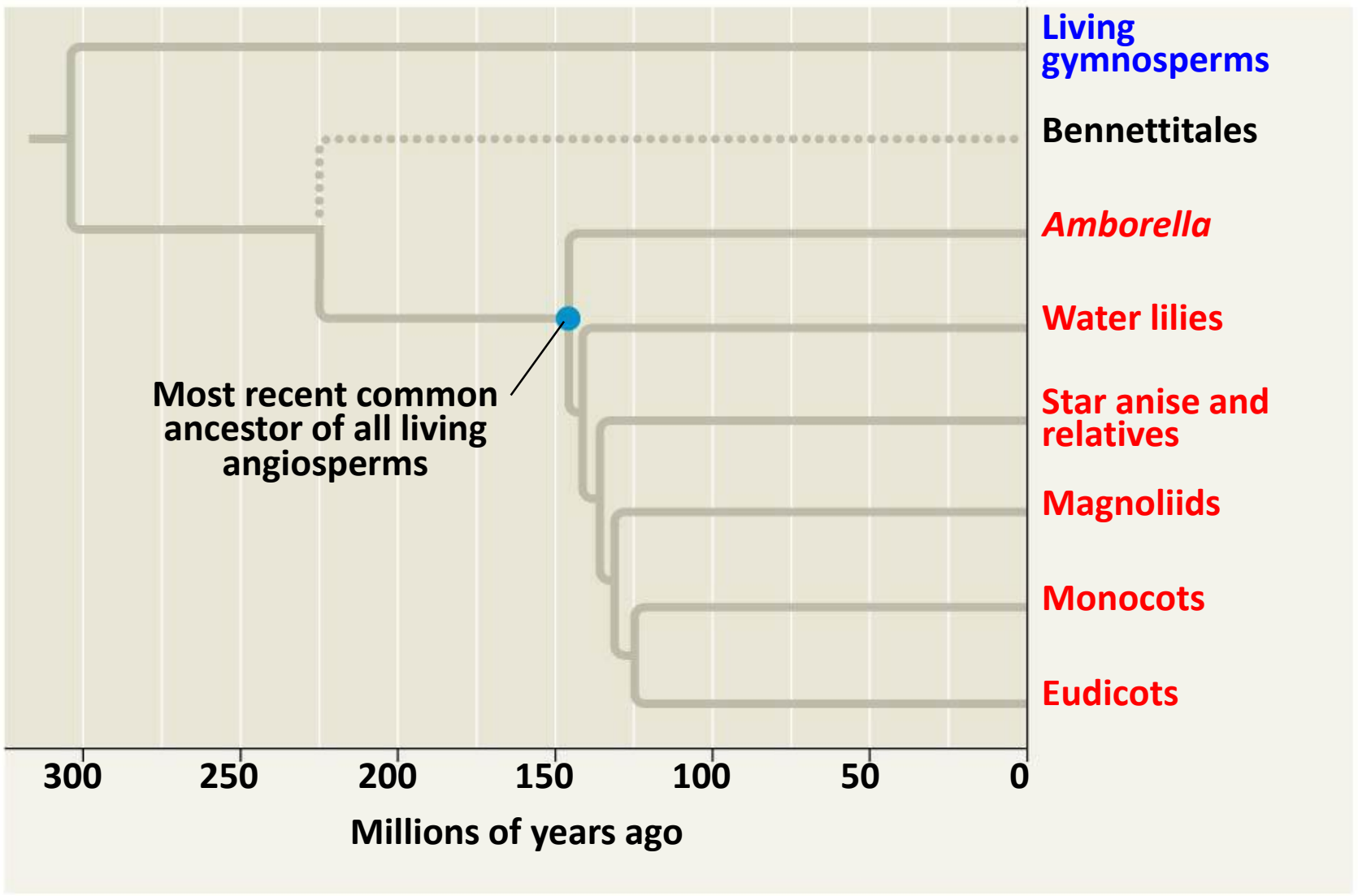
Evolutionary Links with Animals

Many animals and angiosperms have coevolved due to close relationships that may be adversarial or mutually beneficial:

- **angiosperms have evolved defenses in response to herbivores that would eat them**
- **angiosperms and their animal pollinators have evolved characters to reinforce their mutualistic symbioses**

Angiosperm Phylogeny

Fossil and molecular evidence dictate the evolutionary history shown here.



Angiosperm Diversity

Angiosperms used to be divided into 2 groups – monocots & dicots – however now there are 6 distinct clades:

1. **Amborella**
2. **Water Lilies**
3. **Star Anise & relatives**
4. **Magnoliids**
5. **Monocots**
6. **Eudicots**

Basal Angiosperms

Water lily (*Nymphaea "Rene Gerard"*)

Star anise (*Illicium*)

Amborella trichopoda

Water lilies, star anise and *Amborella* are minor angiosperm lineages that diverged from the rest of the angiosperms fairly early and collectively are referred to as basal angiosperms.

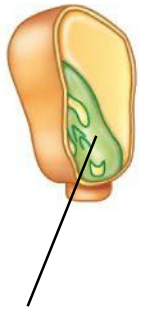
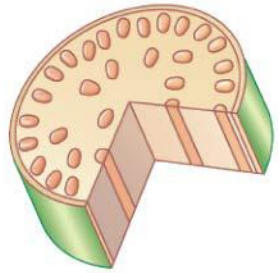
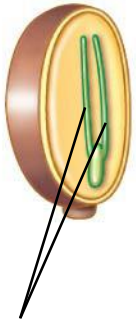
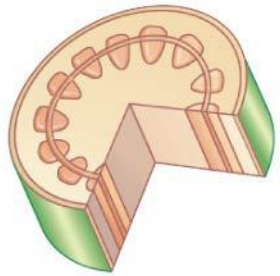
Magnoliids

Magnoliids are more closely related to the monocots & eudicots than the 3 basal angiosperms.

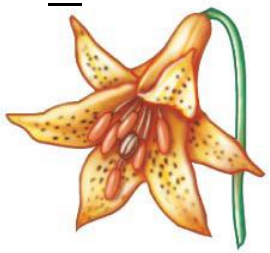
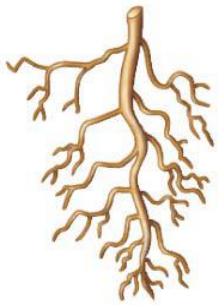
- **includes magnolias, laurels & black pepper plants**

Southern magnolia
(Magnolia grandiflora)

Monocots vs Eudicots

	Embryos	Leaf venation	Stems
Monocot Characteristics	 One cotyledon	 Veins usually parallel	 Vascular tissue scattered
Eudicot Characteristics	 Two cotyledons	 Veins usually netlike	 Vascular tissue usually arranged in ring

Monocots vs Eudicots (cont'd)

	Roots	Pollen	Flowers
Monocot Characteristics			
	Root system usually fibrous (no main root)	Pollen grain with one opening	Floral organs usually in multiples of three
Eudicot Characteristics			
	Taproot (main root) usually present	Pollen grain with three openings	Floral organs usually in multiples of four or five

Monocots

Orchid
(Lemboglossum rossii)

Pygmy date palm *(Phoenix roebelenii)*

Barley (*Hordeum vulgare*), a grass

More than ¼ of angiosperm species are monocots, most of which are grasses, palms or orchids.

- **much of the calories consumed by humans come from monocot grasses (e.g., corn, wheat & rice)**

Eudicots

Snow pea *(Pisum sativum)*, a legume

Dog rose *(Rosa canina)*, a wild rose

More than 2/3 of angiosperm species are eudicots of which there is great variety.

- the largest group is the legumes which includes peas & beans
- this also includes most fruit and non-conifer trees

Pyrenean oak *(Quercus pyrenaica)*