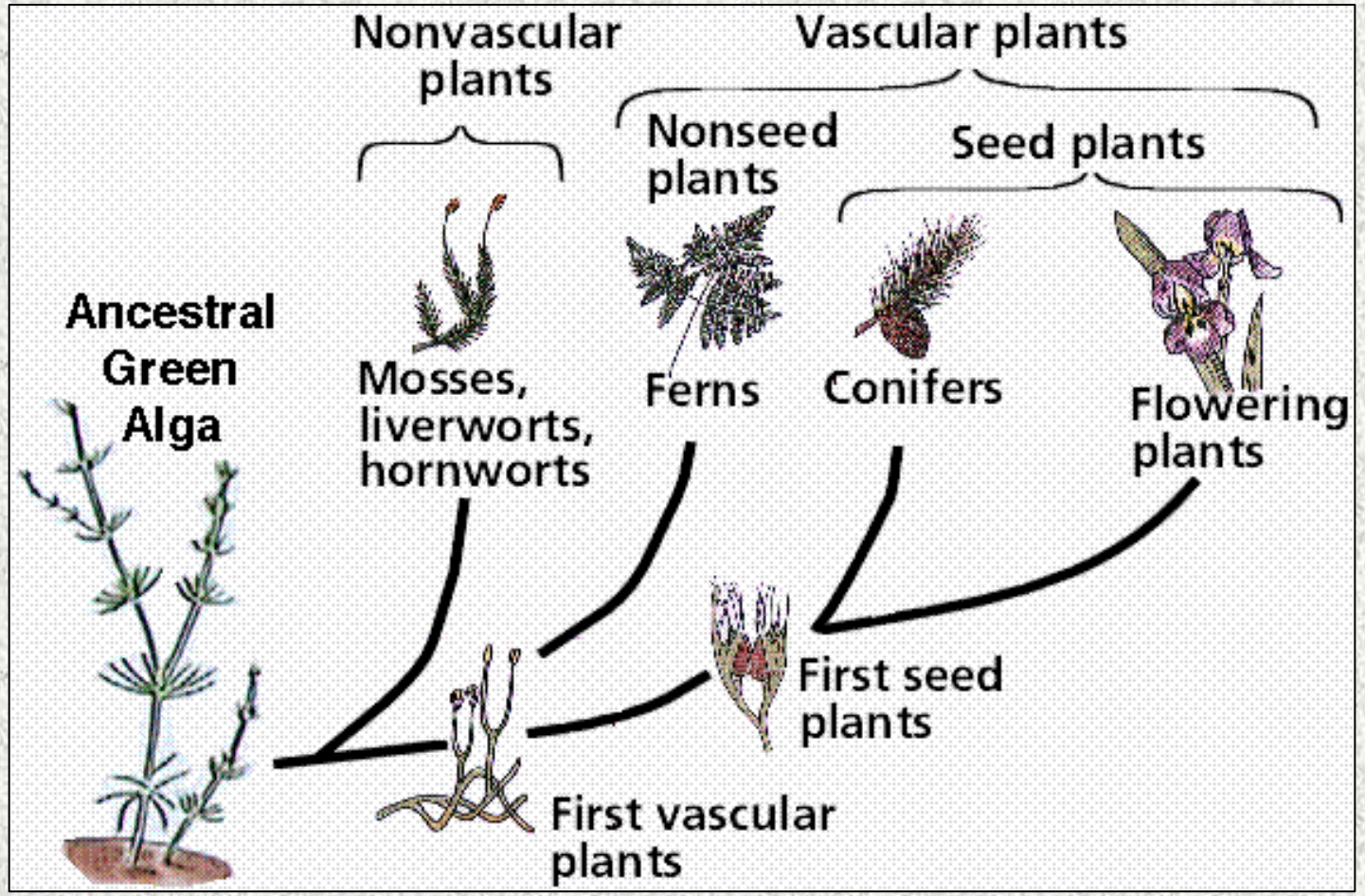
Land Plant Diversity

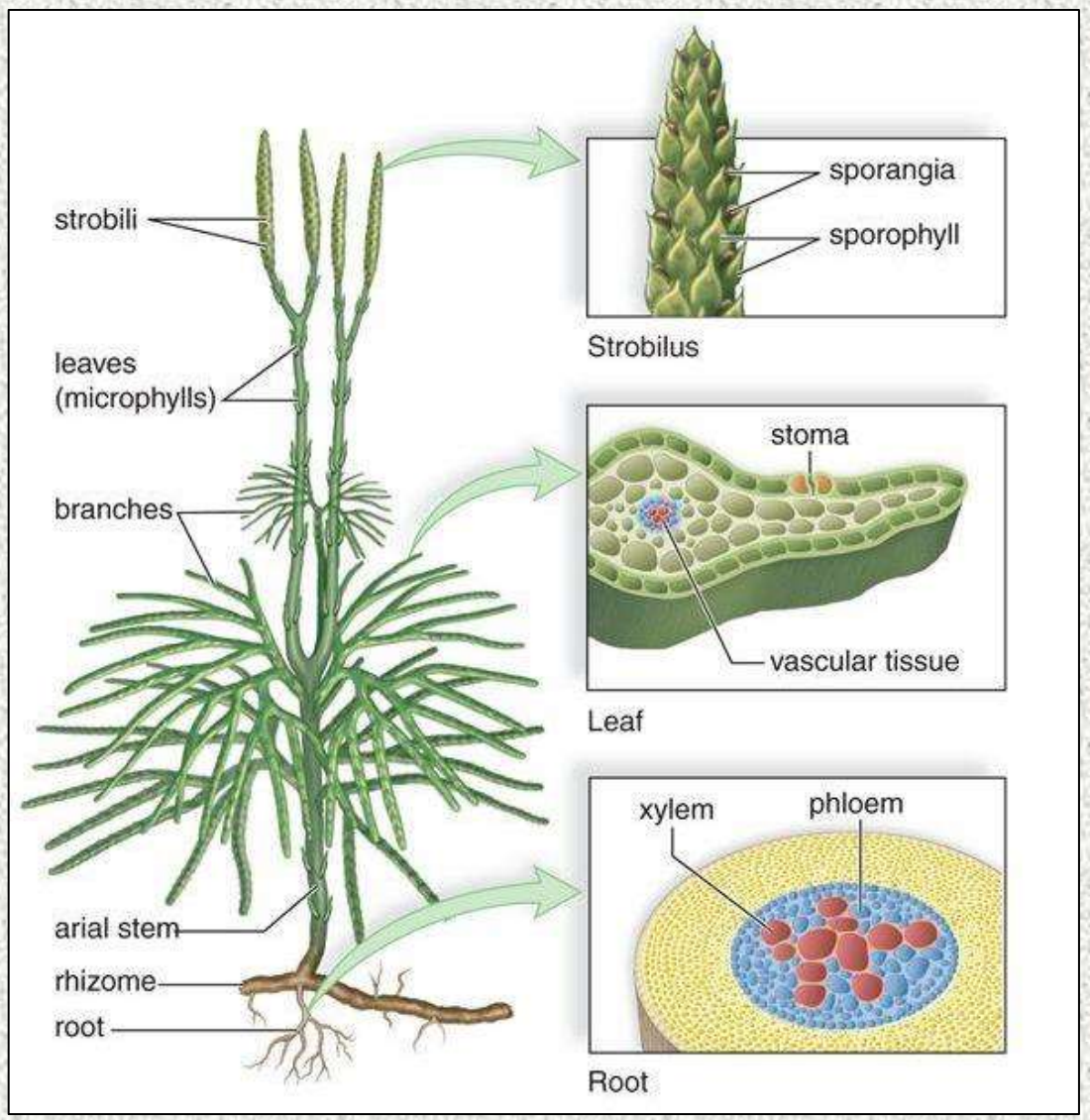
Seed Plants: Gymnosperms and Angiosperms



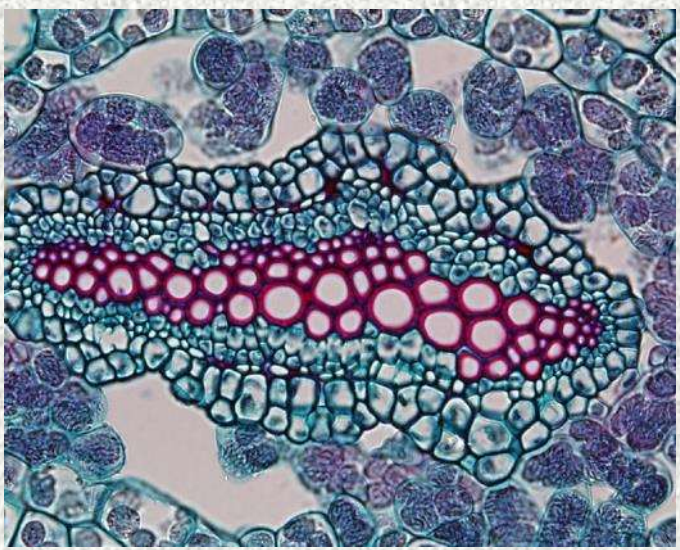
Non-vascular Plants – the Bryophytes

Vascular Seedless Plants – Ferns and Fern Allies

Adaptations for Life on Land



Vascular tissue (xylem and phloem)



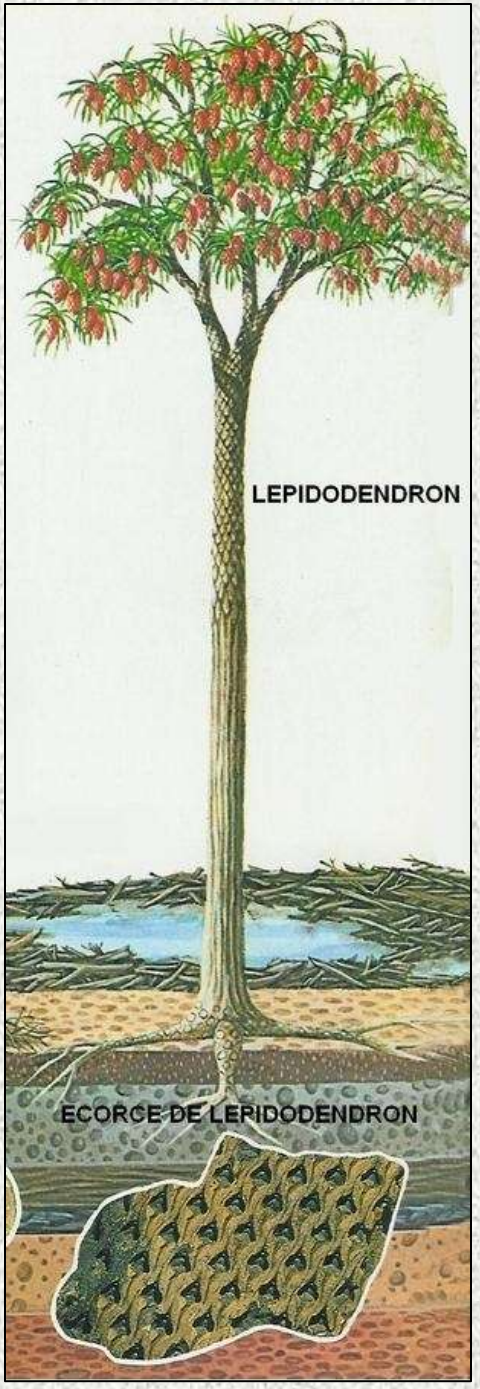
Carboniferous – Lycophyte Forests

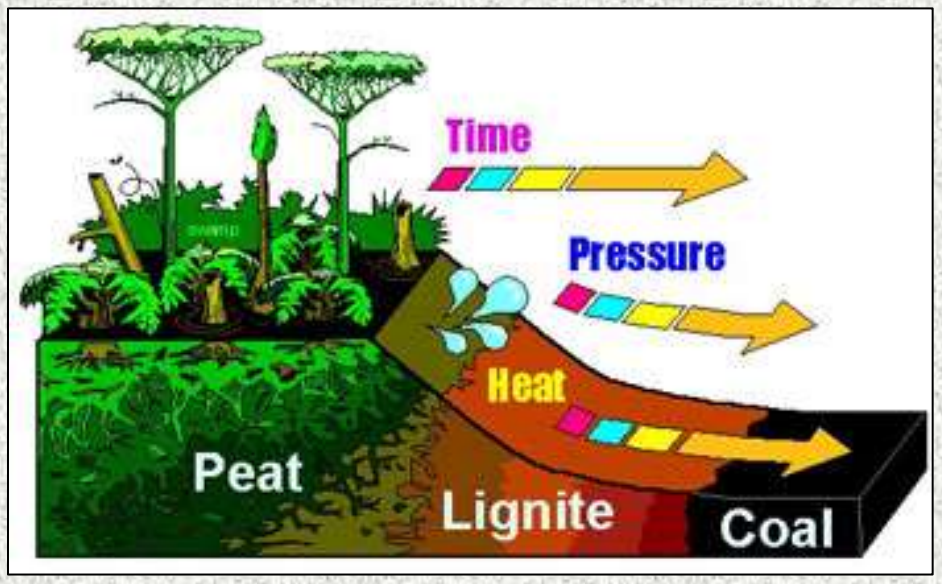
Seedless vascular plants: Ferns and fern allies

- Giant tree ferns, horsetails and lycopods were the dominant vegetation of the Carboniferous period.
- Their fossilized remains formed extensive coal beds.
- They were ultimately superseded by the seed plants and far fewer survive today.

Carboniferous Forest – 300 mya

Coal Fromation





Smoky St. Louis, Nov. 28, 1939

Missouri currently gets more than 80 percent of its electricity from coal-fired power plants like Ameren's Labadie power plant, pictured here.

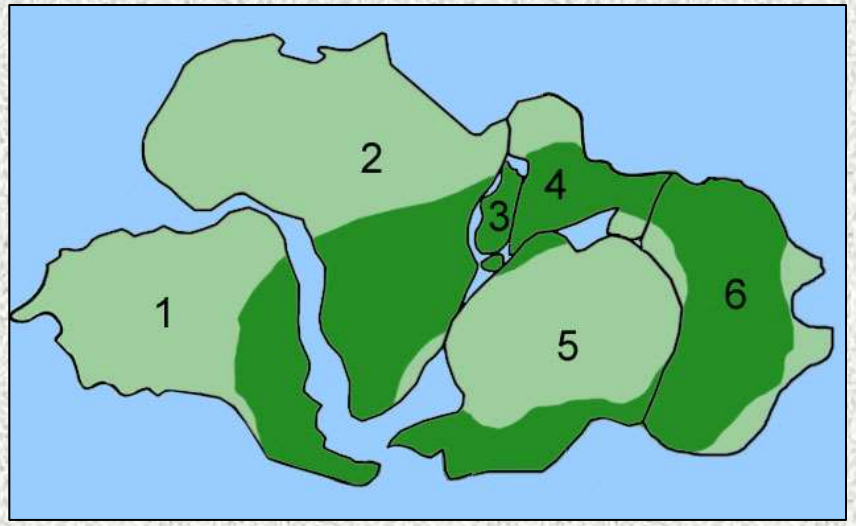
Spores and seeds

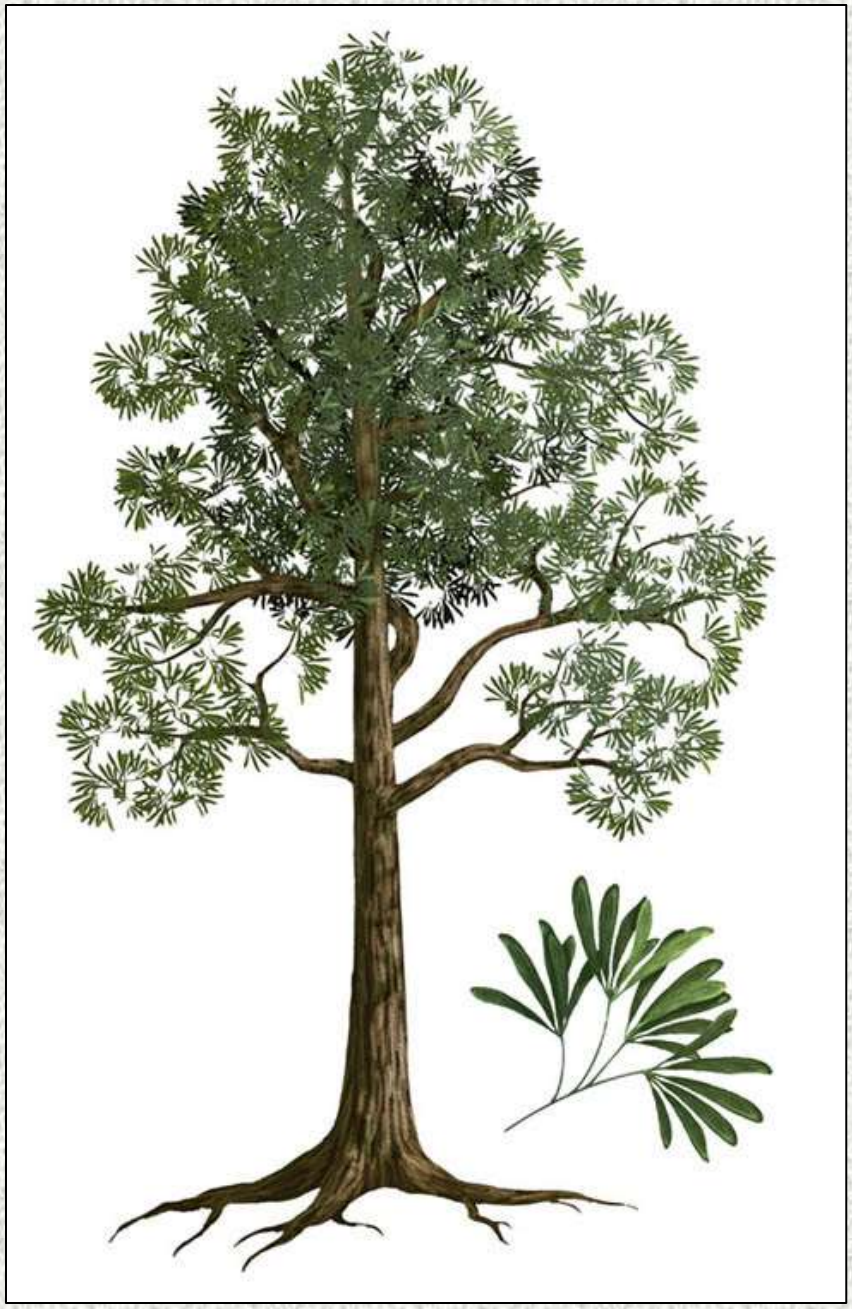
- The spores of ferns are tiny and vast numbers are produced. However, their prospects of survival are low.
- Spores are thinner walled and more vulnerable to pathogens and damage.
- Spores have a short lifetime

- Seeds arose in the Carboniferous Period. Seeds and later fruit proved to be enormously successful and seed plants came to dominate the planet.

Glossopteris – A Seed Fern

Permian





Fossilized Seed Fern Seeds

Medullosan seed fern Trigonocarpus

Found in the coal measures of England, UK, and date from the Upper Carboniferous (310 to 280 million years ago).

Seeds!

Advantages of seeds

- **Protection and nourishment**: for developing embryo.
- **Dispersal**: seeds can be dispersed more widely than spores by enclosing them in a bribe (fruit) and having animals move them.
- **Dormancy**: the developing embryo is protected and can wait a long time to germinate when conditions are good.

Gymnosperms

Gymnosperms

- Naked seeds
- Lack the enclosed chambers (ovaries) in which angiosperm ovules and seeds develop
  - Rather, gymnosperm ovules and seeds develop on the surfaces of specialized leaves called sporophylls
- Wind pollination
  - Water not needed for pollination
- All are woody plants (no herbaceous species)
- Date from 350 mybp

Gymnosperm Life Cycle

- In gymnosperms dominant generation is the tree (sporophyte),

- Pine trees (and other gymnosperms) produce both ovulate and pollen cones.

Gymnosperm Life Cycle

- Pollen cone contains sporangia that undergo meiosis to produce haploid microspores that develop into male gametophytes (n).

- Pollen is wind dispersed and some lands on ovulate cones.

Gyymnosperms – “naked seed” plants
Have no flowers or fruit, seeds borne naked

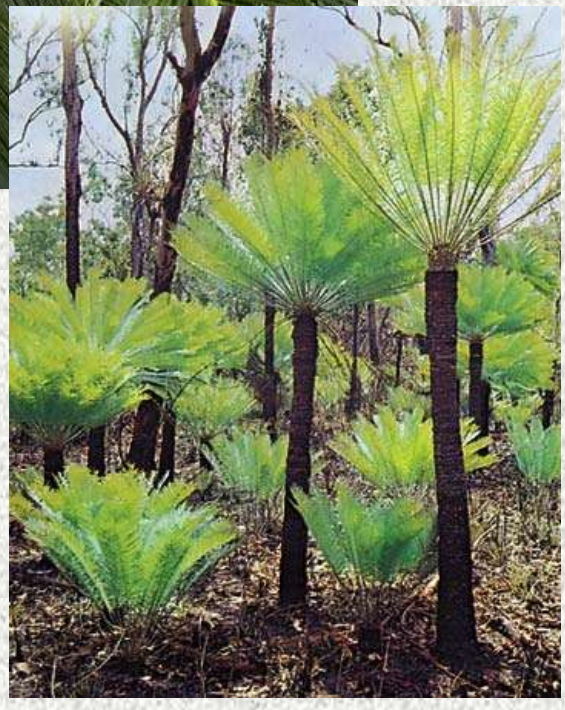
Gymnosperms were the dominant plants during the Age of Dinosaurs (Mesozoic 245-65 mya).

Modern Gymnosperms

- Gymnosperms have “naked” seeds that are not enclosed in an ovary (as angiosperm seeds are).
- There are four extant groups.
  - -Cycads
  - -Ginkgo
  - -Gnetales
  - -Conifers

Cycads

- 130 species
- New and Old World tropics
- Large palm-like leaves and large cones.
- Dioecious, separate sexes
- Large seeds
- Motile sperm cells



a. An African cycad

(tree): © Hoberman Collection/Alamy; (cone): © PlazaCameraman/Getty RF

Cycads – *Zamia pumila*

Encephalartos Cones

Dioon califanoi

Dioon purpusii

Dioon merolae

Dioon spinulosum

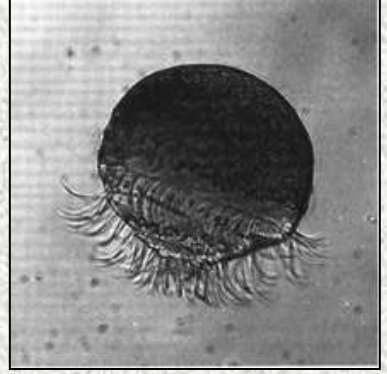
Microcycas calocoma

Microcycas calocoma

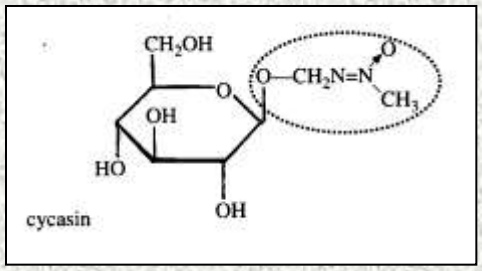
The Strange World of Cycads

Atala Herbivory

Relict Distribution



Motile Spermatozoid



Toxins

Sporophylls

Fern-like Leaves

Insect Pollination

Coralloid Roots

Molecular Data
*trn*L intron, ITS2, *atp*B–*rbc*L, *trn*S-*trn*G

2405 Characters

520 Informative Sites

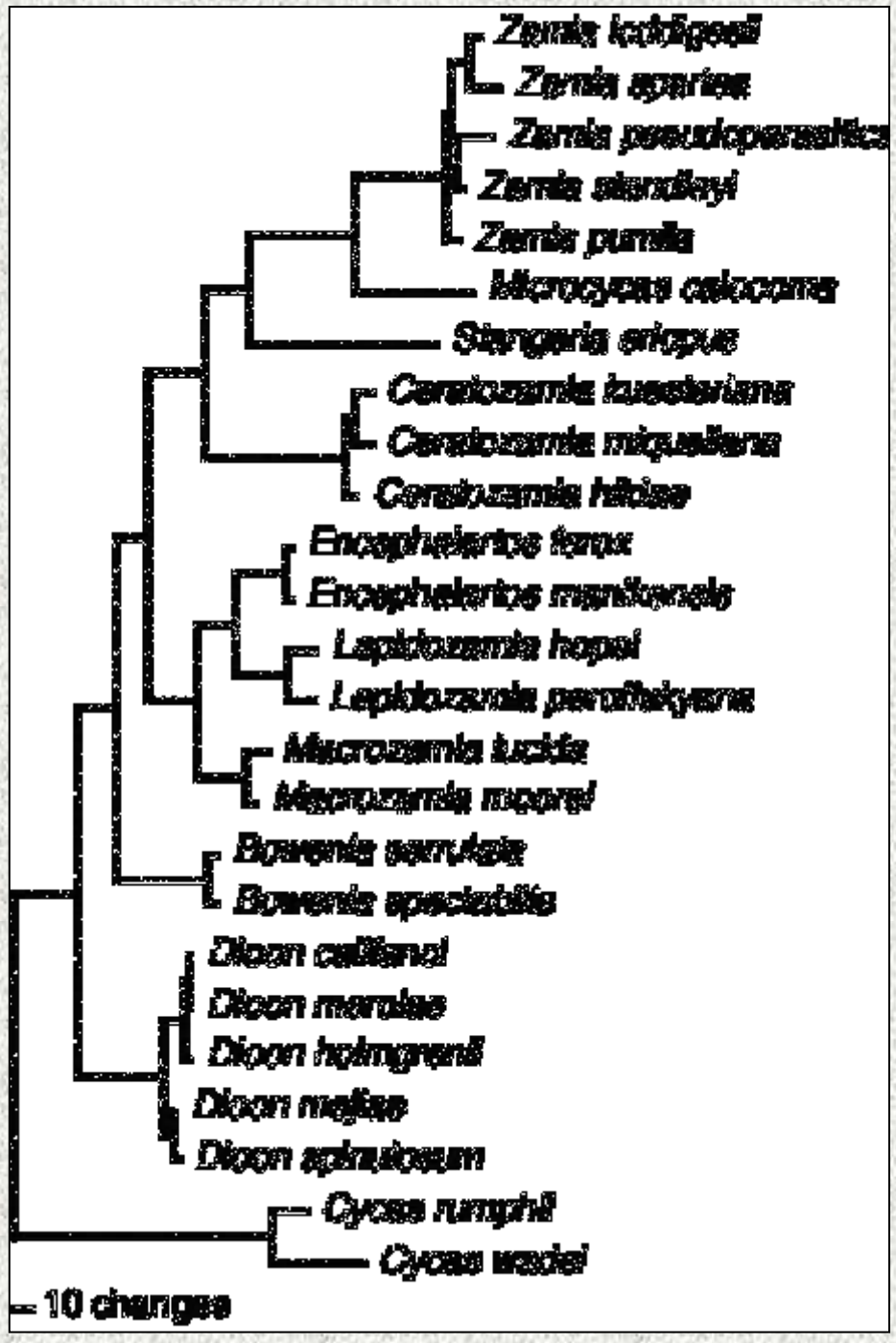
1 Tree

CI = 0.777

RI = 0.861

Single Most Parsimonious Tree

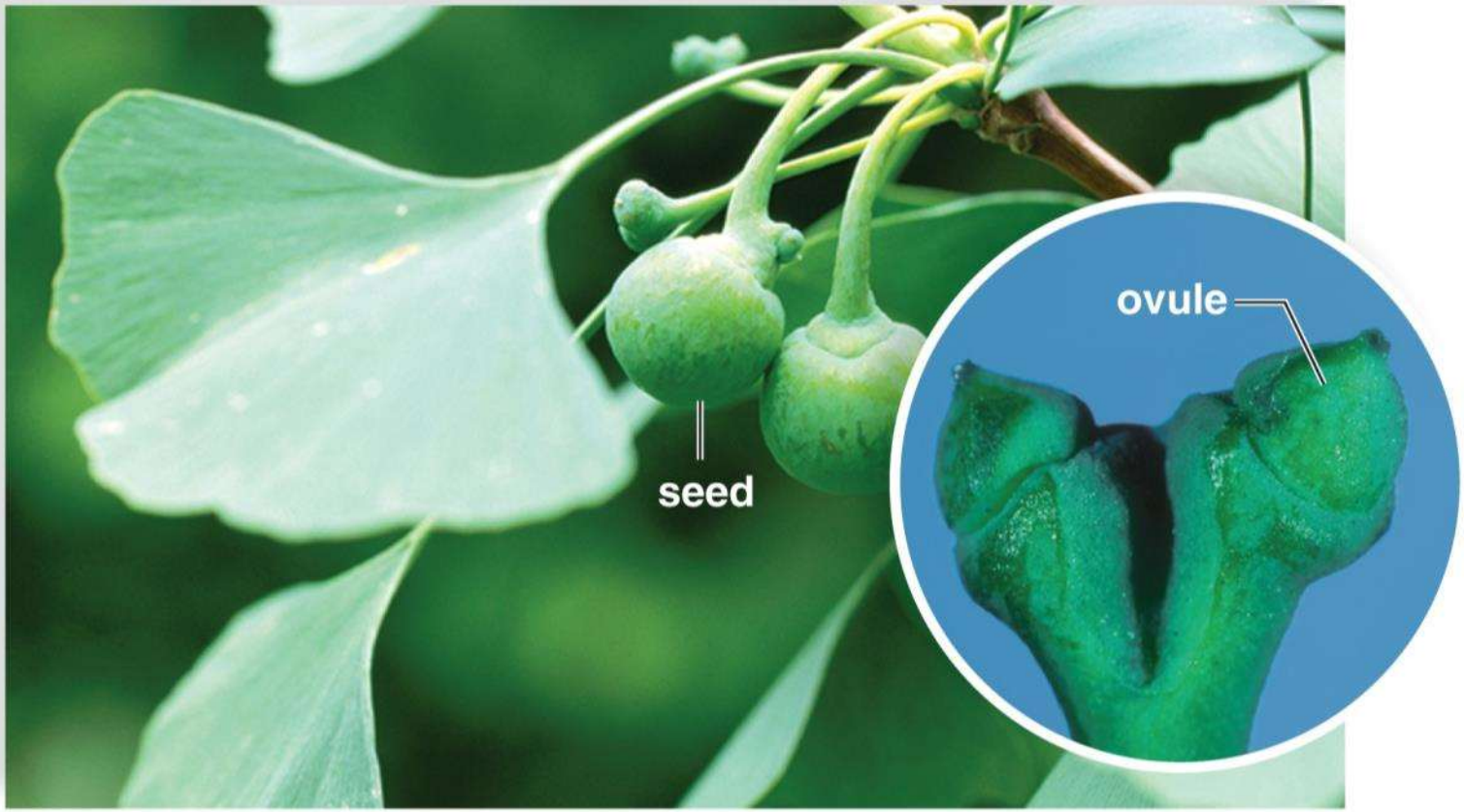
Bogler et al. 2006



Ginkgo

- 1 species
- Unknown in wild, previously widespread
- Seed coat is fleshy.
- Widely planted street tree
- Fleshy seeds ripen in fall and have foul odor

Ginkgo biloba, a Native of China



b. *Ginkgo biloba*, a native of China
(Gingko branch): © blickwinkel/Alamy; (Gingko ovule): © Ken Robertson, University of Illinois/INHS

Ginkgo biloba - MBG

Ginkgo – Tower Grove Park

Gnetophytes

- 3 genera
- 90 species,
- Double fertilization
- Transition to angiosperms?

Ephedra

Welwitschia

Gnetum

Ephedra, a Gnetophyte

c. *Ephedra*, a type of gnetophyte

c(ephedra plant): © Evelyn Jo Johnson; c(ephedra inset): © Karl J. Niklas

Welwitschia

- Found in the Namib Desert
- Two enormous leaves, the longest lived of any plant
- Grow about five inches a year
- Each leaf can reach several hundred square feet in size

Welwitschia miribilis, a Gnetophyte

d. *Welwitschia*, a type of gnetophyte

Conifers

a. Pine

b. Spruce

c. Juniper

a(seed cones): © Steven P. Lynch; a(pollen cones): © Maria Mosolova/Photolibrary/Getty RF; a(forest): © Steven P. Lynch; b: © Ed Reschke/ Peter Arnold/Getty Images; c(tree): © Steffen Hauser/botanikfoto/Alamy

Conifers

- Produce **cones**
- Tough, needlelike leaves of pines conserve water with a thick cuticle and recessed stomata.
- Sporophyte is dominant.
- Pollen grains are windblown.
- Seed is the dispersal stage.
- **Monoecious** – A single plant produces both pollen (male reproductive structure) and seed cones (female reproductive structure).

Conifers

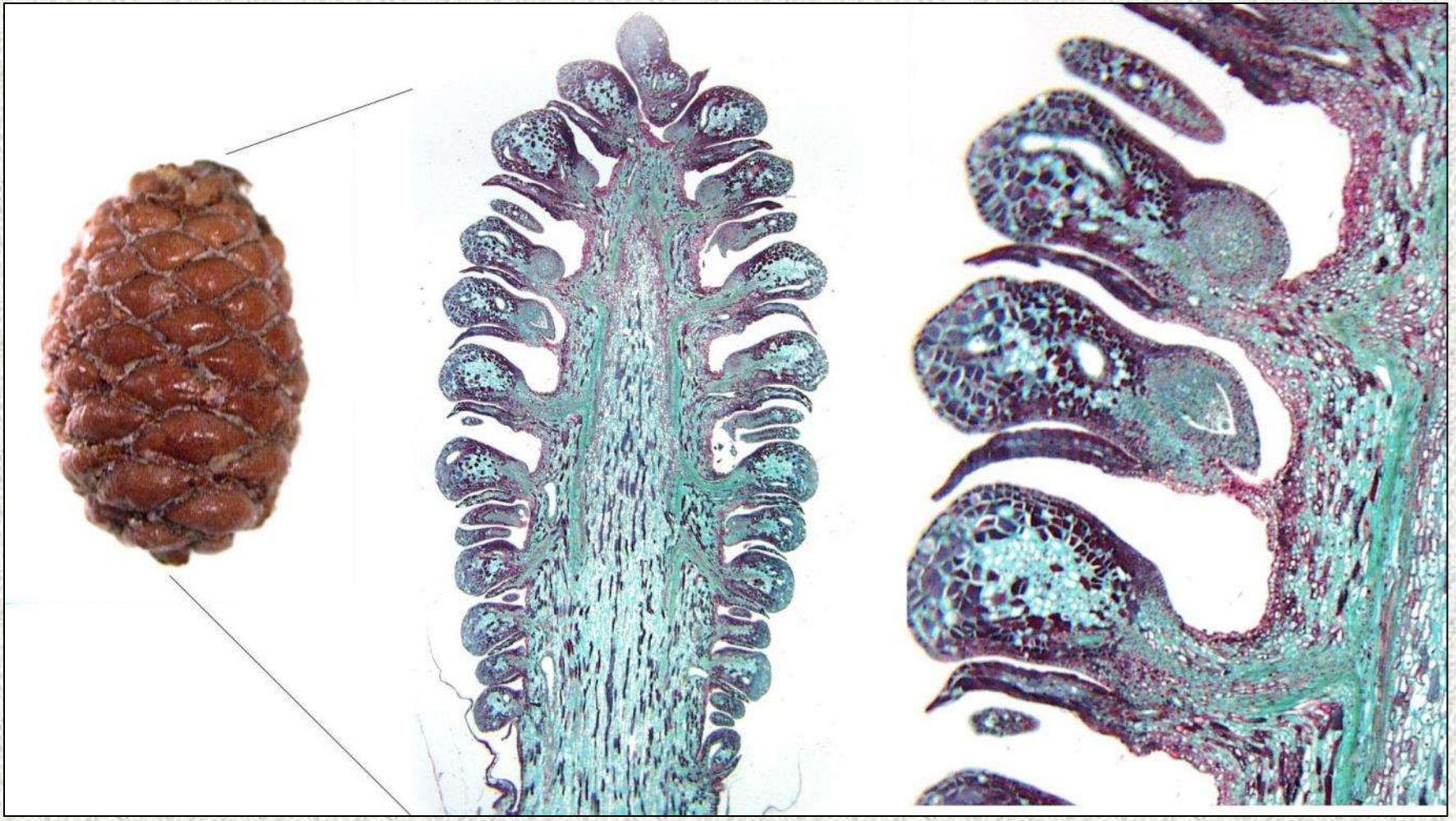
- 600 species in 7 families
- Most important gymnosperms
- Pine, spruce, fir, cedar, etc.
- Complex seed cones
- Needled leaves reduce water loss

Picea abies

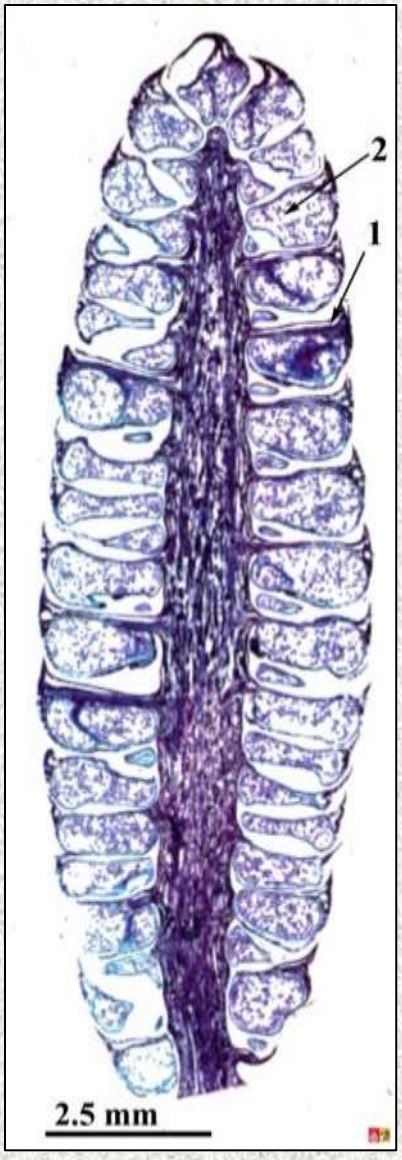
Pinus densiflorus

Cedrus libani

Pine Life Cycle: Female Cone (Megastrobilus)



Pine Life Cycle: Male Cone (Microstrobilus)



Pinus Pollen

Life Cycles of a White Pine Tree

Conifer – Gymnosperm

Adult Tree
Sporophyte Generation

Male Cone

Female Cone

Seeds inside

Mature Fruit
developed from ovary
to protect seeds and
promote seed dispersal

Pollen Grain
Male Gametophyte
Generation
(haploid)

Embryo
Female Gametophyte
Generation
(haploid)

pollen tube brings
pollen into ovary
for fertilization

Angiosperms - Anthophyta

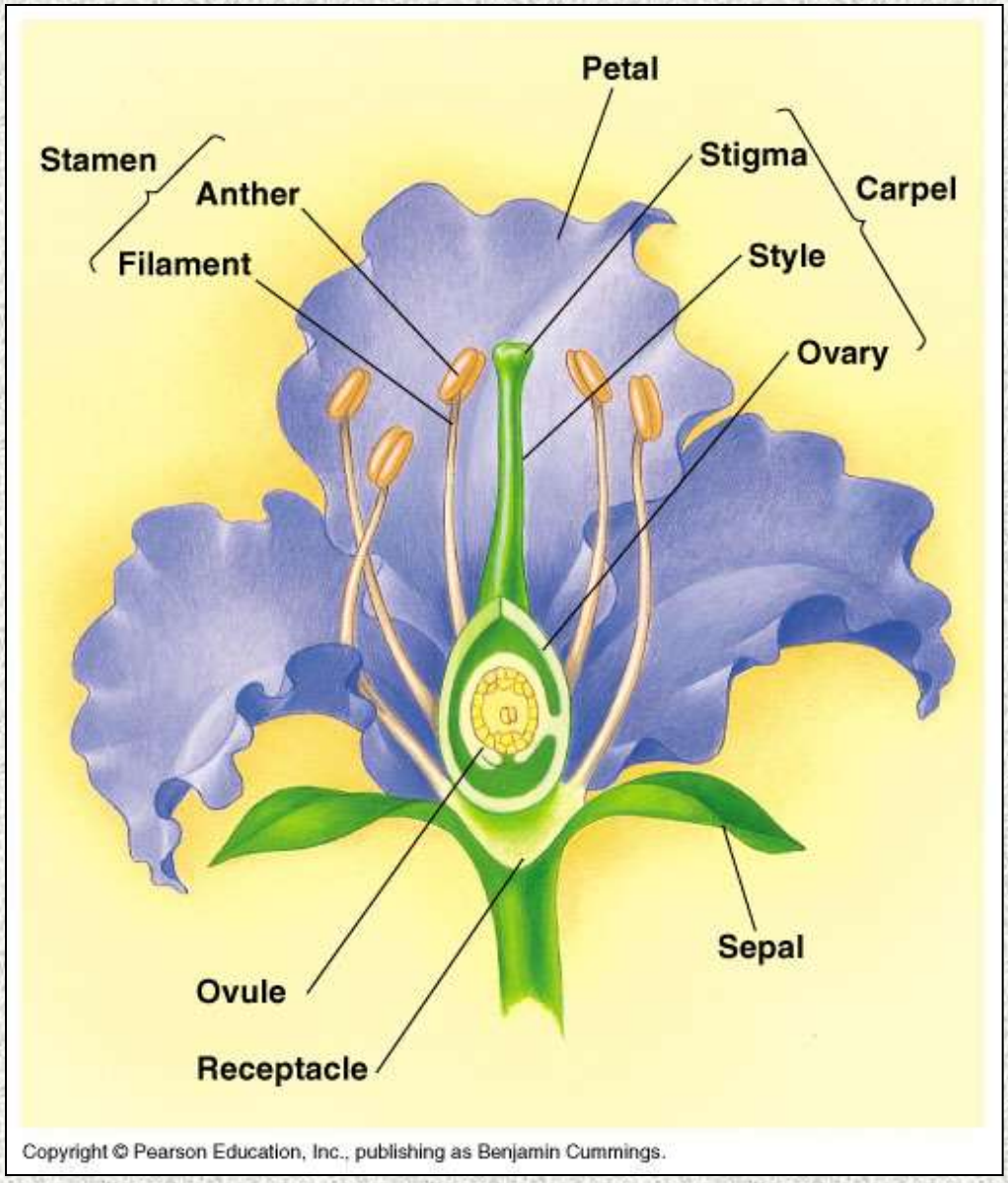
Angiosperms

- Exceptionally large and successful group of plants, with 250,000 known species.
- Range in size from tiny duckweed to *Eucalyptus*, over 100 m tall.
- Appeared in the Cretaceous (when dinosaurs still around)
- Dominant plants in modern times

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

Angiosperms: Flowers

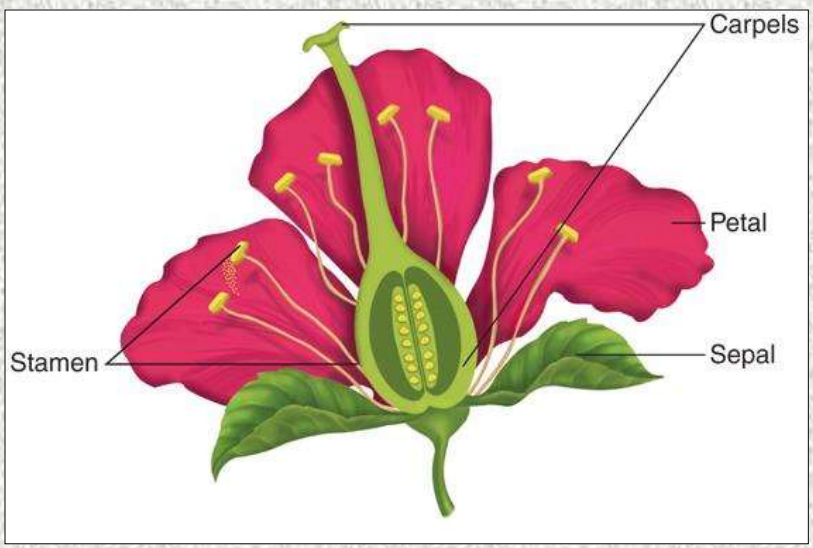


What is a Flower?

- **Flowers advertise Plant Sex**
  - Corolla is the “red-light” advertising!
  - All the naughty parts on display!
  - Even Snacks, Drinks & Comfort provided!

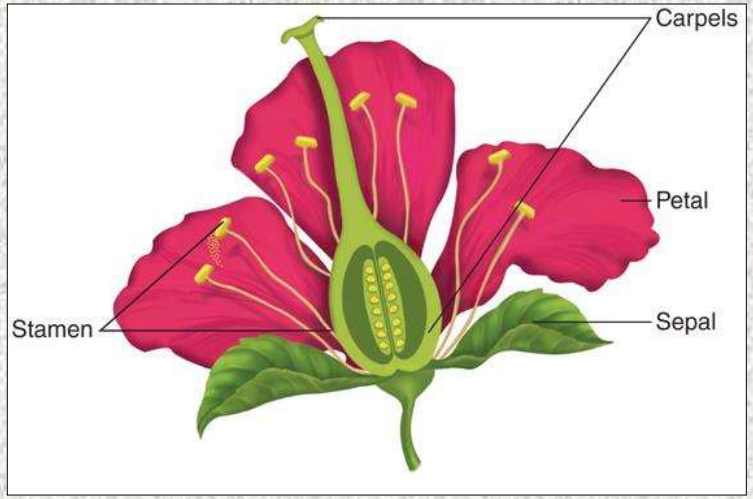
Flower Structure

- Complete flowers have four major parts.
- **Sepals** – located at base of flower; surround and protect the bud.
  - Dicot sepals are usually green and leaf-like.
  - Monocot sepals often resemble petals (called tepals).



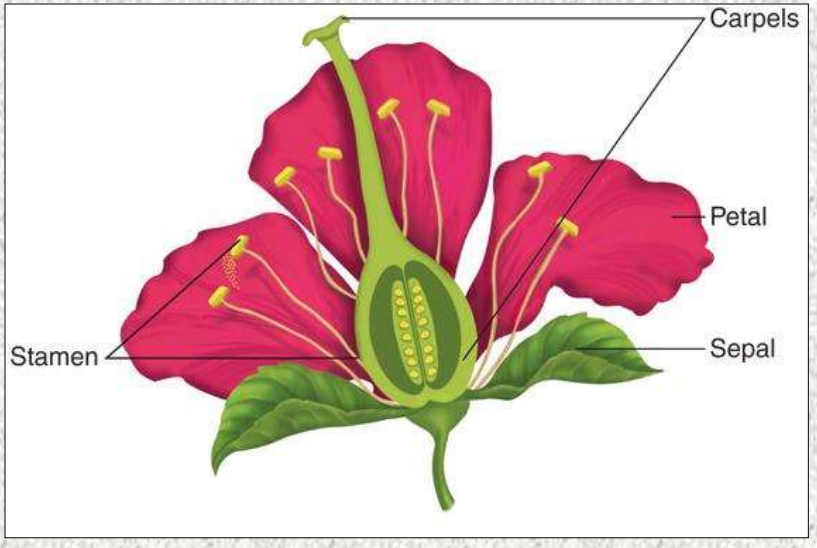
Flower Structure

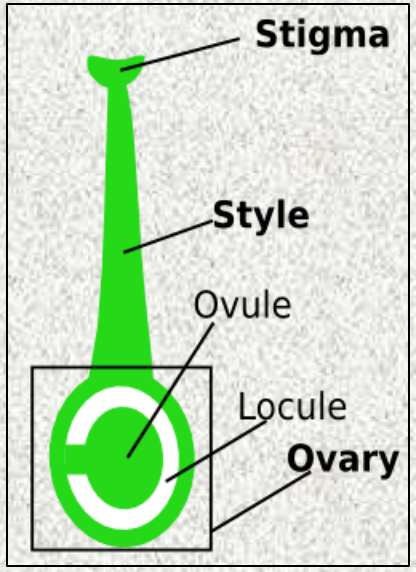
- **Petals** – located above sepals; usually brightly colored and fragrant (attract pollinators).
- **Stamens** (male reproductive structures) – attached above petals.
  - Each consists of a **filament** (stalk) and **anther** (produces pollen).



Flower Structure

- **Carpel** (female reproductive structure) – centrally located
  - Each consists of a sticky **stigma** (catches pollen), an elongate **style**, and a bulbous **ovary** containing one or more **ovules.**
    - Ovules develop into seeds.
    - Ovary develops into a **fruit.**





Stamens and Carpels are the Reproductive Organs

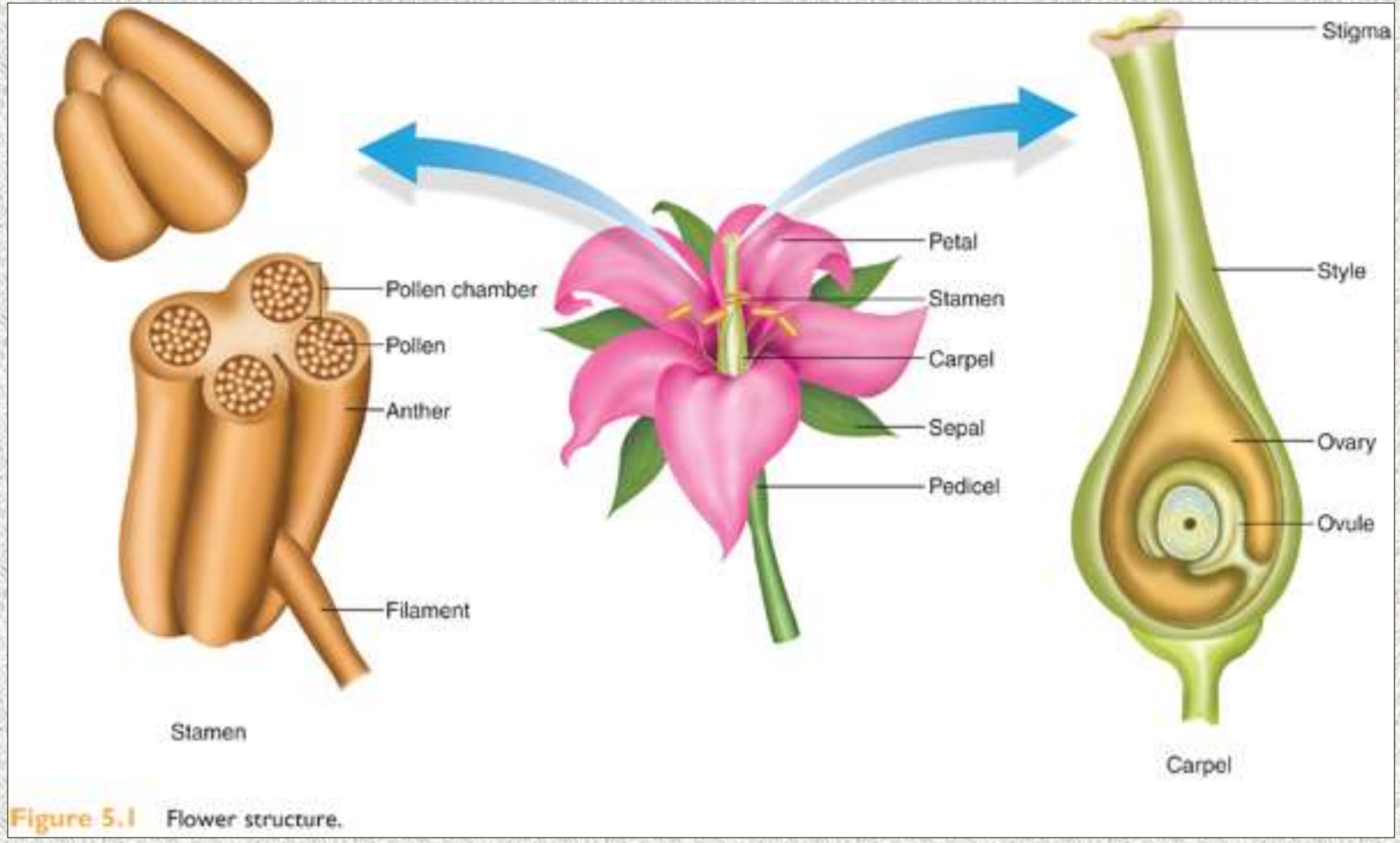
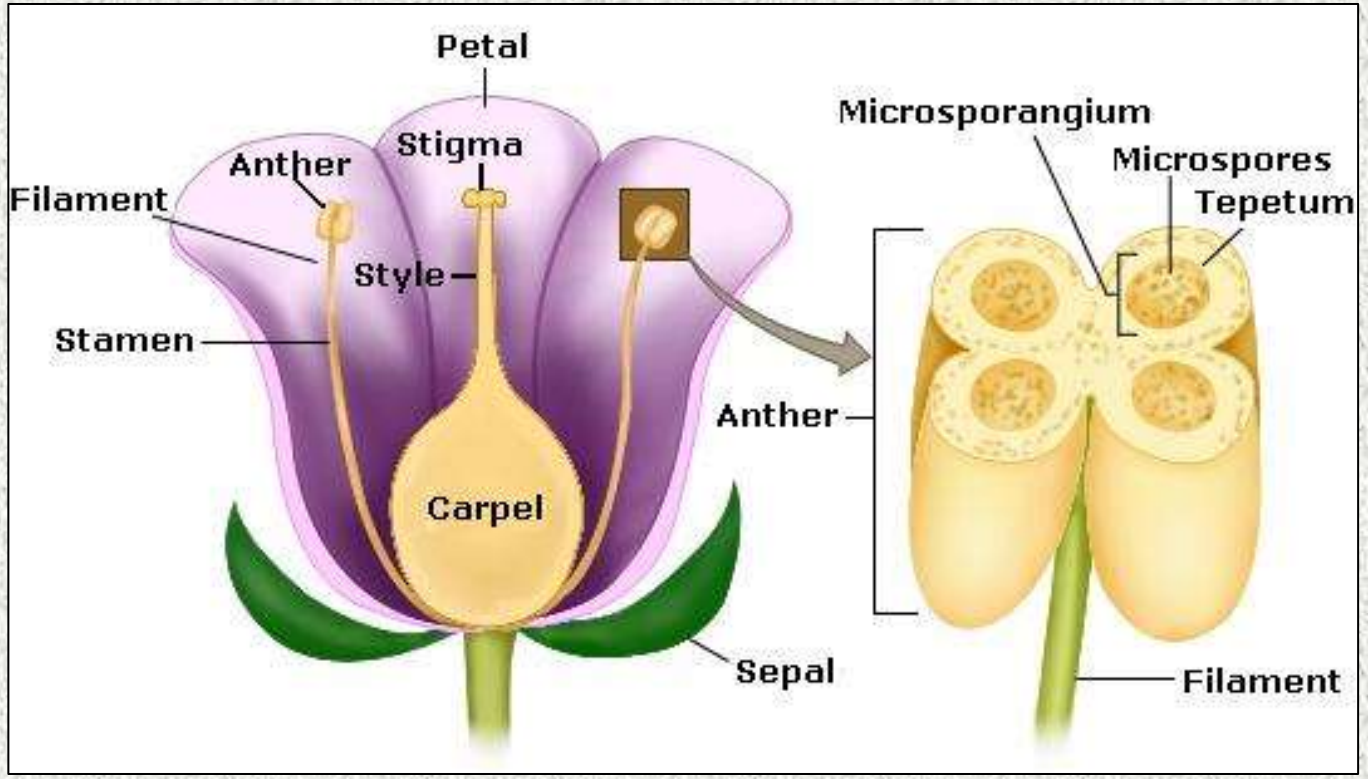
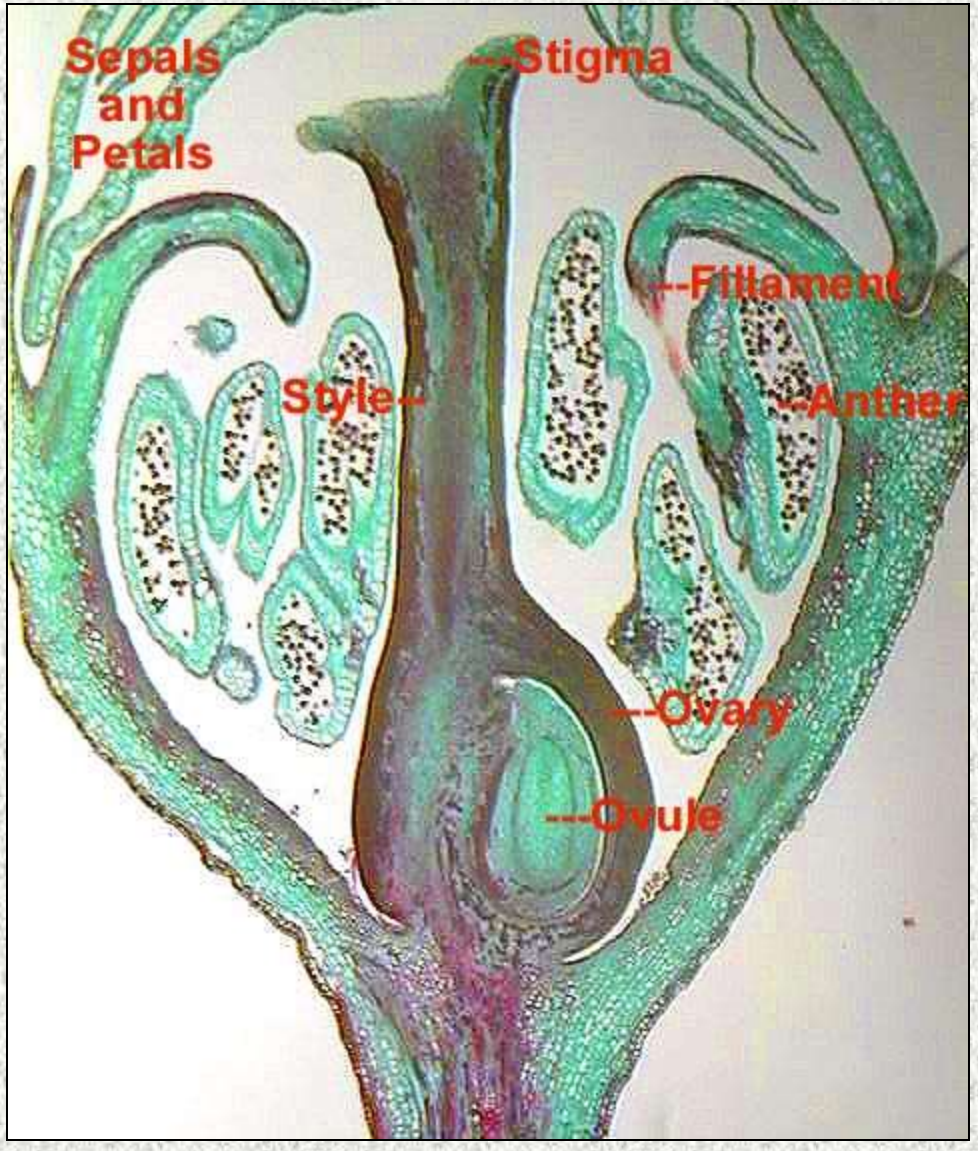


Figure 5.1 Flower structure.



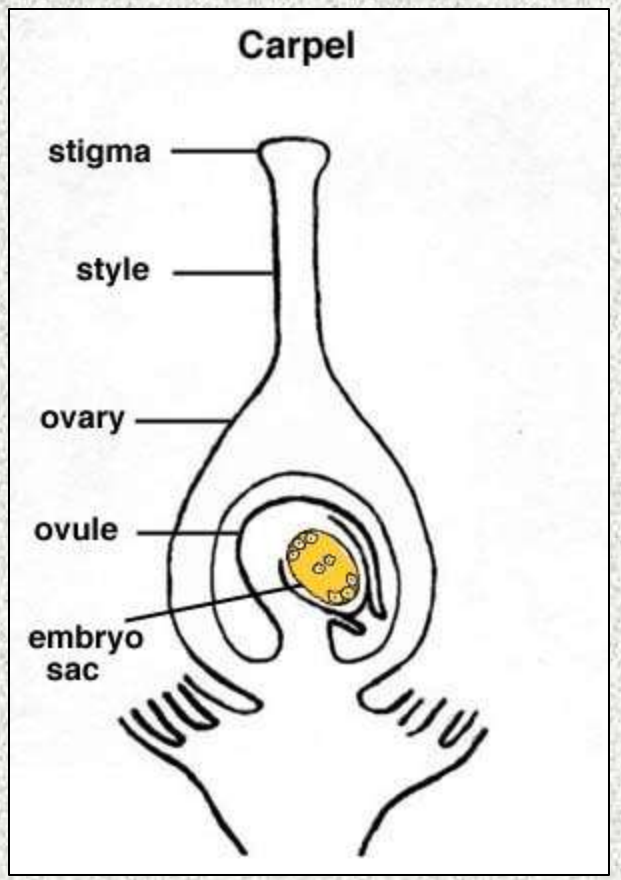
Each **stamen** consists of an anther and a filament (stalk).

Carpel = Pistil = Gynoecium

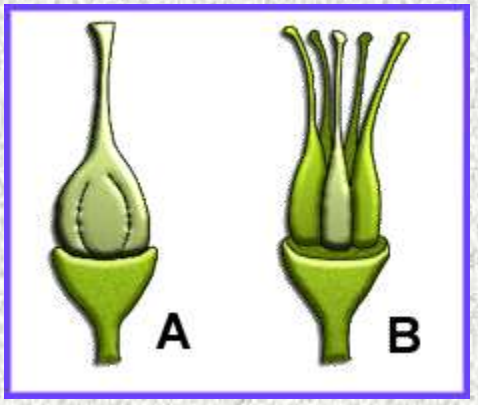


Carpel has three major regions

- **Ovary** – Swollen base enclosing ovules
  - Ovules develop into seeds.
  - Ovary develops into fruit.
- **Style** – Elevates stigma
- **Stigma** – Sticky receptor of pollen grains



Carpels can be single, separate, or united



Cross Section of Carpel (Pistils) Ovary with Ovules

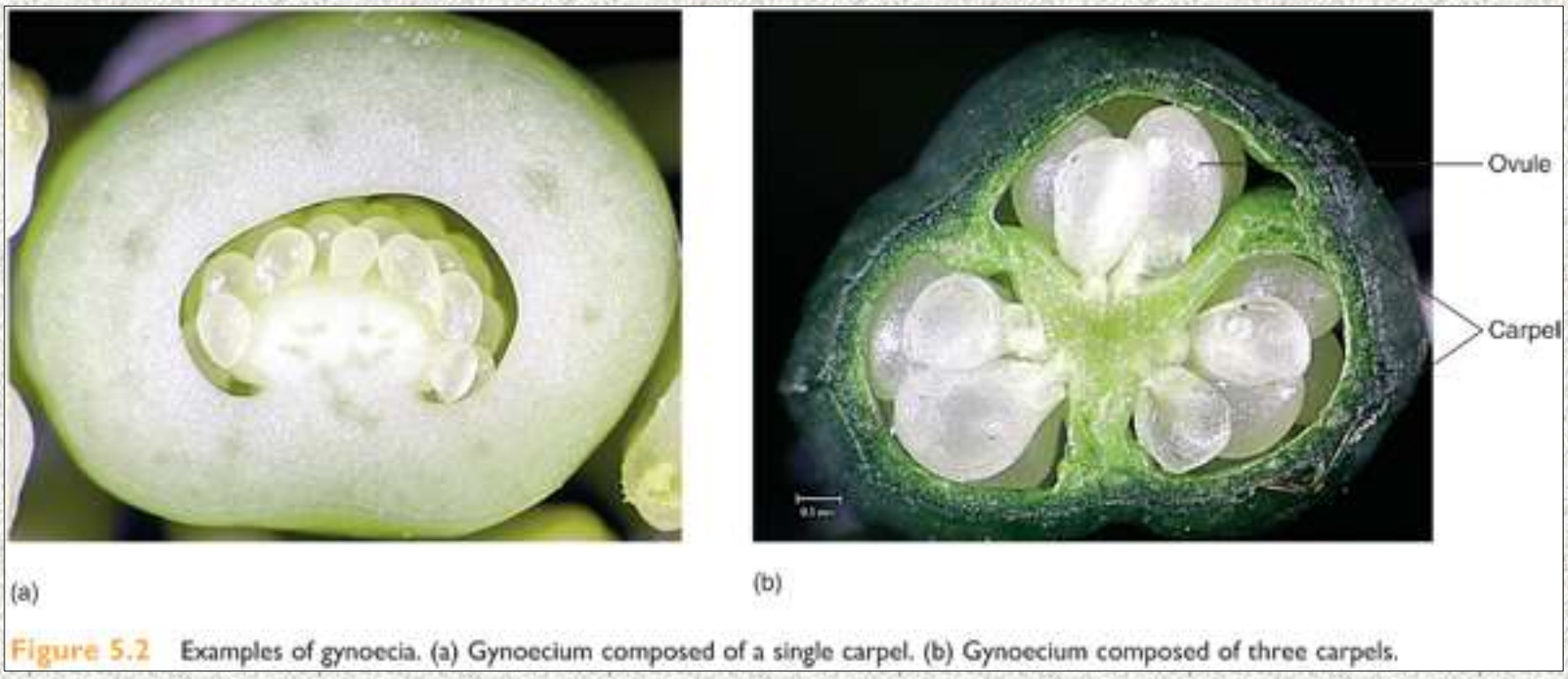
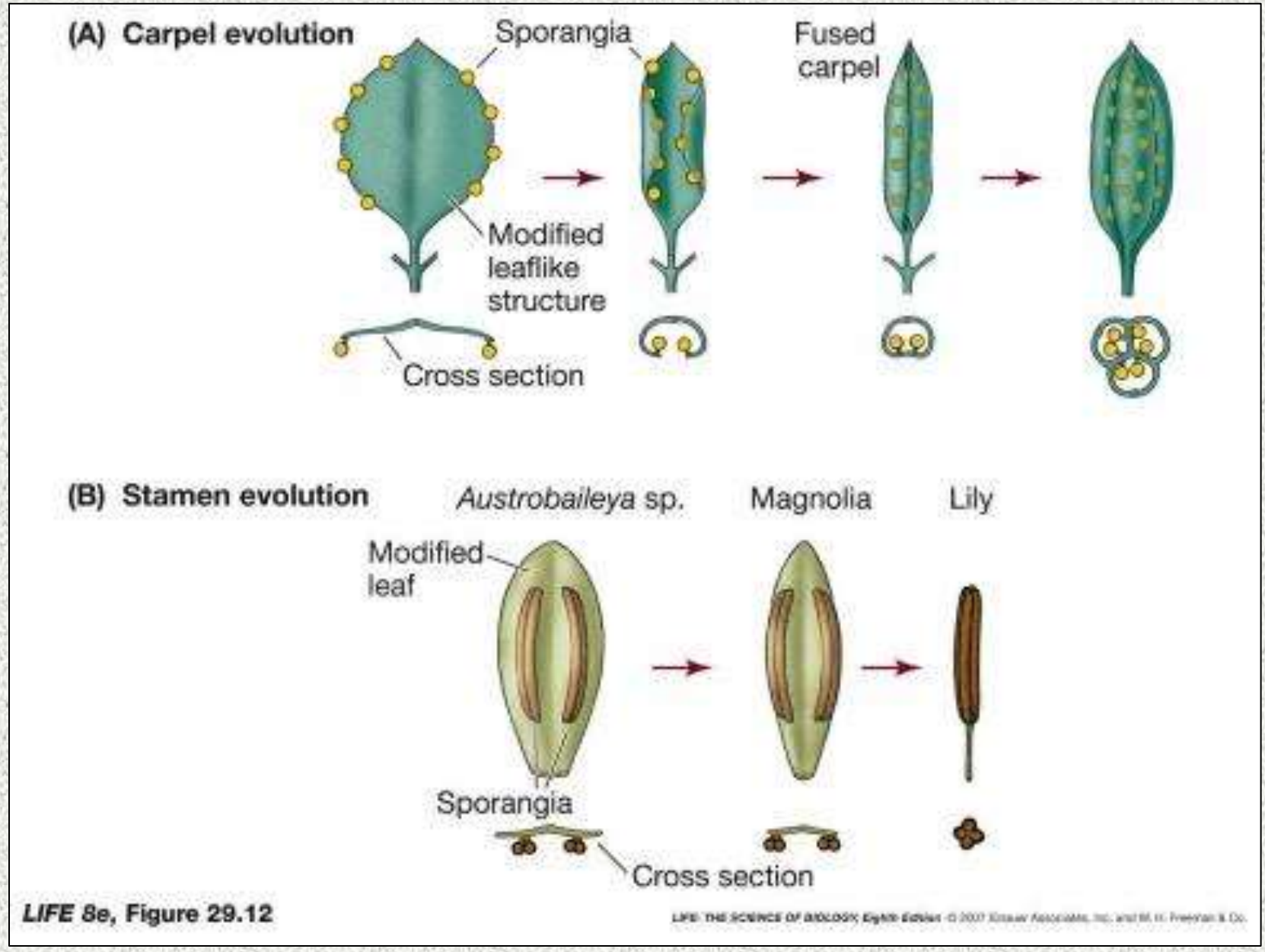


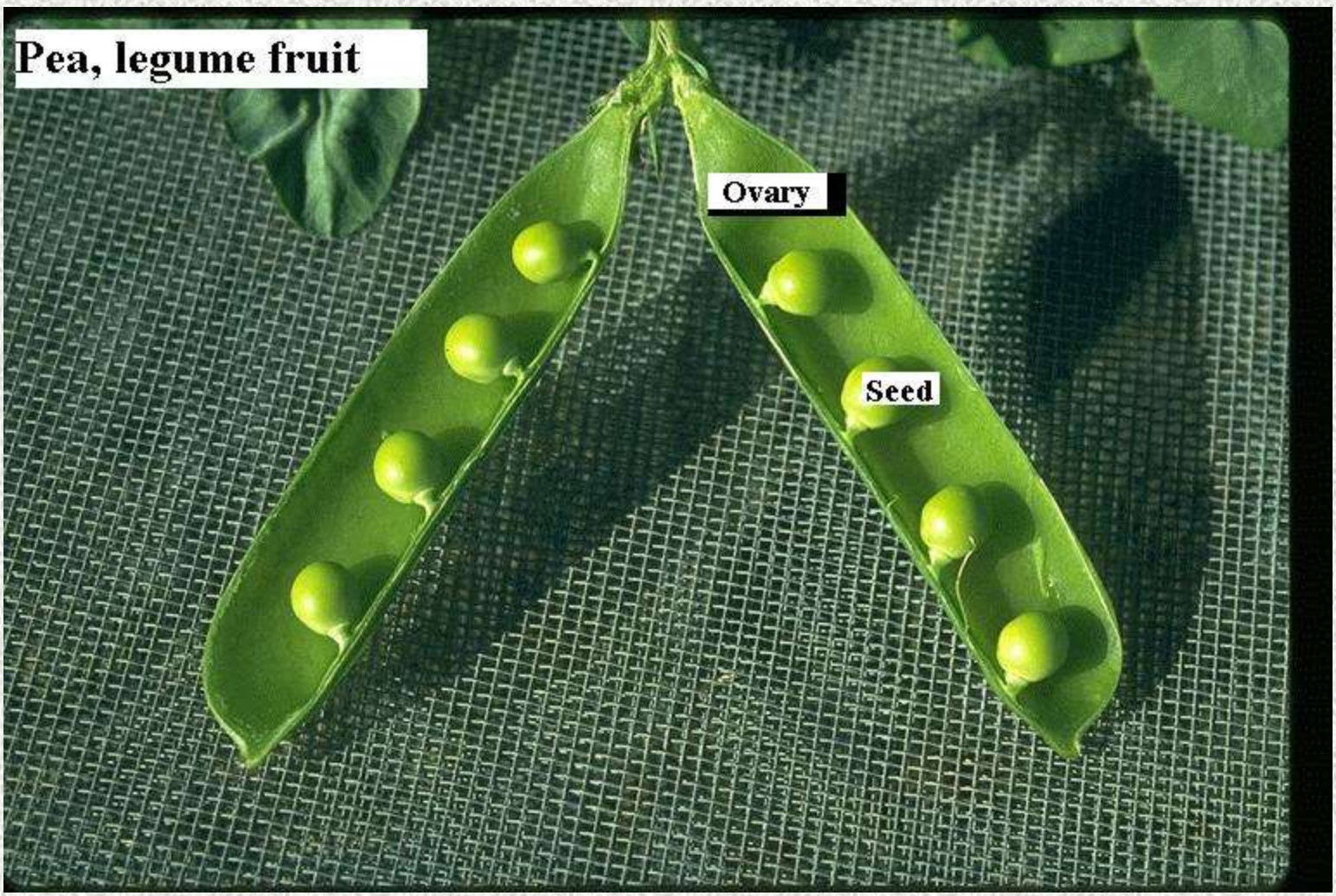
Figure 5.2 Examples of gynoecia. (a) Gynoecium composed of a single carpel. (b) Gynoecium composed of three carpels.

Carpel and Stamen Evolution from sporophylls



LIFE 8e, Figure 29.12

Carpels



Two Big Groups of Angiosperms

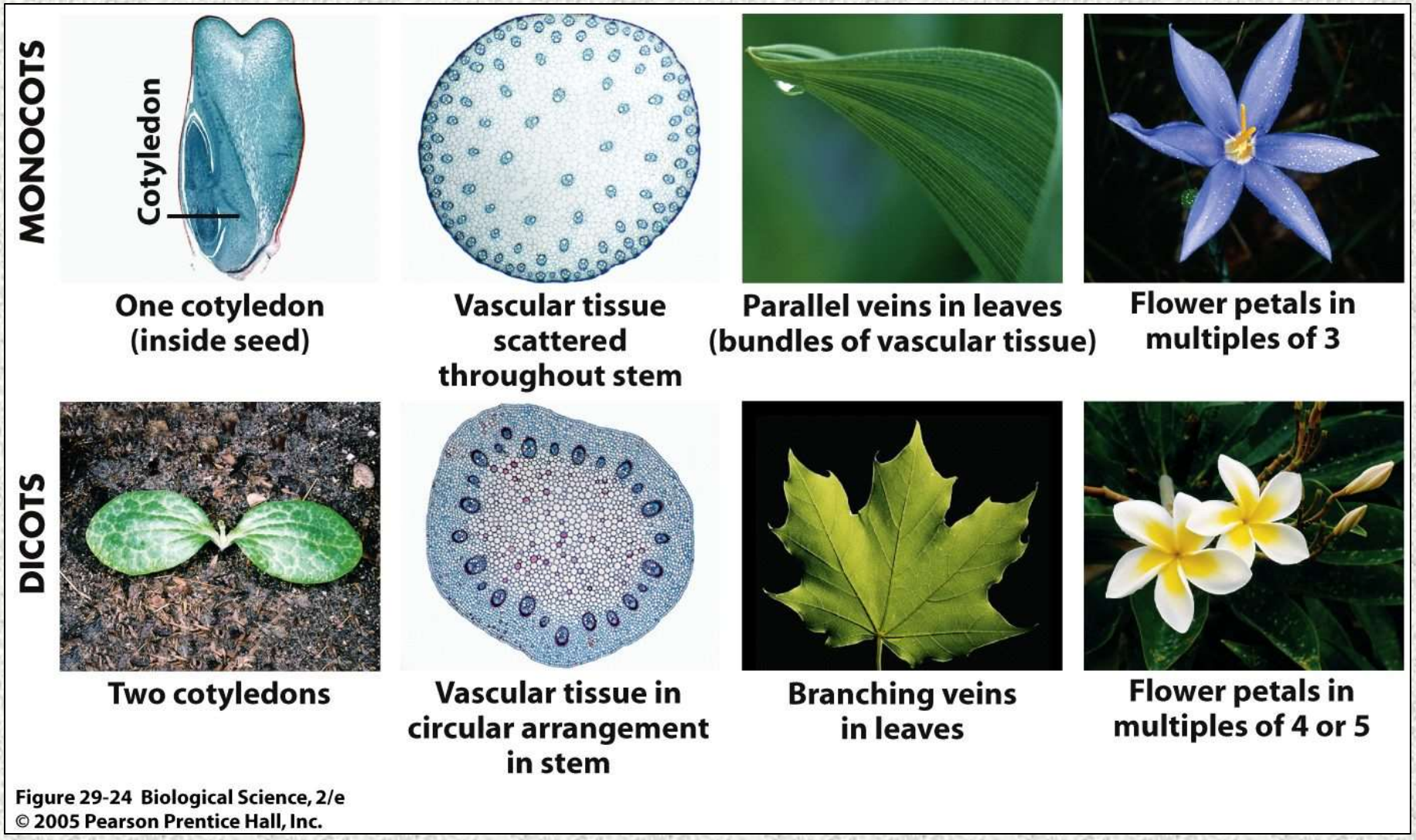
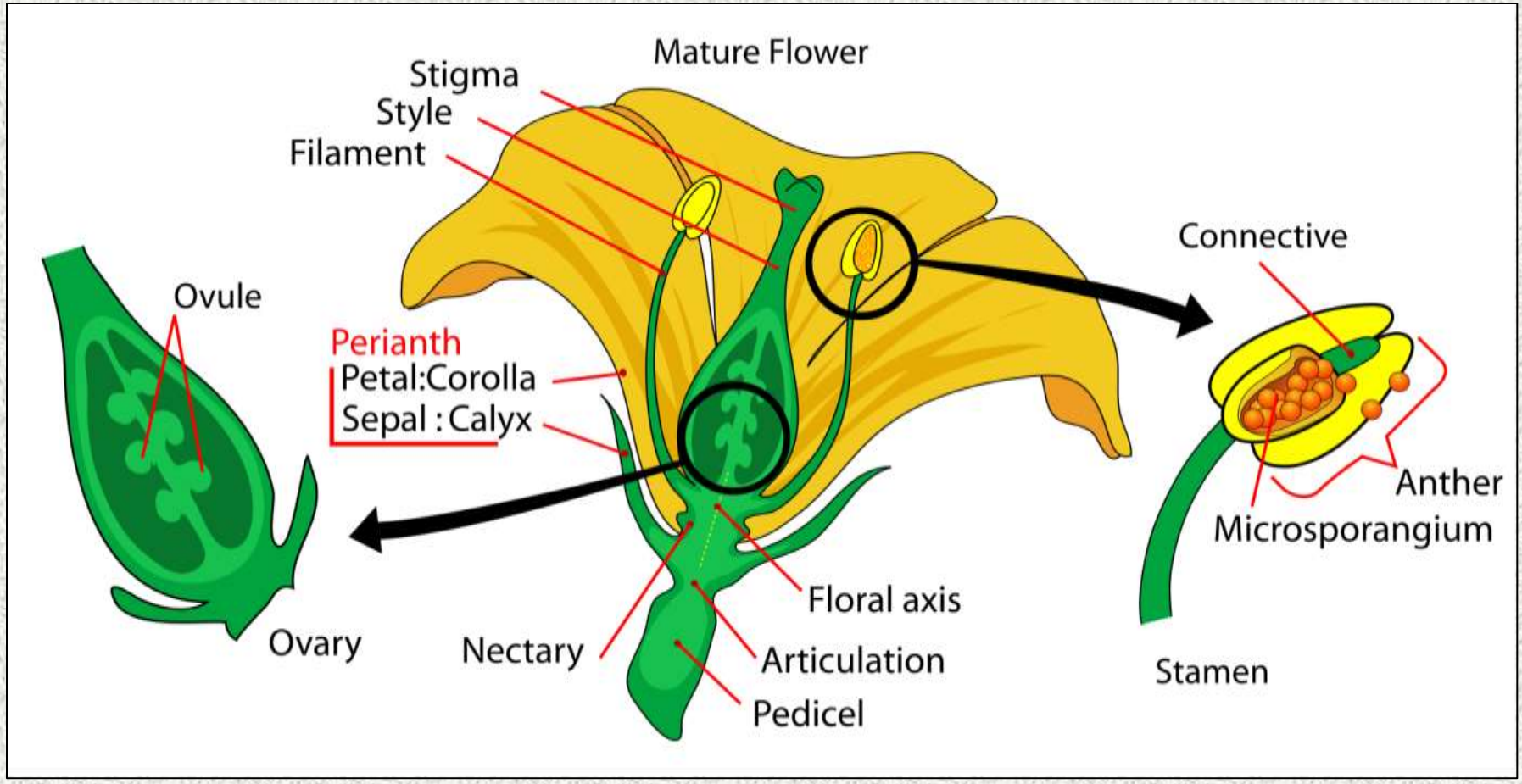


Figure 29-24 Biological Science, 2/e

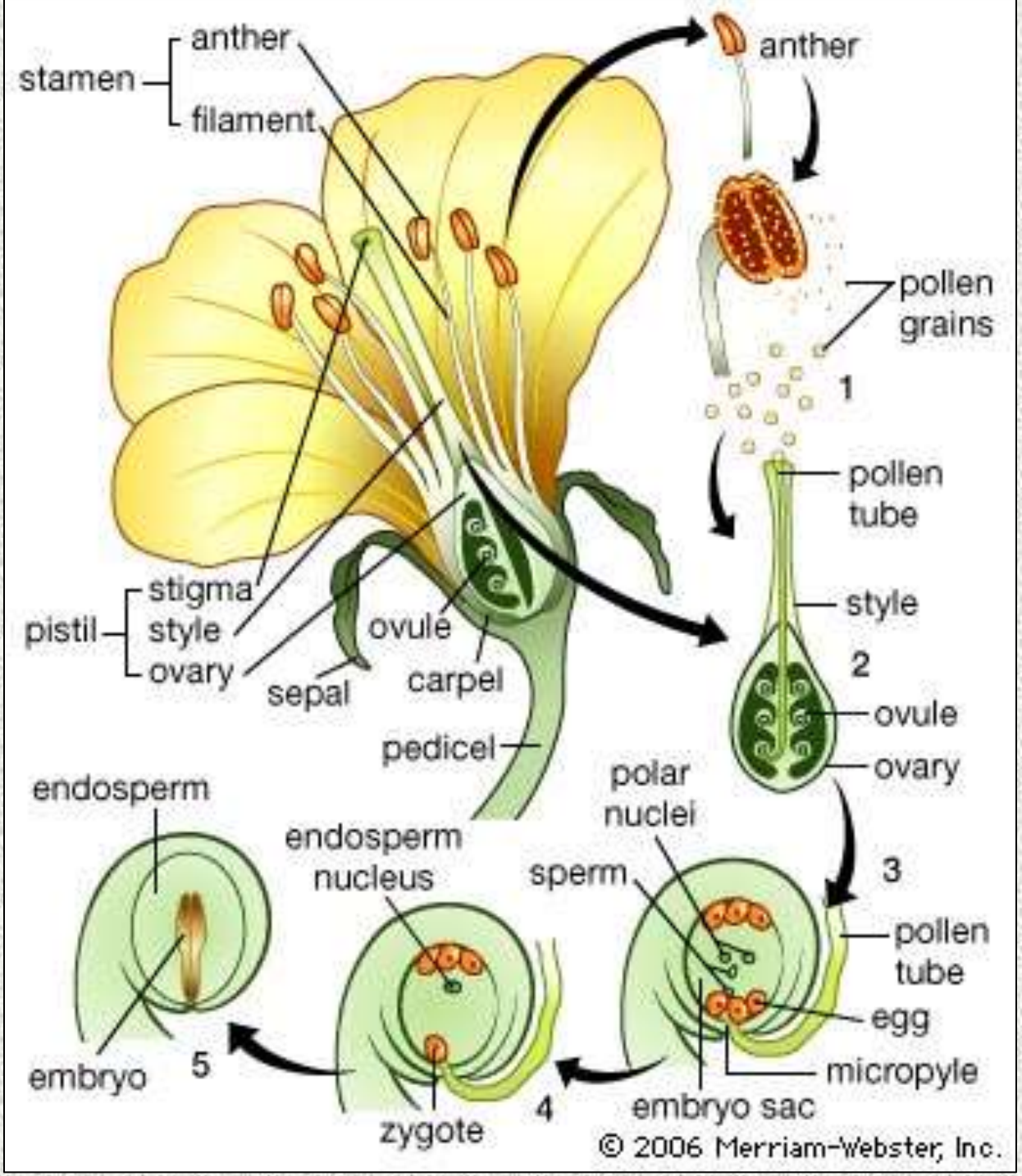
Dicots

Monocots

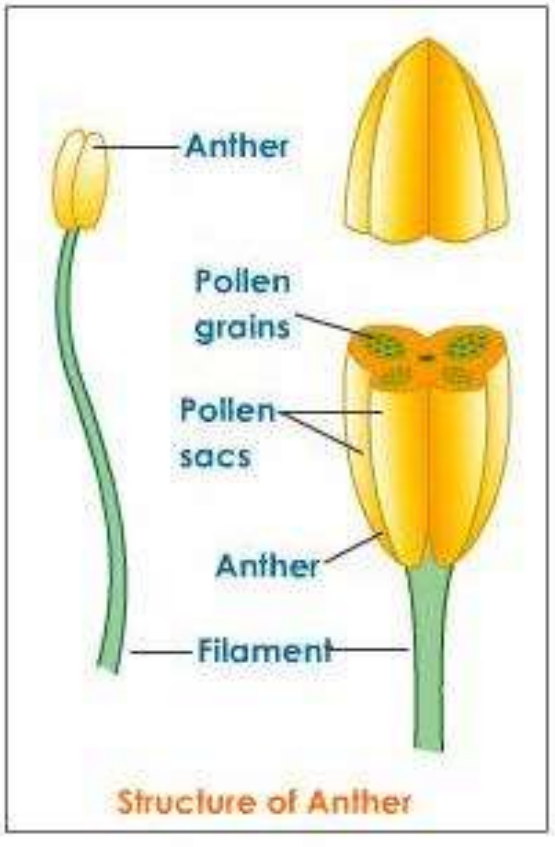
Flowers and Life Cycle

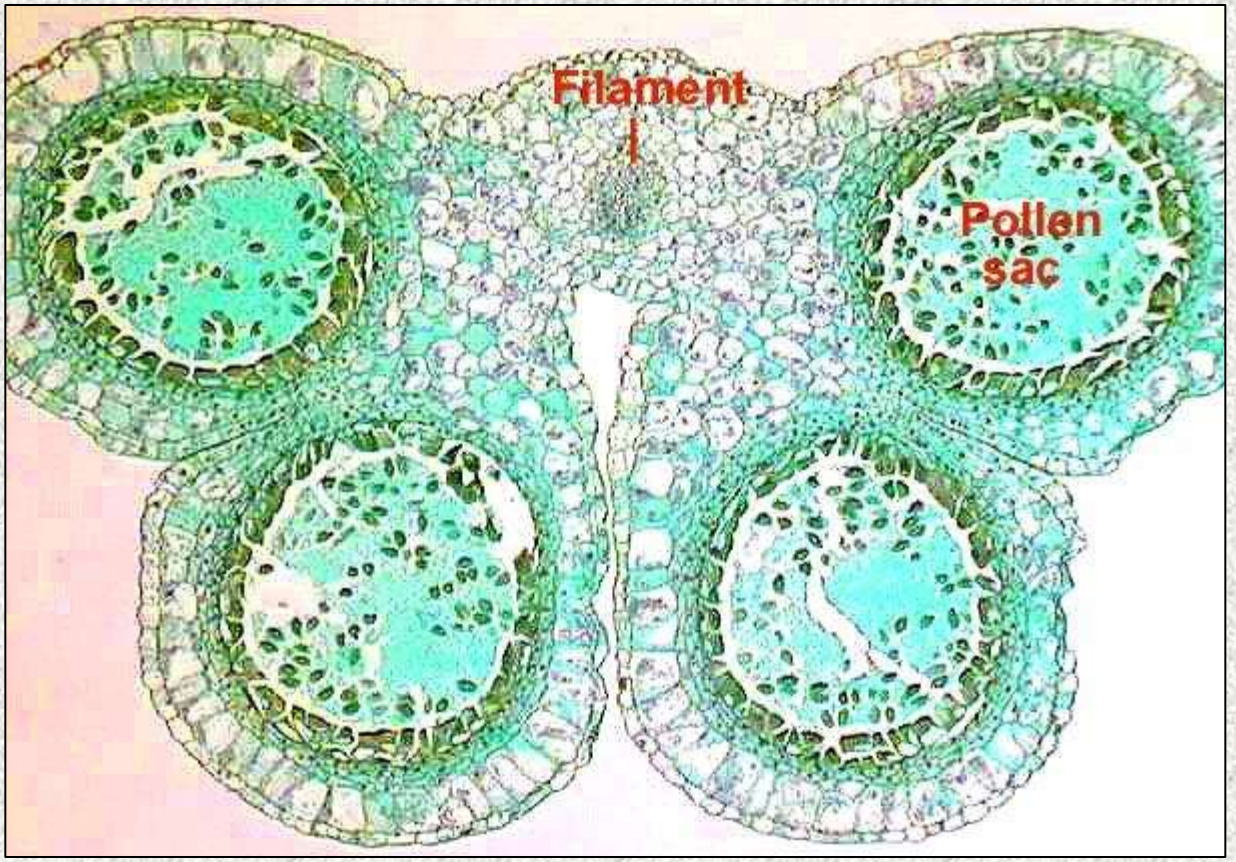


Angiosperm Life Cycle

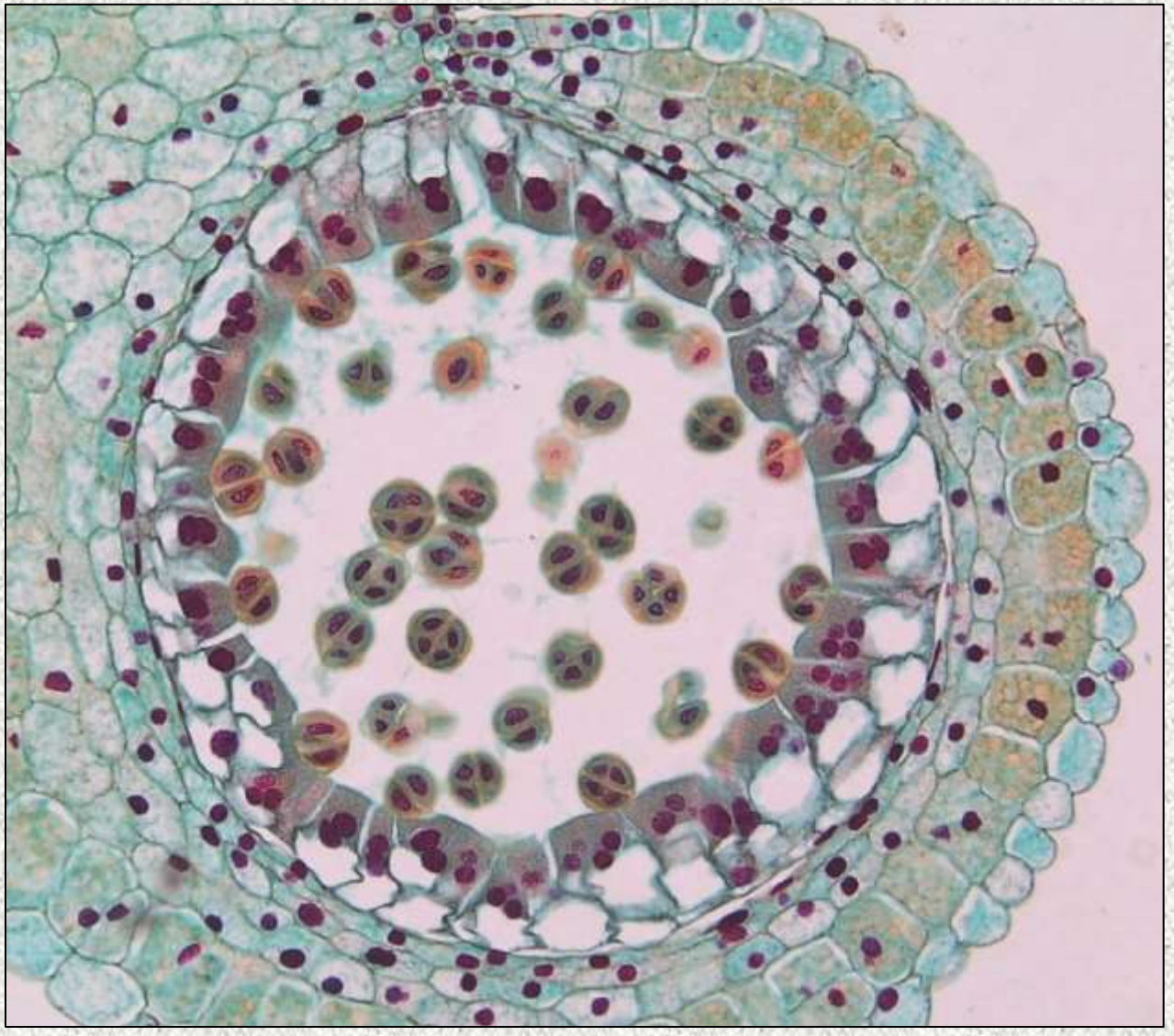


Anther - Structure

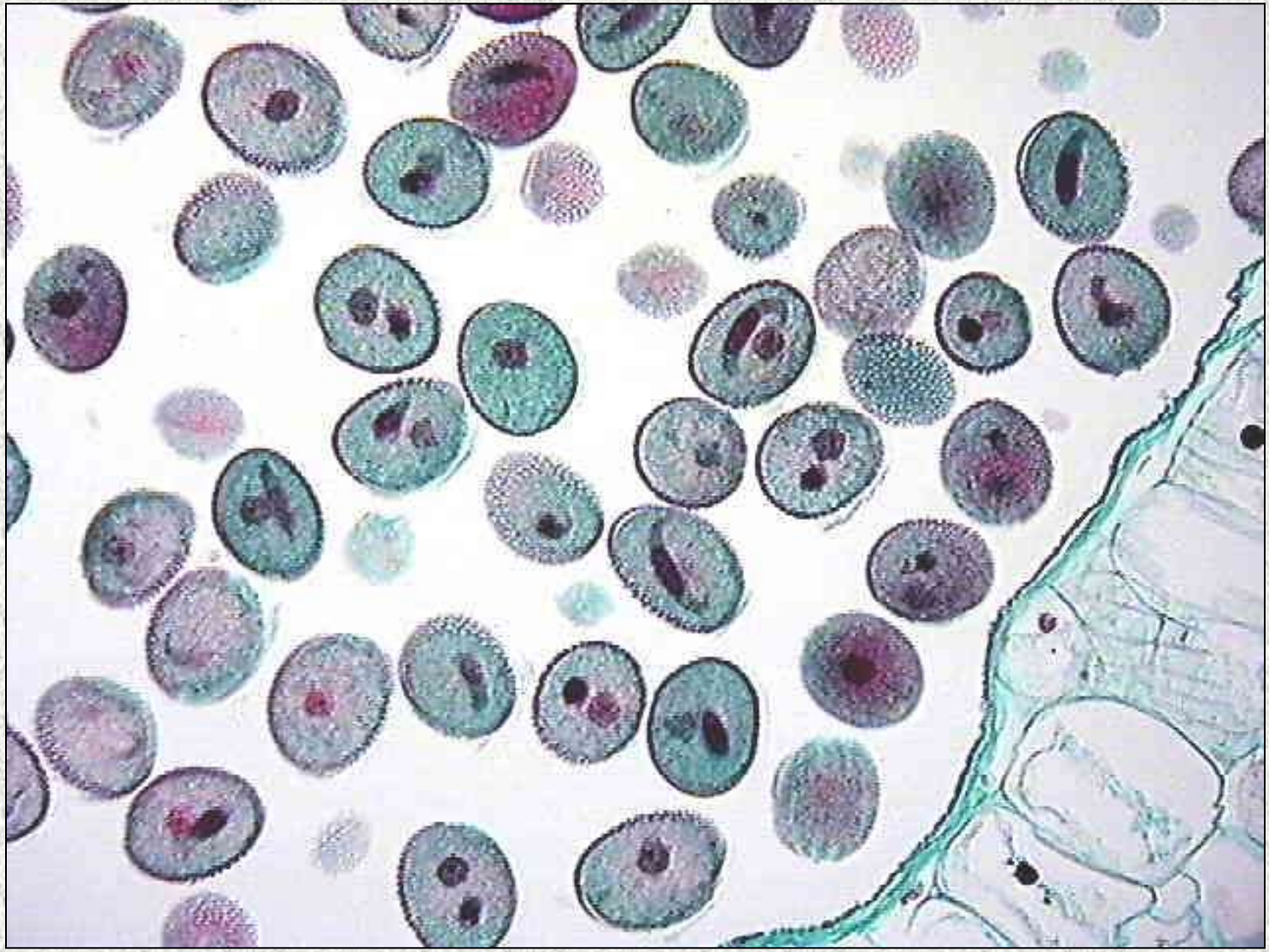


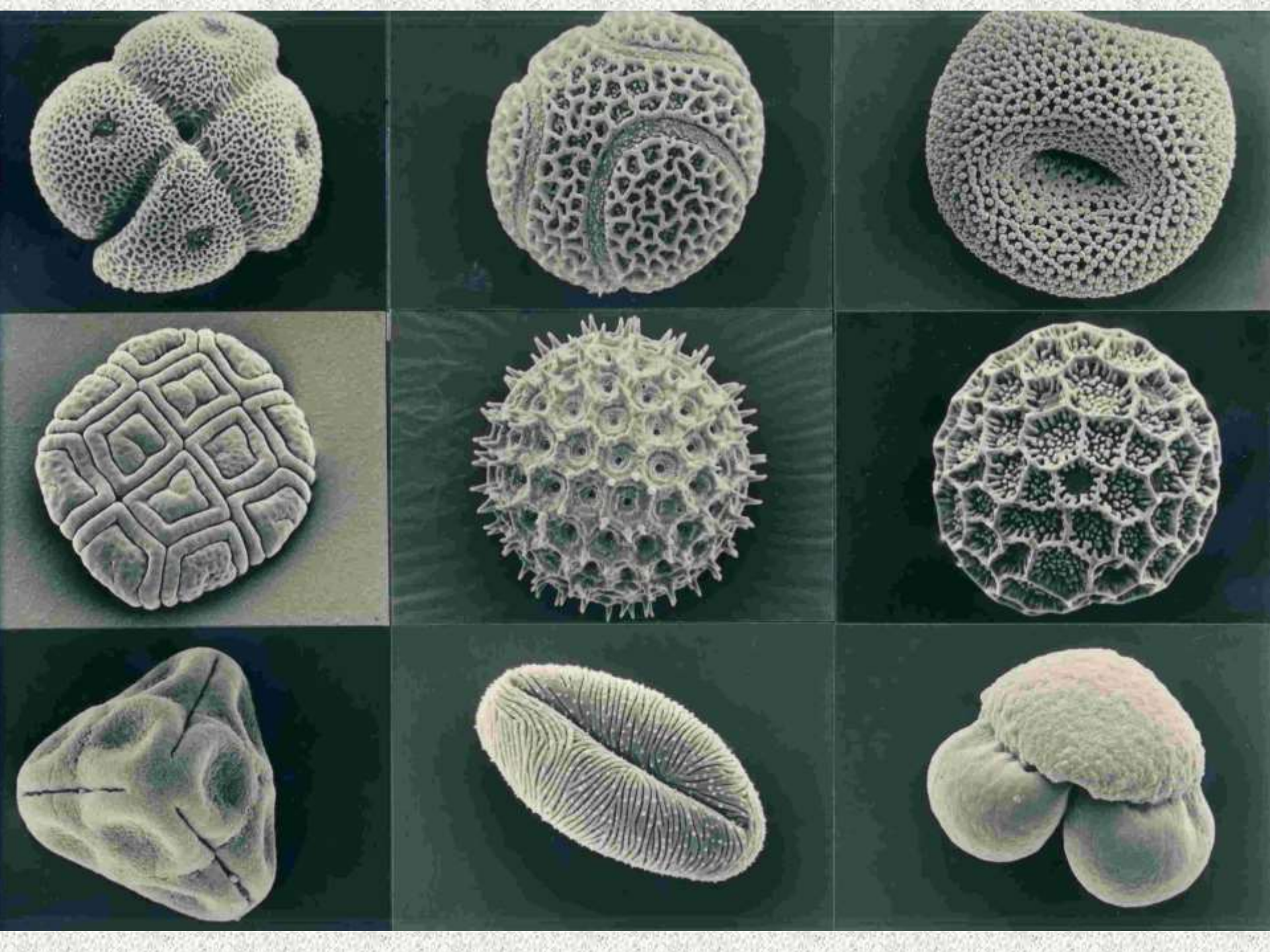


Lilium Anthers - pollen tetrad formation

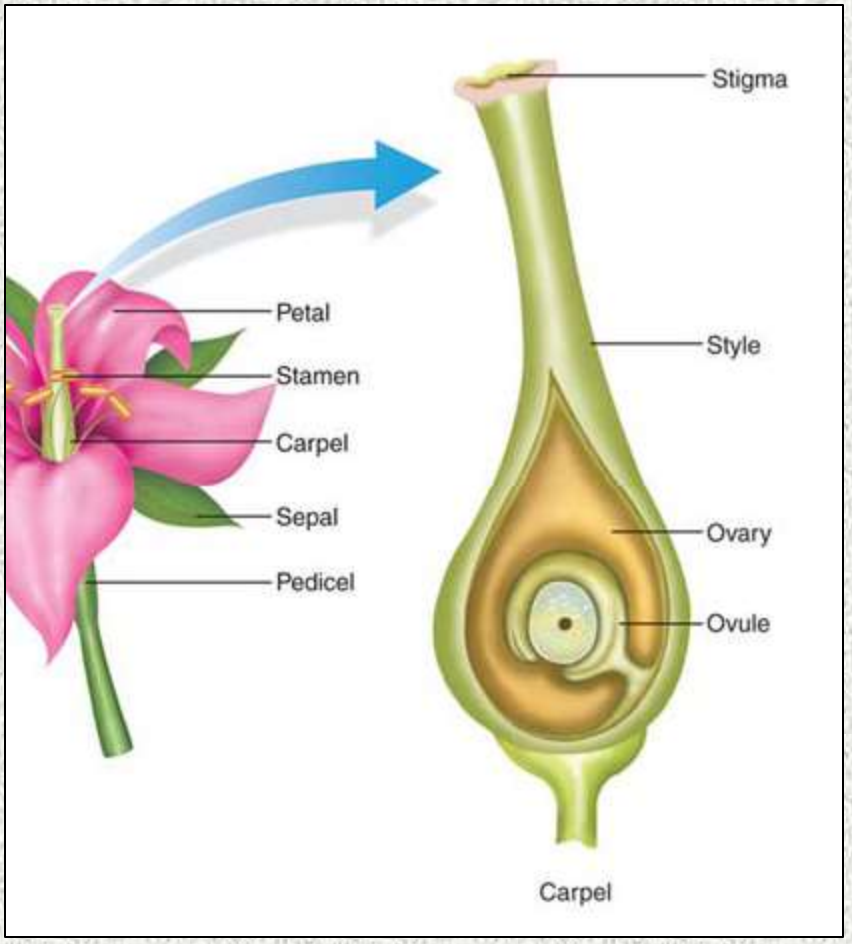


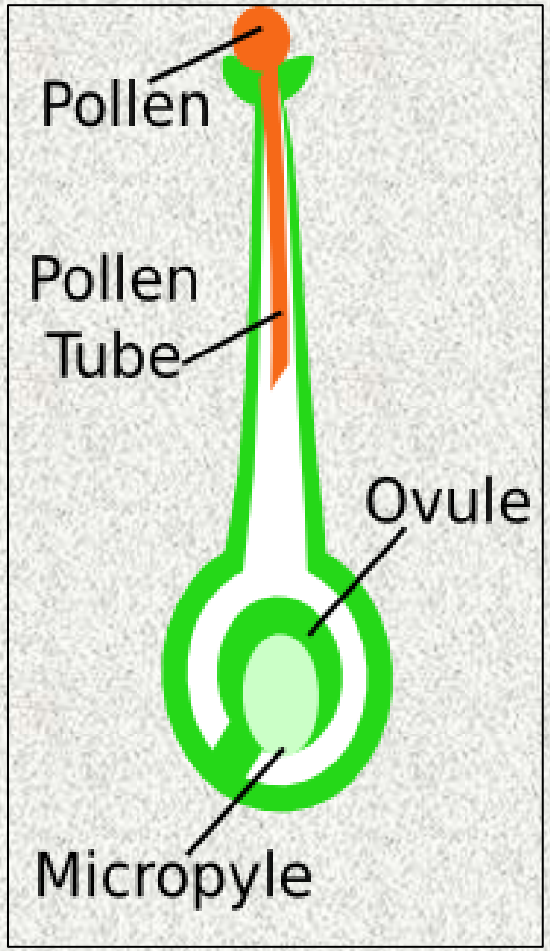
Lilium - Binucleate Mature Pollen





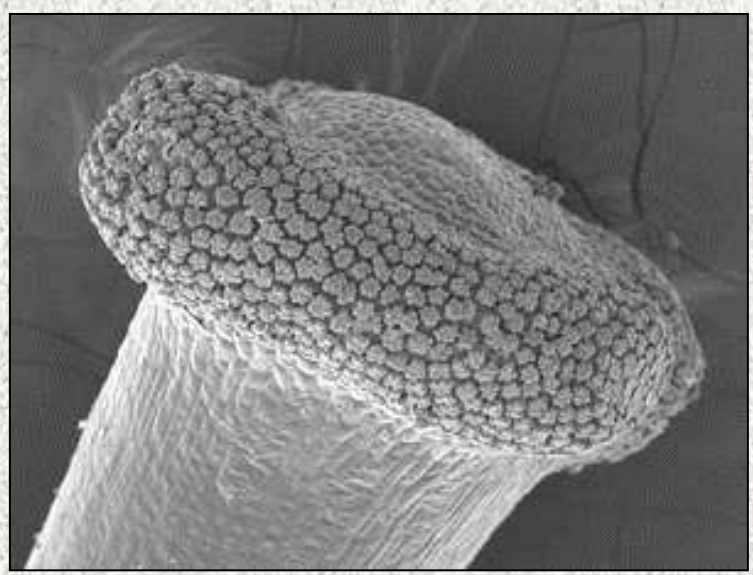
Pollination – transfer of pollen to stigma





Pollinators – great diversity

Stigmas

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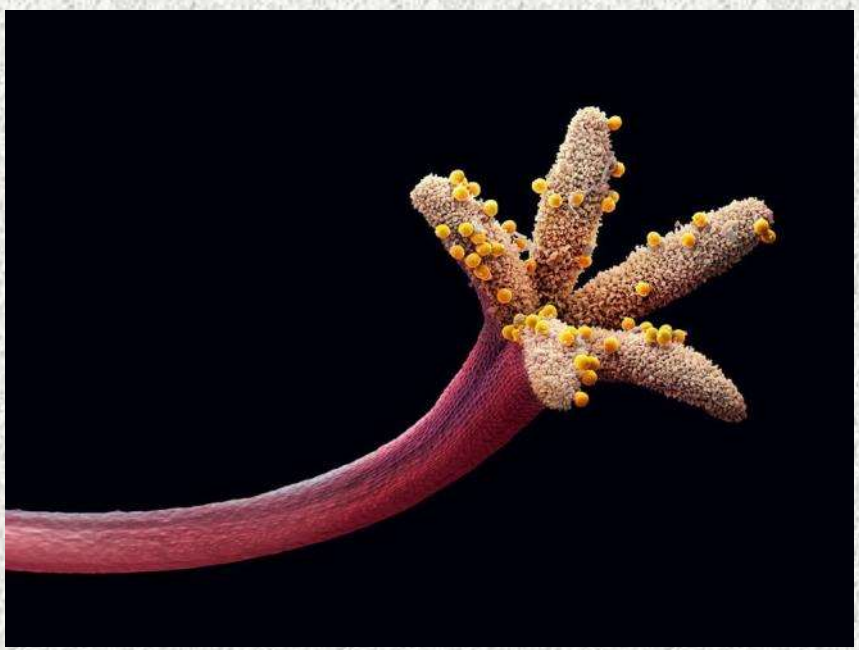
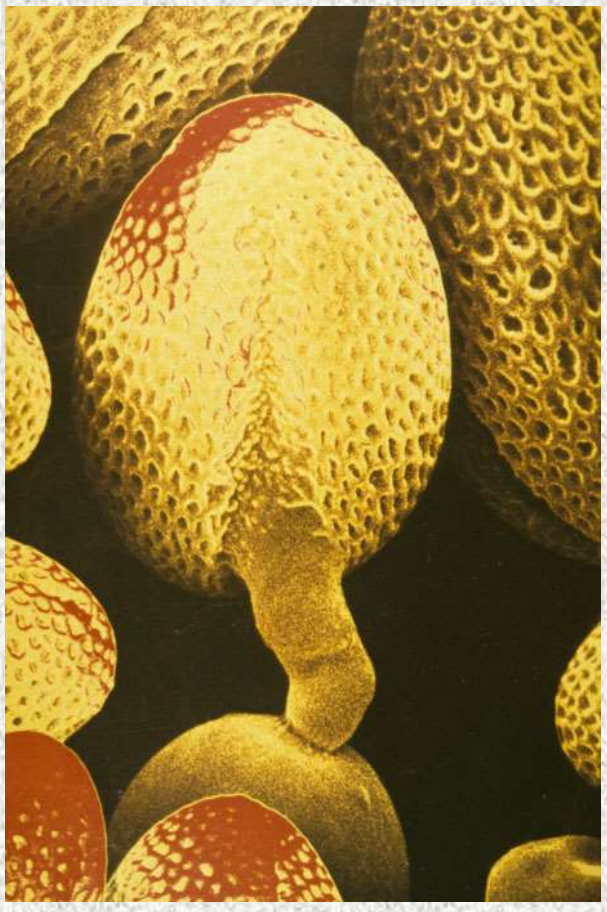
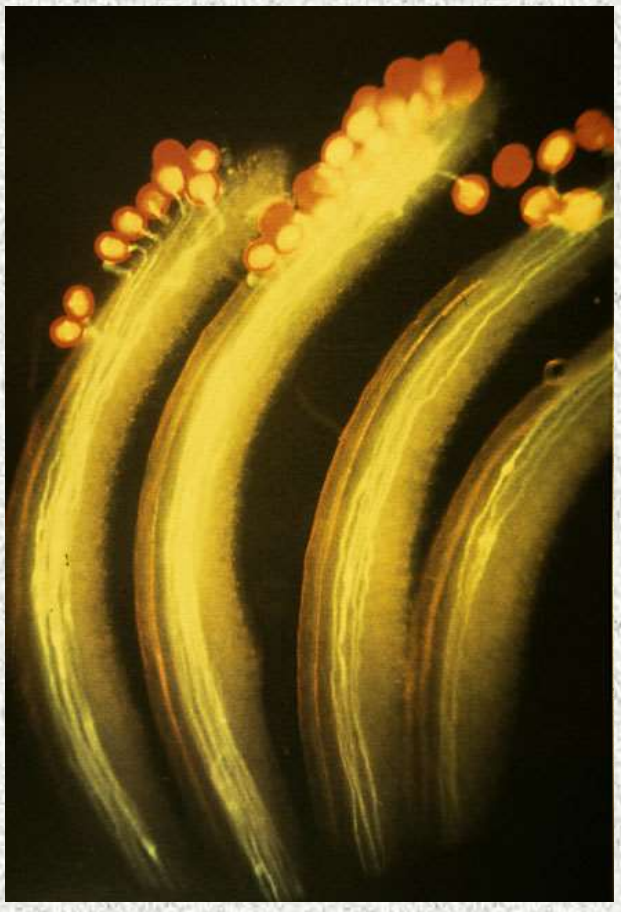
HV spot WD det HFW mag pressure 2 mm
10.00 kV 2.5 15.3 mm LFD 4.83 mm 62 x 24 Pa Amarylis pistil

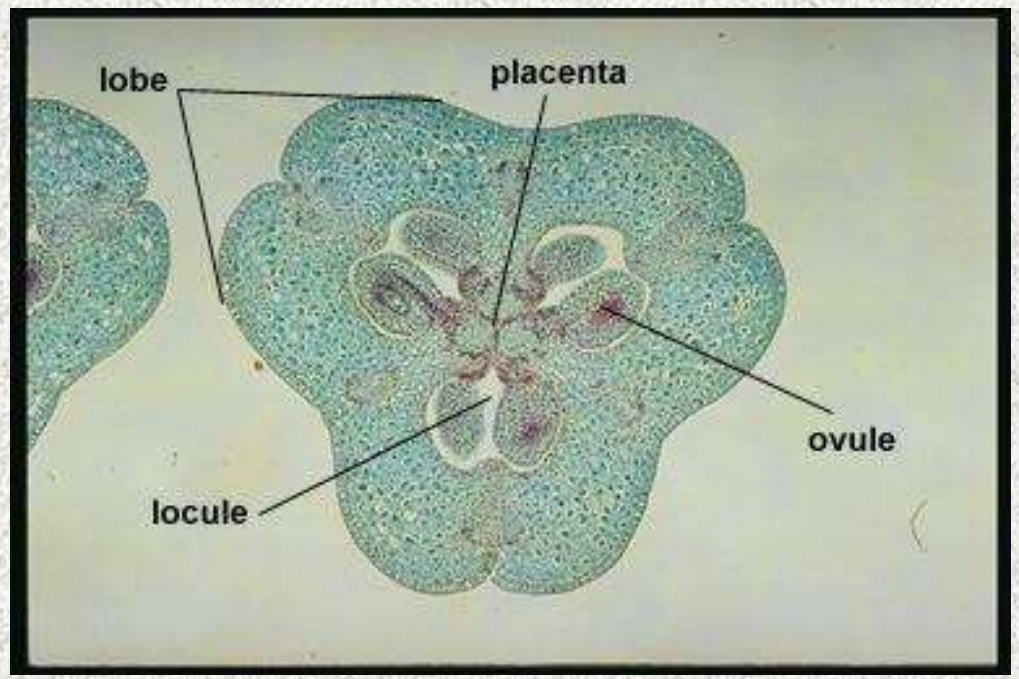


Pollen tube growth

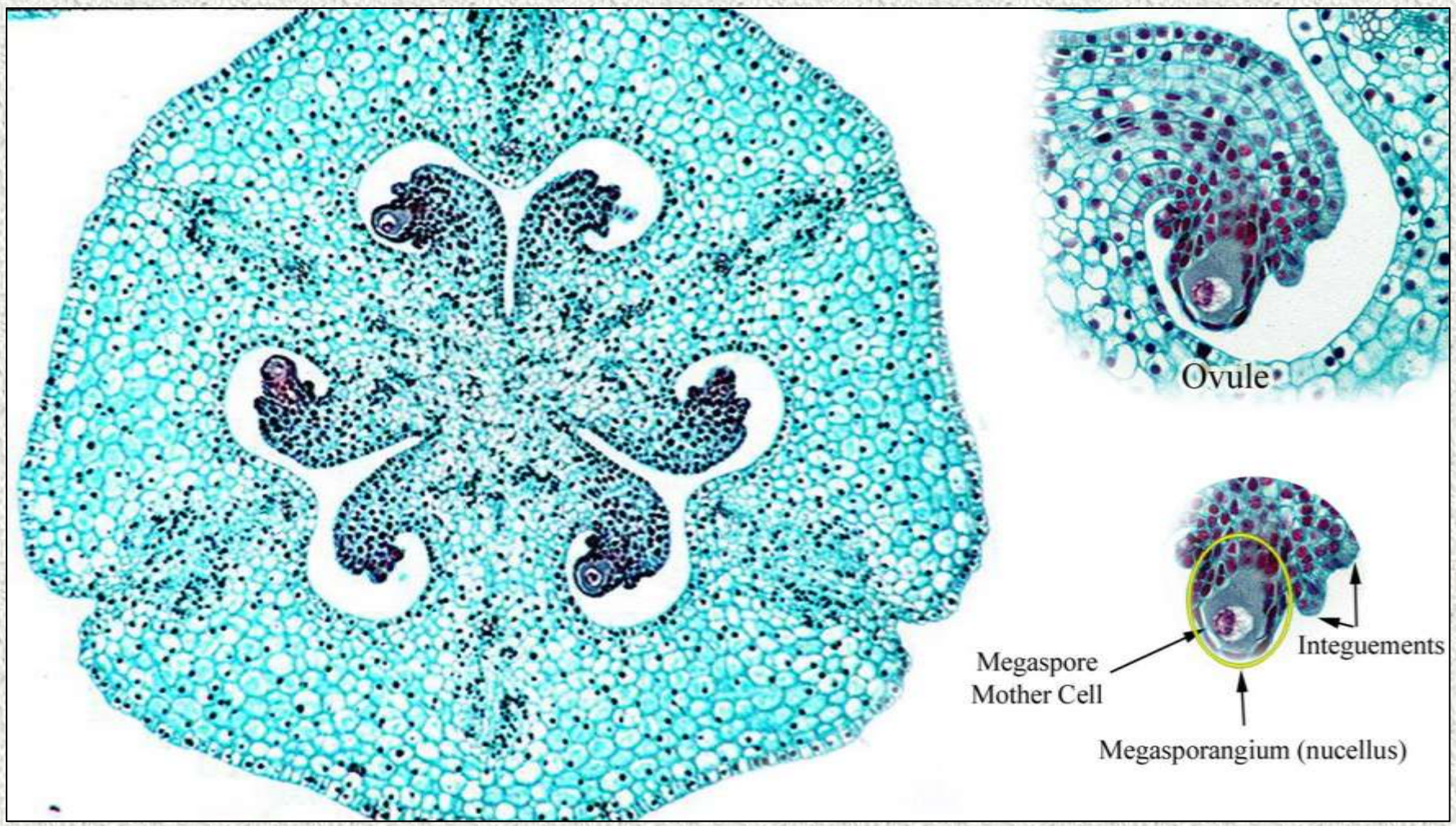


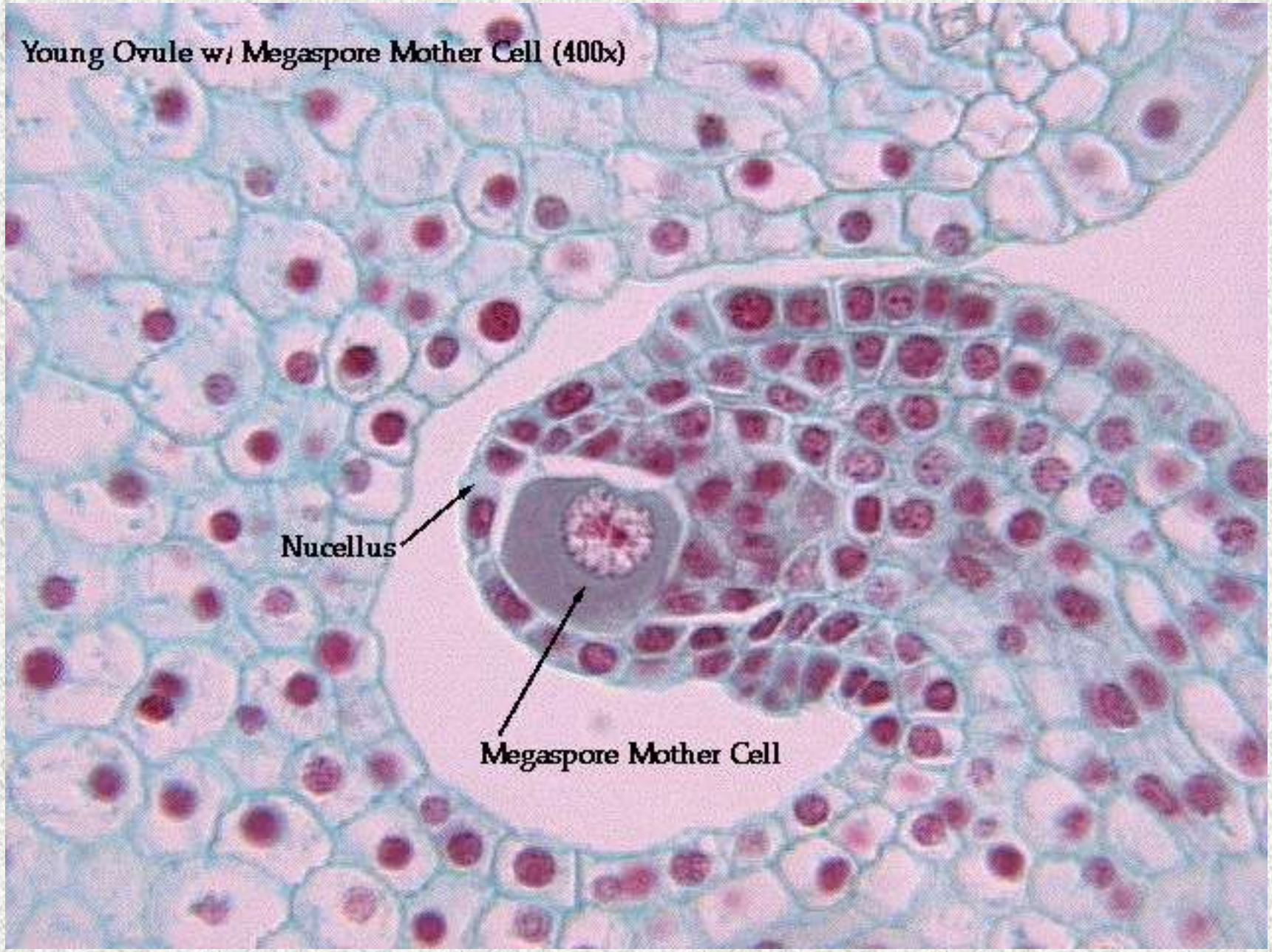


Ovary Cross Section

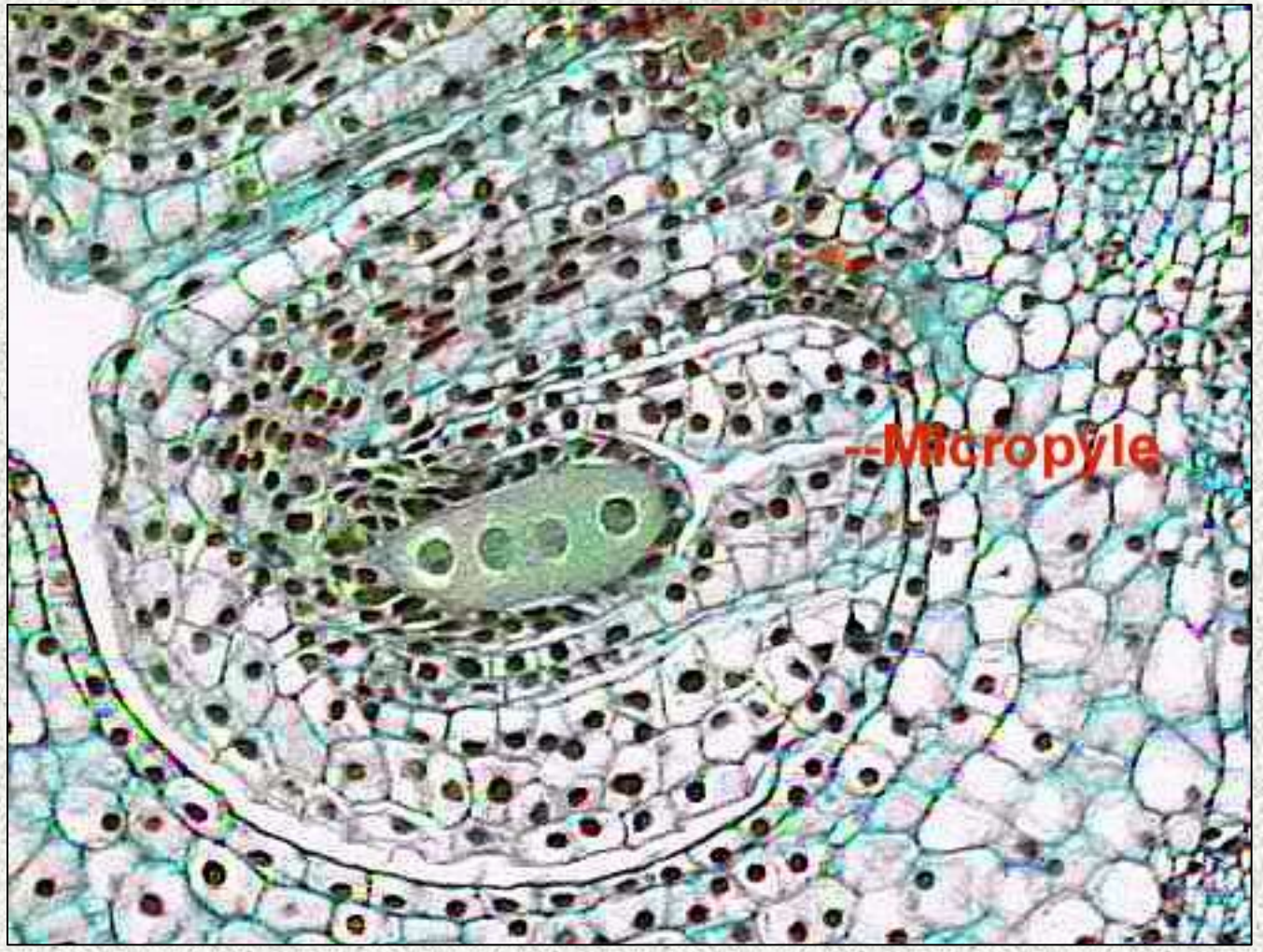


Lilium – ovary cross section

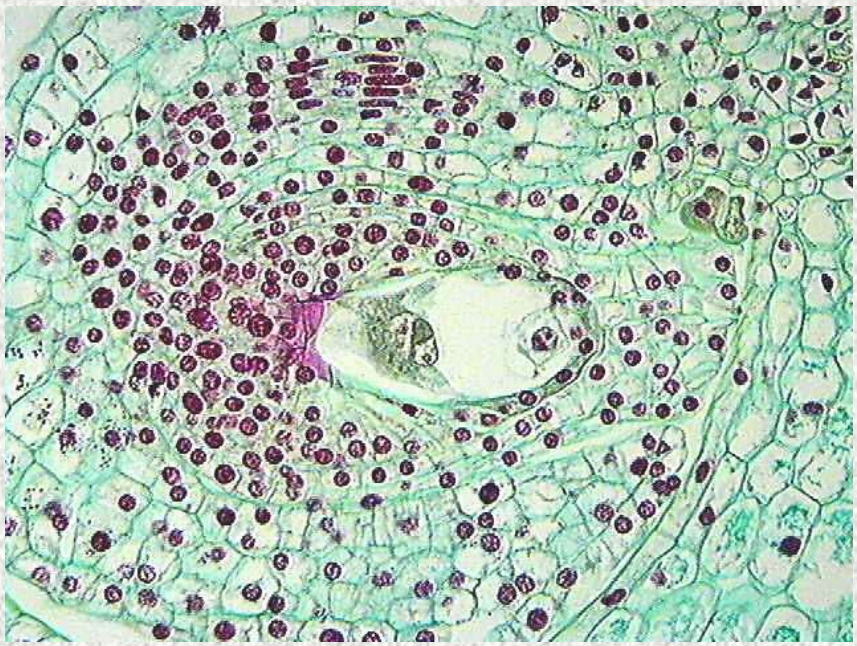


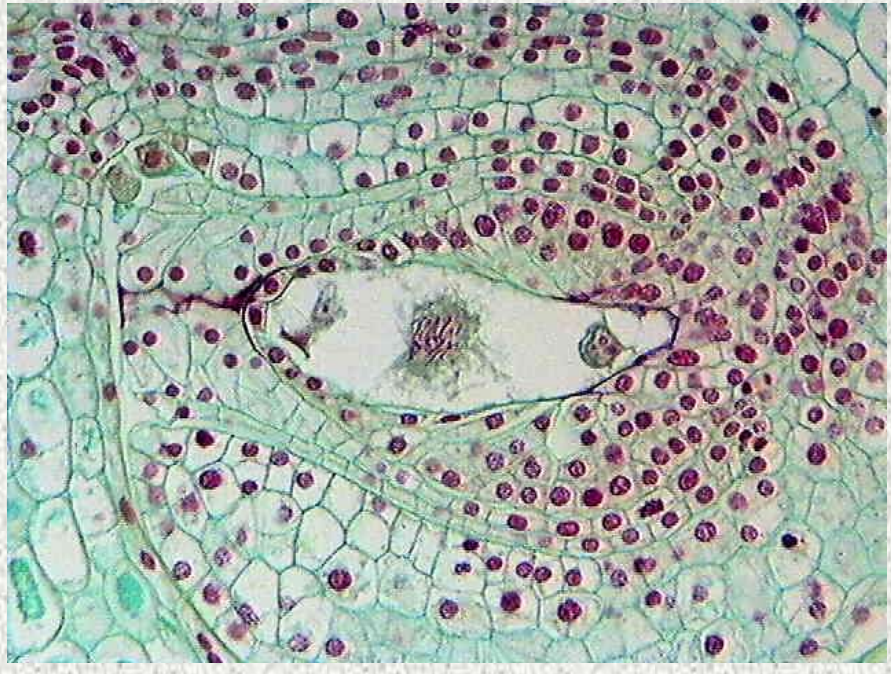

Young Ovule w/ Megaspore Mother Cell (400x)
Nucellus
Megaspore Mother Cell

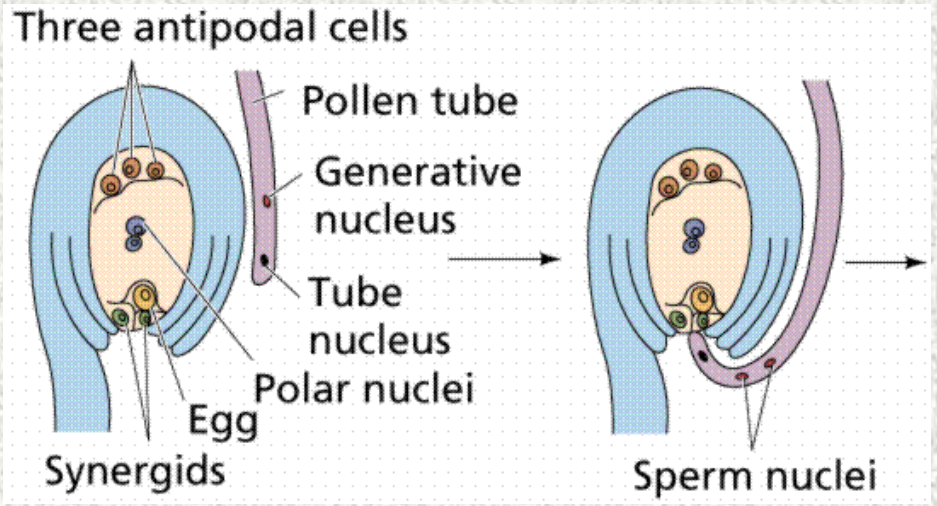
Lilium Embryo Sac

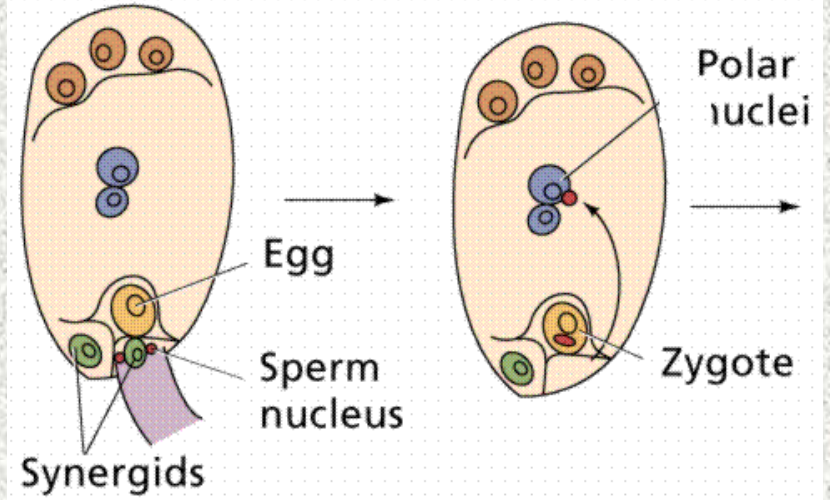


Double Fertilization – egg and polar nuclei

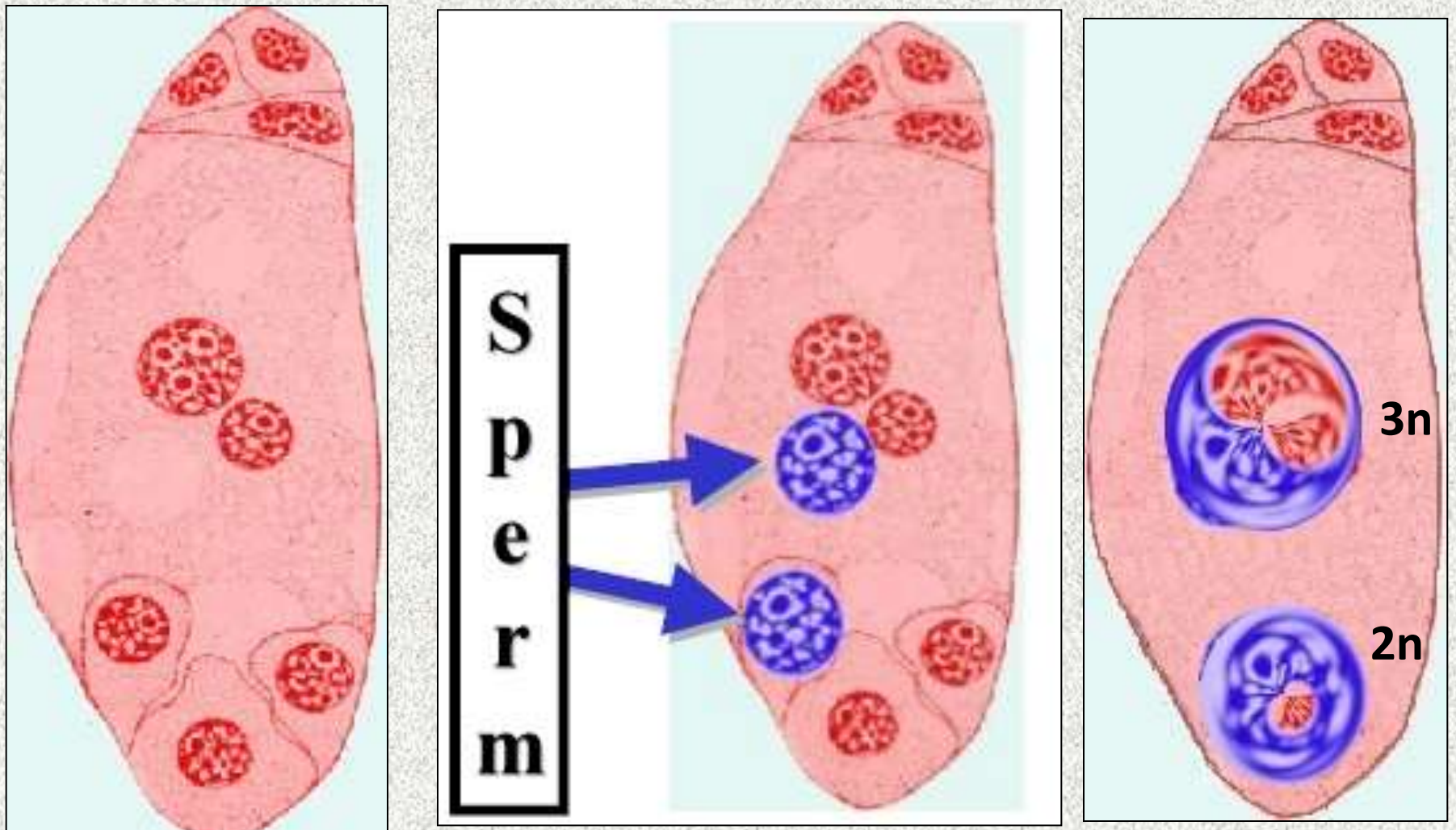


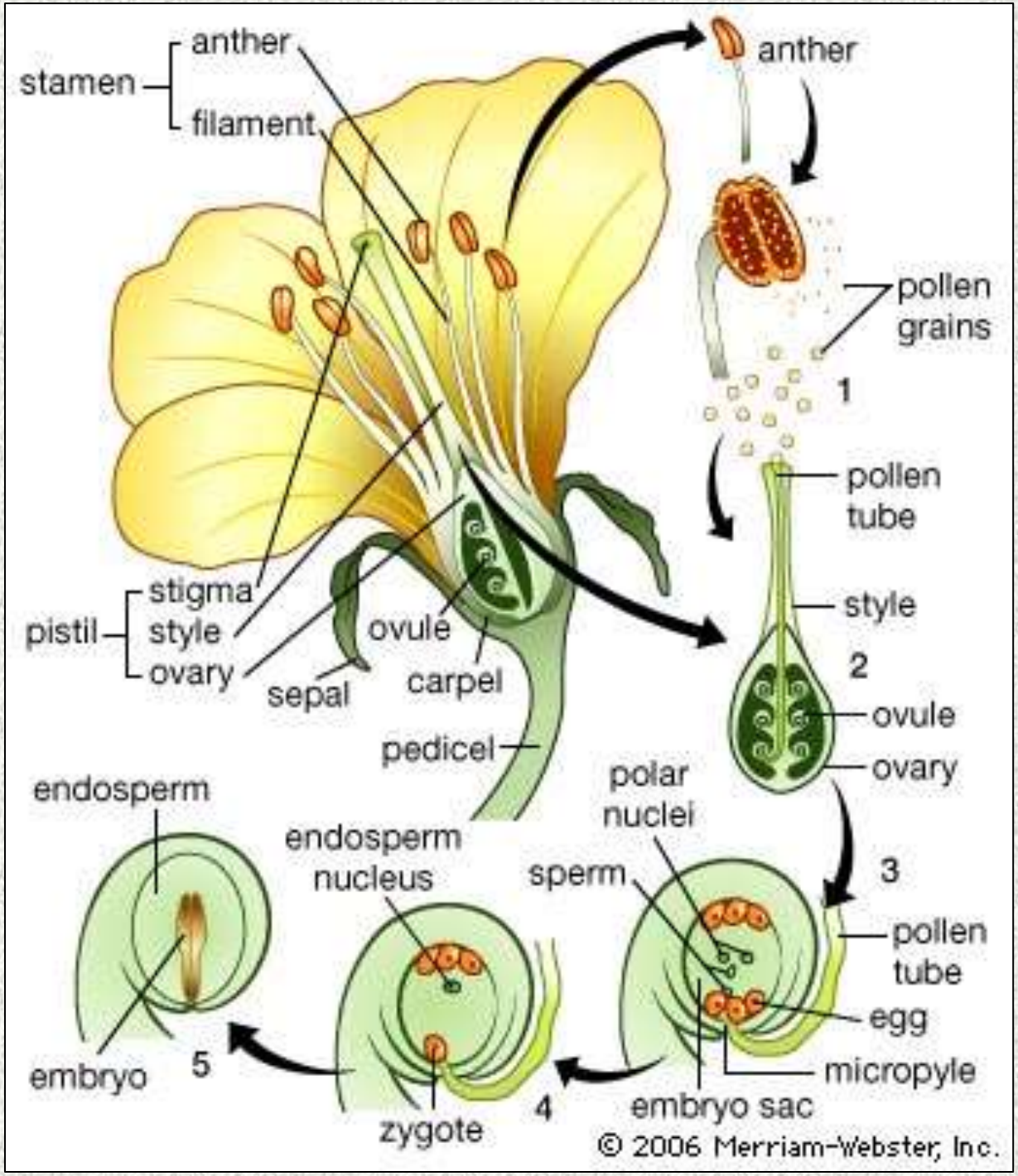






Double Fertilization




stamen
anther
filament
pistil
stigma
style
ovary
sepal
ovule
carpel
pedicel
anther
pollen grains
1
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style
2
ovule
ovary
endosperm
endosperm nucleus
polar nuclei
sperm
3
pollen tube
egg
micropyle
embryo sac
4
zygote
embryo
5
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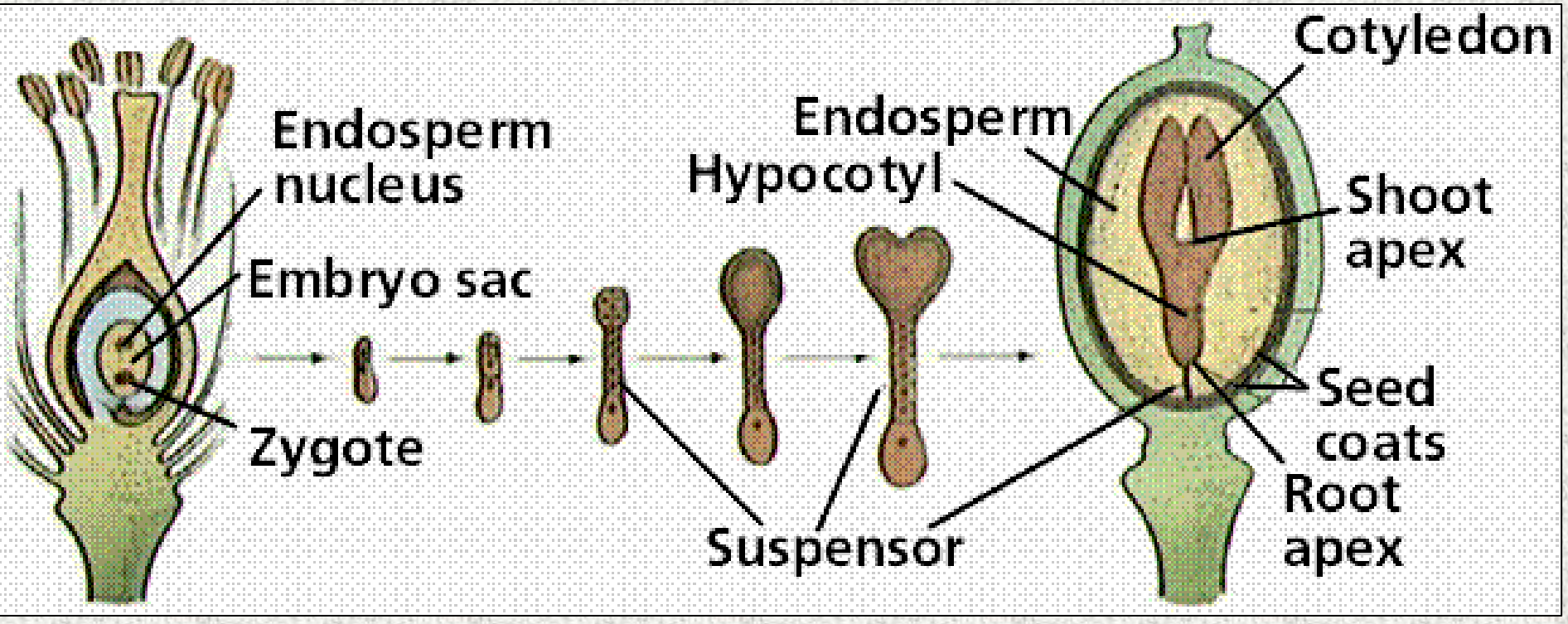
Embryo development following fertilization



End