BIOL 01112
General Biology II Lecture

CHAPTER 30
Plant Diversity II The Evolution of Seed Plants

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CH 30 Learning Objectives

1. Explain how seeds and pollen grains were key adaptations for plants.
2. Characterize gymnosperms and their life cycles.
3. Describe the structure and function of flowers and fruits.
4. Give examples of human interactions with plants.

I would suggest completing the crossword puzzle to help you understand the terminology and correlate how the terms relate to topics covered in this chapter.

Transforming the World

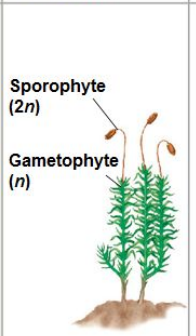
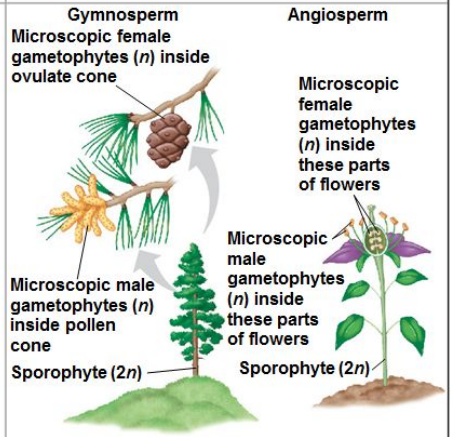
- Seeds changed the course of plant evolution, enabling their bearers to become the dominant producers in most terrestrial ecosystems
- Seed plants originated about 360 million years ago
- A **seed** consists of an embryo and nutrients surrounded by a protective coat
- Seeds can disperse over long distances by wind or other means

Concept 30.1: Seeds and pollen grains are key adaptations for life on land

- In addition to seeds, the following are common to all seed plants
  1. reduced gametophytes
  2. heterospory
  3. ovules
  4. pollen

1. Advantages of Reduced Gametophytes

- The gametophytes of seed plants are microscopic
- They develop within the walls of spores that are retained within tissues of the parent sporophyte
- This arrangement protects the developing gametophyte from environmental stress and enables it to obtain nutrients from the sporophyte

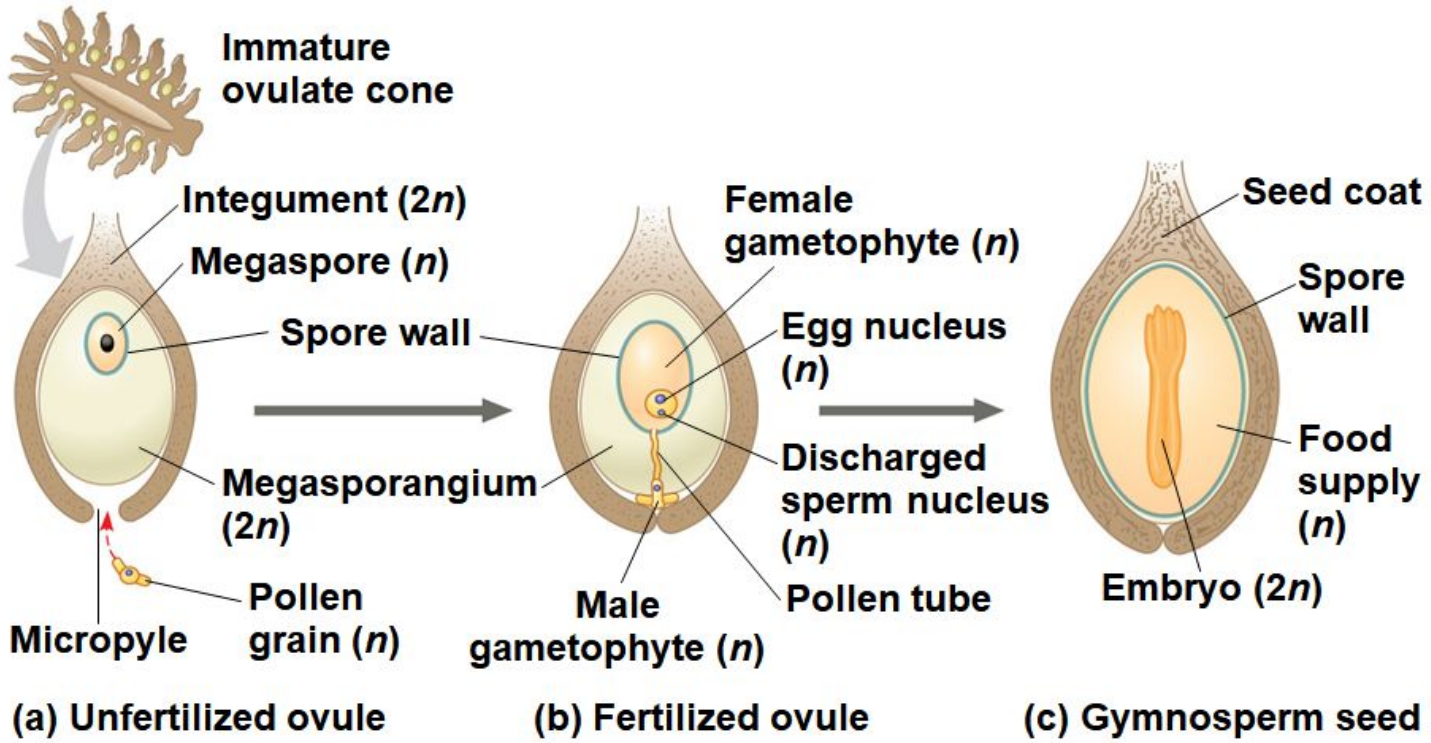
	Mosses and other nonvascular plants	Ferns and other seedless vascular plants	Seed plants (gymnosperms and angiosperms)
Gametophyte	Dominant	Reduced, independent (photosynthetic and free-living)	Reduced (usually microscopic), dependent on surrounding sporophyte tissue for nutrition
Sporophyte	Reduced,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

2. Heterospory: The Rule Among Seed Plants

- Homosporous plants produce one kind of spore, which usually produces a bisexual gametophyte
- Heterosporous plants produce two types of spores
- Ferns and other close relatives are homosporous; seed plants are heterosporous
- Megasporangia produce megaspores that give rise to female gametophytes
- Microsporangia produce microspores that give rise to female gametophytes
- Megasporangia develop on modified leaves called megasporophylls; microsporangia develop on microsporophylls

3. Ovules and Production of Eggs

- An **ovule** consists of a megasporangium, megaspore, and one or more protective **integuments**
- Gymnosperm megasporangia have one integument
- Angiosperm megasporangia usually have two integuments



4. Pollen and Production of Sperm

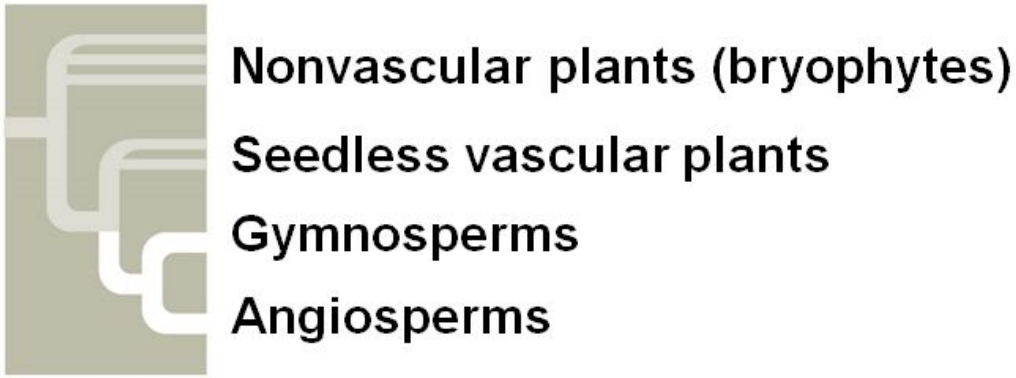
- A microspore develops into a **pollen grain** that consists of a male gametophyte enclosed within the pollen wall
- **Pollination** is the transfer of pollen to the part of a seed plant containing the ovules
- A germinated pollen grain produces a pollen tube that discharges sperm into the female gametophyte within the ovule
- Pollen *eliminates* the need for a film of water and can be dispersed great distances by air or animals

The Evolutionary Advantage of Seeds

- If a sperm fertilizes the egg of a seed plant, the ovule will develop into a seed
- A seed is a sporophyte embryo, along with its food supply, packaged in a protective coat
- Seeds provide some evolutionary advantages over spores
  1. They may remain dormant for days to years, until conditions are favorable for germination
  2. They have a supply of stored food
  3. They may be transported long distances by wind or animals

Concept 30.2: Gymnosperms bear "naked" seeds, typically on cones

- Gymnosperms means "naked seeds"
- The seeds are exposed on sporophylls that form cones
- Angiosperm seeds are found in fruits, which are mature ovaries
- Most gymnosperms are cone-bearing plants called conifers



The Life Cycle of a Pine

- Three key features of the gymnosperm life cycle are
  1. miniaturization of their gametophytes
  2. production of seeds, a dispersible stage in the life cycle
  3. the transfer of sperm to ovules by pollen
- The life cycle of a pine provides an example
- The pine tree is the sporophyte that produces sporangia in male and female cones
- **Male** pollen cones are small and consist of modified leaves (microsporophylls) that bear microsporangia
- **Female** ovulate cones are larger and consist of both modified leaves and modified stem tissue


MALE
CONE


FEMALE
CONE

- Living seed plants can be divided into two clades: gymnosperms and angiosperms
- Gymnosperms appear early in the fossil record, about 305 million years ago
- Conditions became drier at the end of the Carboniferous, favoring gymnosperms over the previously dominant seedless vascular plants
- Gymnosperms dominated terrestrial ecosystems during the Mesozoic era, 252 to 66 million years ago
- Gymnosperms served as food for herbivorous dinosaurs
- Angiosperms began to replace gymnosperms near the end of the Mesozoic era

Gymnosperm Diversity

- Angiosperms now dominate most terrestrial ecosystems, though gymnosperms remain an important part of Earth's flora
  - EX: vast regions in northern latitudes are covered by forests of conifers
- The gymnosperms consist of four phyla:
  1. **Cycadophyta**: cycads
  2. **Ginkgophyta**: one living species, *Ginkgo biloba*
  3. **Gnetophyta**: three genera; Gnetum, Ephedra, and Welwischia
  4. **Coniferophyta**: conifers, such as pine, fir, and redwood

1. Phylum Cycadophyta

- Individuals have large cones and palm-like leaves
- Unlike most seed plants, cycads have flagellated sperm
- These thrived during the Mesozoic, but most of the few surviving species are endangered

Phylum Cycadophyta

Cycas revoluta

2. Phylum Ginkgophyta

- This phylum consists of a single living species, *Ginkgo biloba*
- Like the cycads, this group also has flagellated sperm
- It has a high tolerance to air pollution and is a popular ornamental tree; herbal supplement for memory

3. Phylum Gnetophyta

- This phylum comprises three genera: *Gnetum*, *Ephedra* (diet aid), and *Welwitschia*
- Species vary in appearance, and some are <u>tropical, whereas others live in deserts</u>

Phylum Gnetophyta

Welwitschia

Gnetum

Ovulate cones

Welwitschia

Ephedra

4. Phylum Coniferophyta

- This phylum is the largest of the gymnosperm phyla
- Most species have woody cones, but a few have fleshy cones
- Most conifers are evergreens and can carry out photosynthesis all year round
- Many commerical uses

Common juniper

Wollemi pine

Sequoia

Concept 30.3: The reproductive adaptations of angiosperms include flowers and fruits

- Angiosperms are seed plants with reproductive structures called flowers and fruits
- They are the most widespread and diverse of all plants

Nonvascular plants (bryophytes)

Seedless vascular plants

Gymnosperms

Angiosperms

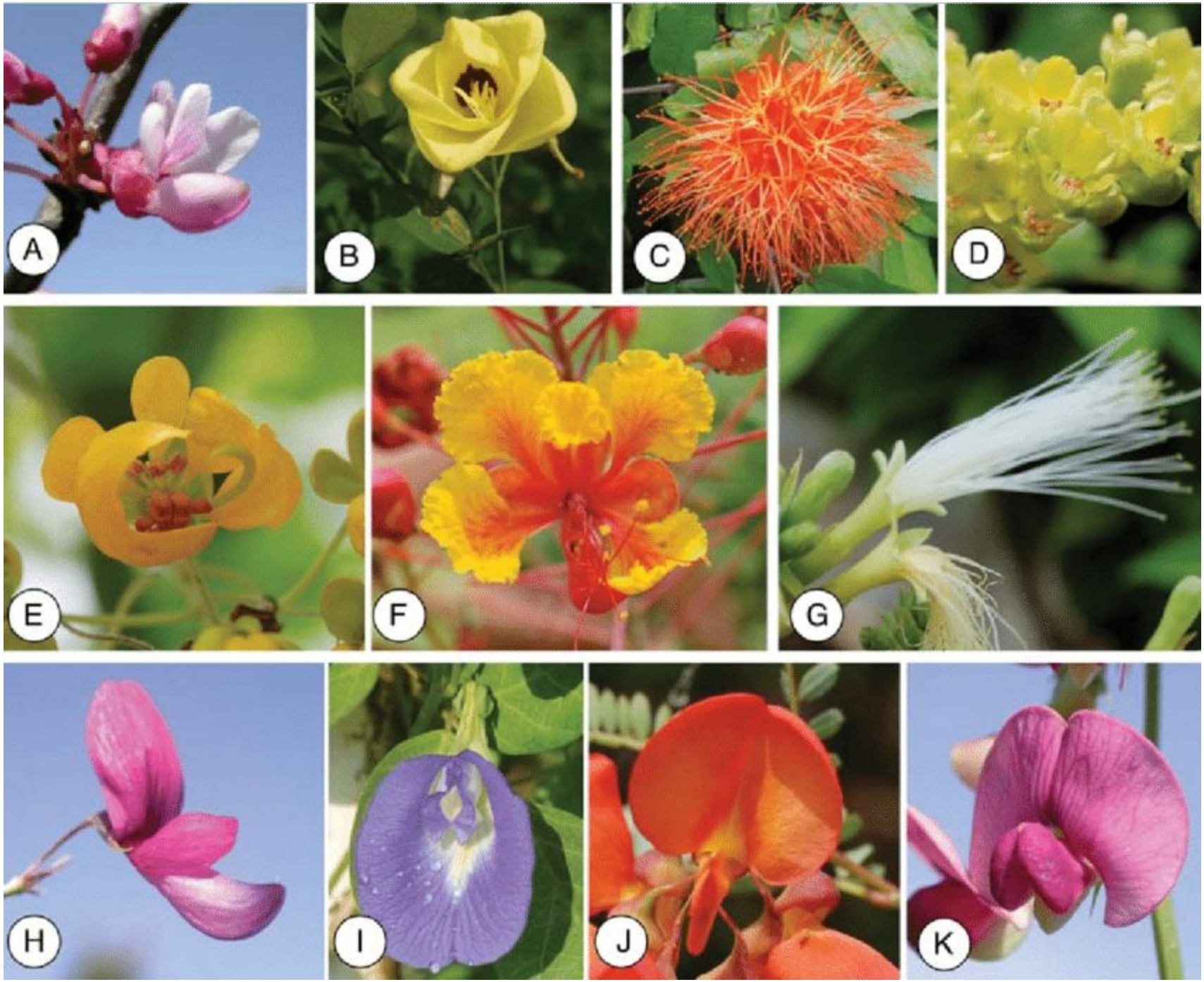
Characteristics of Angiosperms

- All angiosperms are classified in a single phylum, Anthophyta
- Angiosperms have two key adaptations
  1. Flowers
  2. Fruits

Flowers

- The **flower** is an angiosperm structure specialized for sexual reproduction
- Many species are pollinated by insects or animals, while some species are wind-pollinated
- A flower is a specialized shoot with up to four types of modified leaves called floral organs
  - **Sepals**, which enclose the flower
  - **Petals**, which are often brightly colored to attract pollinators; wind-pollinated flowers generally
  - **Stamens**, the male reproductive organs
  - **Carpels**, the female reproductive organs

- A stamen consists of a stalk called a **filament**, with a sac called an **anther**
- Microspores, which are produced in the anthers, develop into pollen grains containing the male gametophytes
- A carpel consists of an **ovary** at the base of a **style** leading up to a sticky **stigma**, where pollen is received
- The ovary contains the female gametophyte(s) within the ovule(s)
- Fertilized ovules develop into seeds
- The term **pistil** can be used to refer to a single carpel or two or more fused carpels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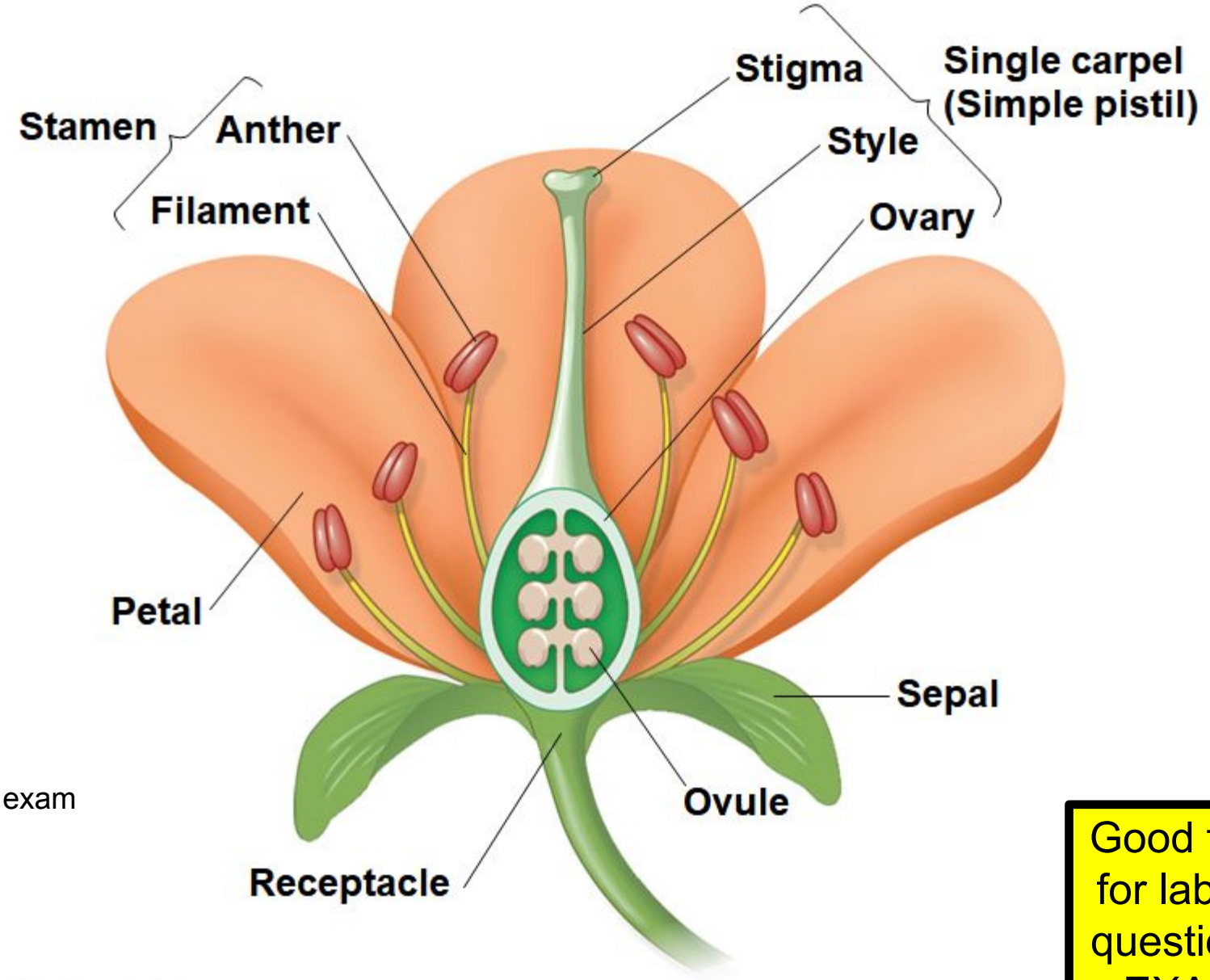
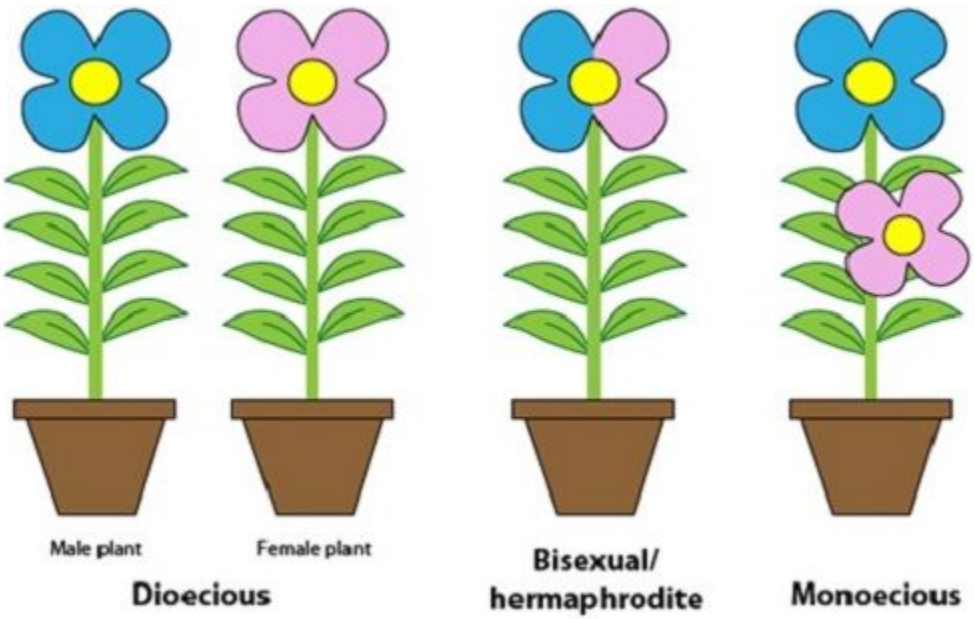
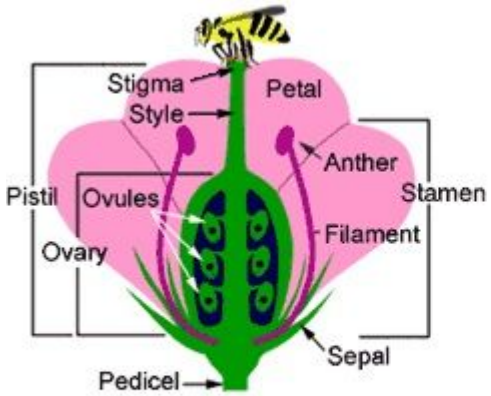


good id for exam

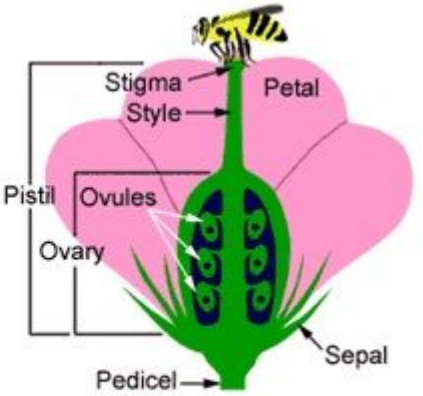
Good figure for labeling question on EXAM 3

Monoecious vs. Dioecious



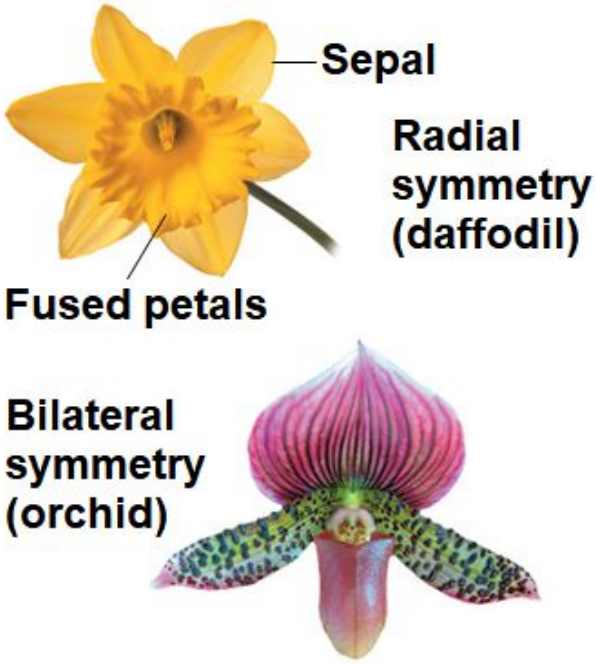


Monoecious (complete) flower



Dioecious (incomplete) flower
gynoecious flower (has only ovules)

- Flowers are variable in shape, size, color, and odor
  - EX: some flowers have radial symmetry, while others have bilateral symmetry
  - In ***radial*** symmetry, any imaginary line through the central axis divides the flower into two equal parts
  - In ***bilateral*** symmetry, a flower can only be divided into two equal parts by a single imaginary line



Fruits

- A **fruit** is formed when the ovary wall thickens and matures
- Fruits protect seeds and aid in their dispersal
- Mature fruits can be either fleshy or dry
- Various fruit adaptations help disperse seeds
- Seeds can be carried by wind, water, or animals to new locations

▼ Tomato

▼ Ruby grapefruit

FLESHY FRUITS

▼ Nectarine

▼ Hazelnut

◄ Milkweed

DRY FRUITS

SEED DISPERSAL MECHANISMS

- Mechanisms that disperse seeds by explosive action

- Wings

- Seeds within berries and other edible fruits

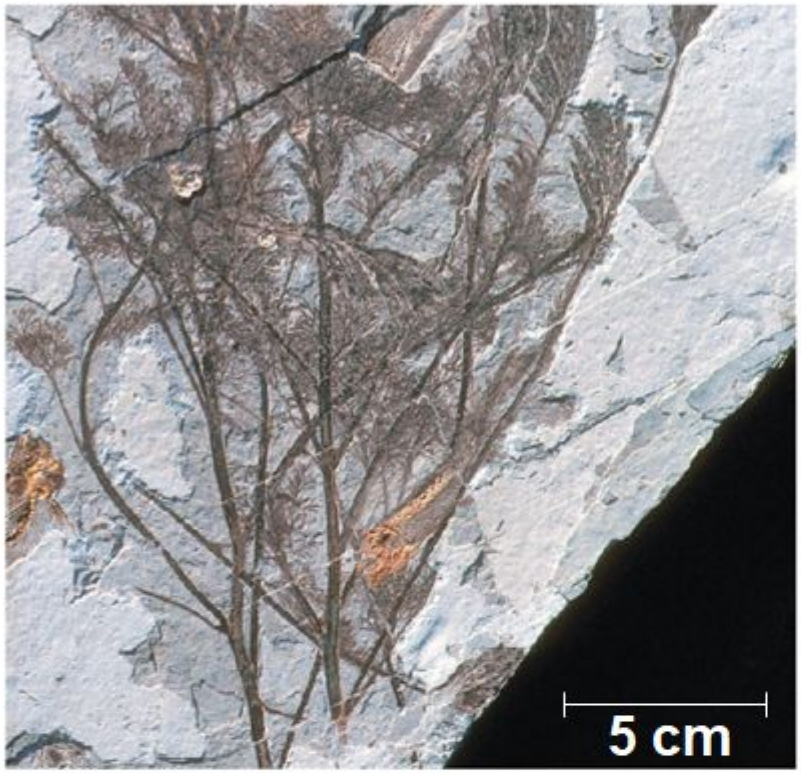
- Barbs

The Angiosperm Life Cycle

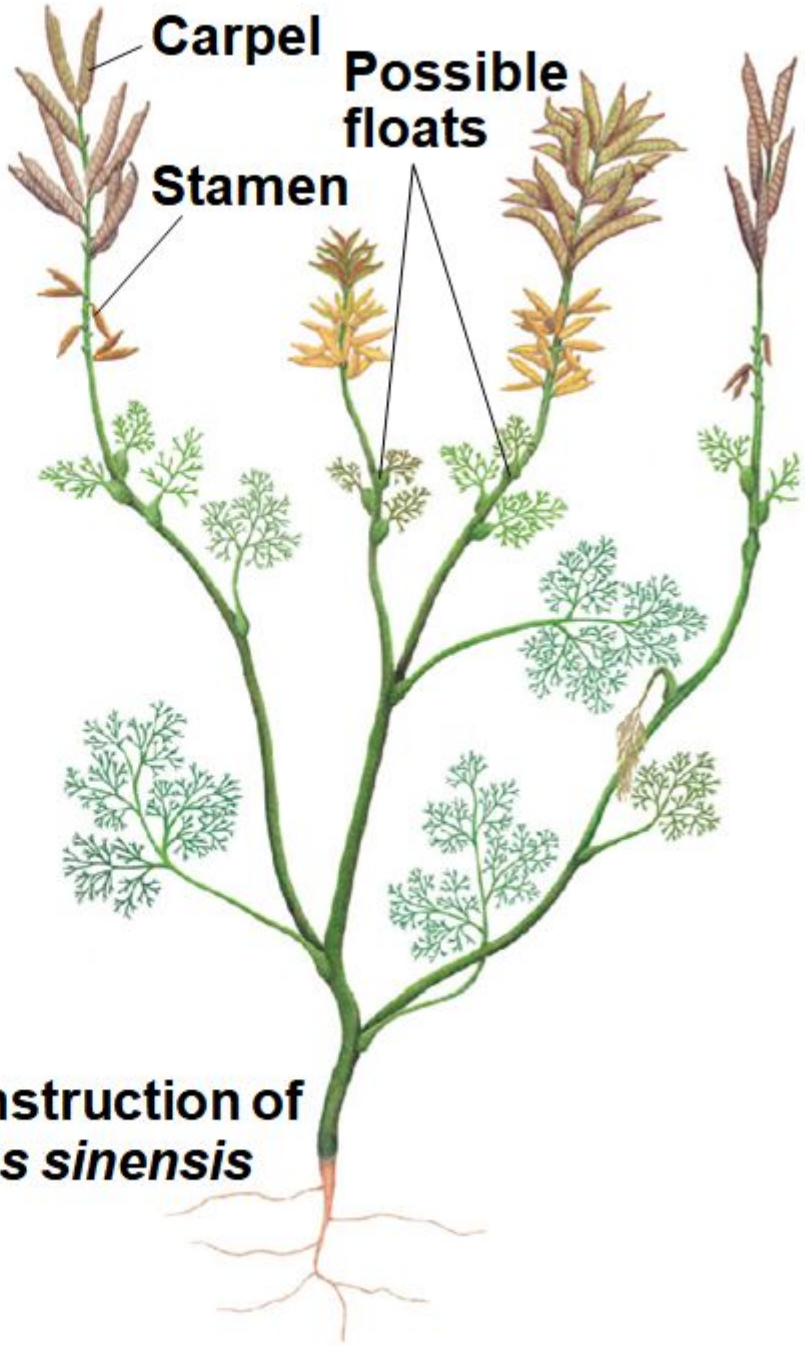
- The flower of the sporophyte is composed of both male and female structures
- Male gametophytes are contained within pollen grains produced by the microsporangia of anthers
- The female gametophyte, or **embryo sac**, develops within an ovule contained within an ovary at the base of a stigma
- Most flowers have mechanisms to ensure **cross-pollination** between flowers from different plants of the same species
- A pollen grain that lands on a stigma germinates, and the pollen tube of the male gametophyte grows down to the ovary

Angiosperm Evolution

- Darwin called the origin of angiosperms an "abominable mystery" due to their sudden and geographically widespread appearance
- Progress is being made through the study of fossils and phylogenetic analysis, but the mystery has not been resolved
- Fossil evidence suggests that angiosperms originated about 140 million years ago and diversified over a 20- to 30-million-year period
- One of the earliest angiosperm fossils, *Archaefructus*, was herbaceous and likely aquatic
- The common ancestor to angiosperms is thought to be woody and not aquatic



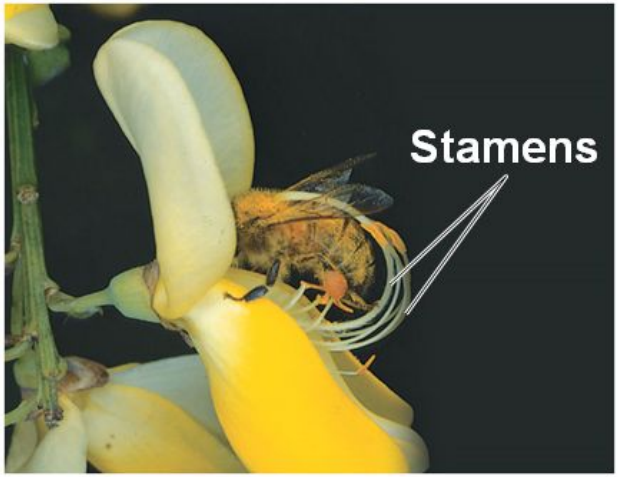
(a) *Archaefructus sinensis*, a 125-million-year-old fossil



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

Evolutionary Links with Animals

- Animals influence the evolution of plants & vice versa
  - EX: Interactions between pollinators and flowering plants select for mutually beneficial adaptations
- Flowers with bilateral symmetry restrict the movement of pollinators
- They deposit pollen on parts of the pollinator's body that will come into contact with the stigma of another flower of the same species



Angiosperm Diversity

- Angiosperms comprise more than 250,000 living species
- Previously, angiosperms were divided into two main groups
  1. **Monocots:** one cotyledon
  2. **Dicots:** two cotyledons
- The clade **eudicot** ("true" dicots) includes most dicots
- **Basal angiosperms** include the flowering plants belonging to the oldest lineages
- **Magnoliids** share some traits with basal angiosperms but evolved later

Good figure for a matching question on EXAM 3

	Embryos	Leaf venation	Stems	Roots	Pollen	Flowers
Monocot Characteristics	 One cotyledon	 Veins usually parallel	 Vascular tissue scattered	 Root system usually fibrous (no main root)	 Pollen grain with one opening	 Floral organs usually in multiples of three
Eudicot Characteristics	 Two cotyledons	 Veins usually netlike	 Vascular tissue usually arranged in ring	 Taproot (main root) usually present	 Pollen grain with three openings	 Floral organs usually in multiples of four or five

Basal Angiosperms

- About 100 species composing three small lineages constitute the basal angiosperms
- These include water lilies, star anise, and Amborella trichopoda

Basal Angiosperms

Water lily (*Nymphaea "Rene Gerard"*)

Star anise (*Illicium*)

Amborella trichopoda

Magnoliids

- Magnoliids consist of about 8,000 species, including both woody and herbaceous plants
- Magnoliids are more closely related to monocots and eudicots than basal angiosperms

Magnoliids

Southern magnolia (*Magnolia grandiflora*)

Monocots

- About one-quarter of angiosperms, about 70,000 species, are monocots
- The largest groups are the orchids, grasses, palms

Monocots

Orchid (*Lemboglossum rossii*)

Barley (*Hordeum vulgare*), a grass

Pygmy date palm (*Phoenix roebelenii*)

Eudicots (or "Dicots")

- More than two-thirds of angiosperms, about 170,000 species, are eudicots
- Eudicots include the large legume family and the economically important rose family

Eudicots

Snow pea (*Pisum sativum*), a legume

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

Pyrenean oak (*Quercus pyrenaica*)

Concept 30.4: Human welfare depends on seed plants

- Seed plants are key sources of food, fuel, wood products, and medicine (i.e. atropine, belladonna)
- Our reliance on seed plants makes preservation of plant diversity critical
- Most of our food comes from angiosperms
- Six crops (wheat, rice, maize, potatoes, cassava, and sweet potatoes) yield 80% of the calories consumed by humans
- Modern crops are products of relatively recent genetic change resulting from artificial selection
  - EX: Edibles and seed plants are used in medicines

Threats to Plant Diversity

- Destruction of habitat causes plant species extinction
- In the tropics, 63,000 km^2 are cleared each year
- At this rate, the remaining tropical forests will be eliminated in 175 years
- Loss of forests reduces the absorption of atmospheric CO_2 that occurs during photosynthesis
- Loss of plant species is often accompanied by loss of the animal species that plants support
- Estimated 50% of Earth's species will become extinct within the next few centuries
- The tropical rain forests may contain undiscovered medicinal compounds