BarCharts, Inc.®
WORLD'S #1 ACADEMIC OUTLINE

Quick Study® ACADEMIC

BOTANY

• Study of the Plant Kingdom... Our Essential Partners in Life •

INTRODUCTION

What's so special about plants?

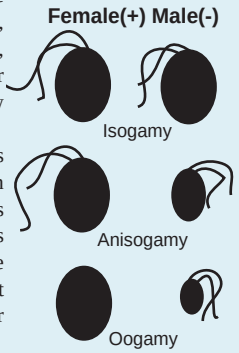
- They are photosynthetic, using the ultimate energy source, the sun, to make their own food. For this reason they are called **autotrophs**. Plants power most ecosystems and are thus essential to life on Earth.

Have you thanked a plant today?

GAMETE EVOLUTION

Plants have developed different strategies for gamete production and fusion.

- **Isogamy** – Gametes are equally motile and of similar size.
- **Anisogamy** – One gamete is large and less motile, with nutrient reserves, while the other is smaller and more motile, with few nutrient reserves.
- **Oogamy** – One gamete is non-motile and large, with large nutrient reserves (egg), while the other is smaller and motile (sperm) and must locate the larger gamete.



PLANT EVOLUTION

Plant evolution: Land colonization occurred about 400 mya, likely from aquatic, green algae ancestor.

- **New problems on land**: Plants must adapt to living in the air, a non-aquatic, dry medium. This presents some problems:
  - Obtaining water and preventing water loss.
  - Transporting water and nutrients.
  - Gas exchange (requires moisture)
  - Gravity
  - Reproduction when gametes swimming in water is limited.
  - Temperature flux of air is more rapid than in water.

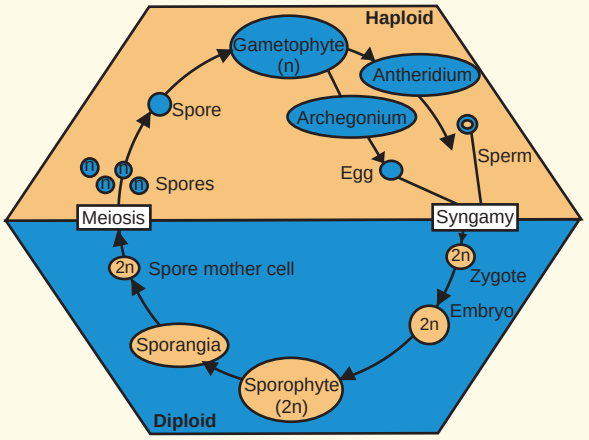
Plant adaptations/solutions

- Chlorophyll A & B, to capture sunlight – similar to green algae chlorophyll.
- Starch storage, for prolonged inactive periods during seasonal variations.
- Gametes protected and kept moist inside plant tissues.
- Stomata (leaf openings) to regulate gas exchange.
  - Wax surfaces to prevent excess water loss.
  - Root system to pull in water and nutrients from soil.
  - Conduction tissues to transport water, nutrients and food.
- Support tissues to battle gravity for vertical growth.
- All of these adaptations have greatly enhanced the success of plants on land today.

ALTERNATION OF GENERATIONS

A unique evolutionary strategy for reproduction where a single plant organism has two phases to its life history.

- **Gametophyte** – Haploid, multicelled individual produces gametes via mitosis. Dominant form in lower plants.
- **Sporophyte** – Diploid, multicelled individual from gamete fusion (zygote); produce haploid spores via meiosis for dispersal; spores germinate via mitosis to produce gametophytes. Dominant form in higher plants.
- **Isomorphic A/G** – Gametophyte and sporophyte individuals are morphologically indistinguishable.
- **Heteromorphic A/G** – Gametophyte and sporophyte individuals are morphologically distinct.



PLANT CLASSIFICATION

SEEDS, VASCULAR

- Angiosperms
- Gymnosperms

SEEDLESS, VASCULAR

- Ferns
- Horsetails
- Whisk Ferns
- Club Mosses

NONVASCULAR

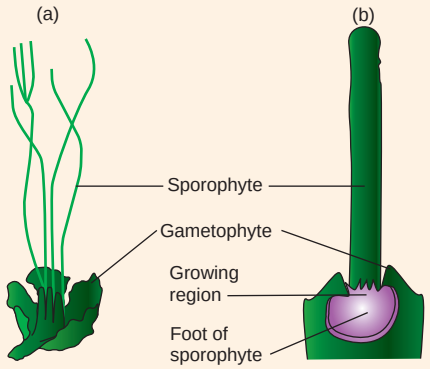
- Mosses
- Liverworts
- Hornworts

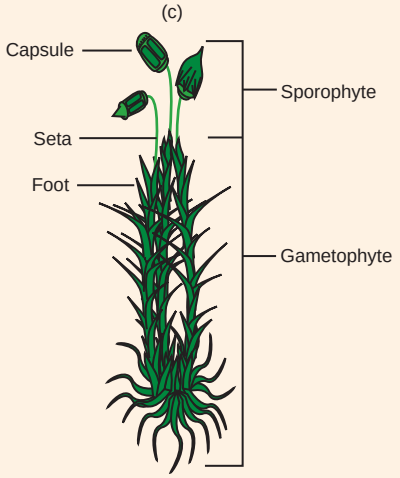
GREEN ALGAL ANCESTOR

NONVASCULAR PLANTS

1st Plants on Land

- Lack vascular tissues
- Gametophyte is dominant, sporophyte nutritionally dependent on gametophyte.
- Small; live in moist environments; gametes released into water.
  a. **Division Hepatophyta** (Liverworts)
  b. **Division Anthocerophyta** (Hornworts)
  c. **Division Bryophyta** (Mosses)





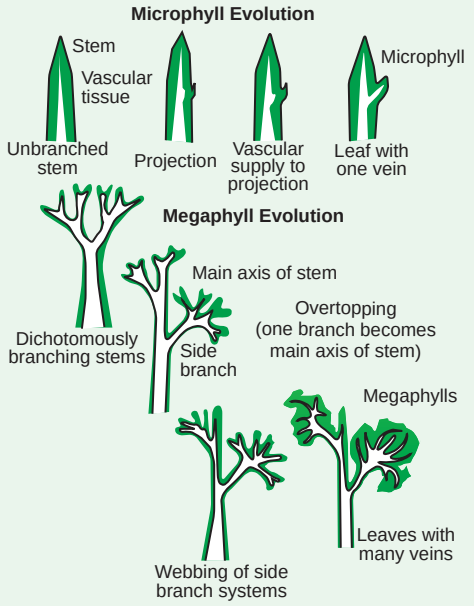
SEEDLESS VASCULAR PLANTS

Seedless Vascular plants

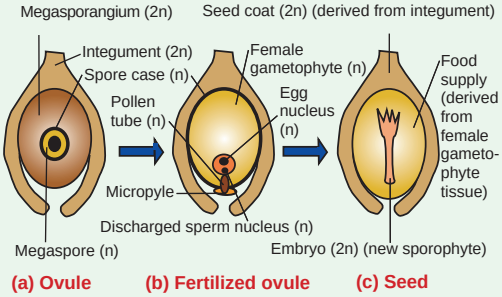
- Possess xylem & phloem for transport of materials.
- Sporophyte is dominant.
- Evolution of leaf for efficient light capture.
  - Microphylls, megaphylls (In botany, the prefixes "micro" and "mega" generally refer to similar structures in male and female parts of the plant, respectively).
- **Division Lycophyta** (Club Mosses)
  - Roots present.
  - Leaves present (microphylls).
- **Division Psilophyta** (Whisk Ferns) No roots or leaves
- **Division Sphenophyta** (Horsetails)
  - Roots present.
  - Stems contain silica.
  - Leaves present (microphylls).
  - Division Pterophyta (Ferns)
  - Roots present.
  - Leaves (= fronds)
  - Fronds present (megaphylls).
  - Fern life history (see fig. below)
  - Sporophyte, sori, sporangia, spores, gametophyte (= prothallus), archegonium with eggs and antheridium with sperm
- The Plant Scene (300 mya): Many seedless vascular plants and some nonvascular plants exhibited lush, dense growth covering large expanses in Earth's history.
- Much of today's oil, coal and gas deposits were formed by these plants.

Evolution of the "seed" plants

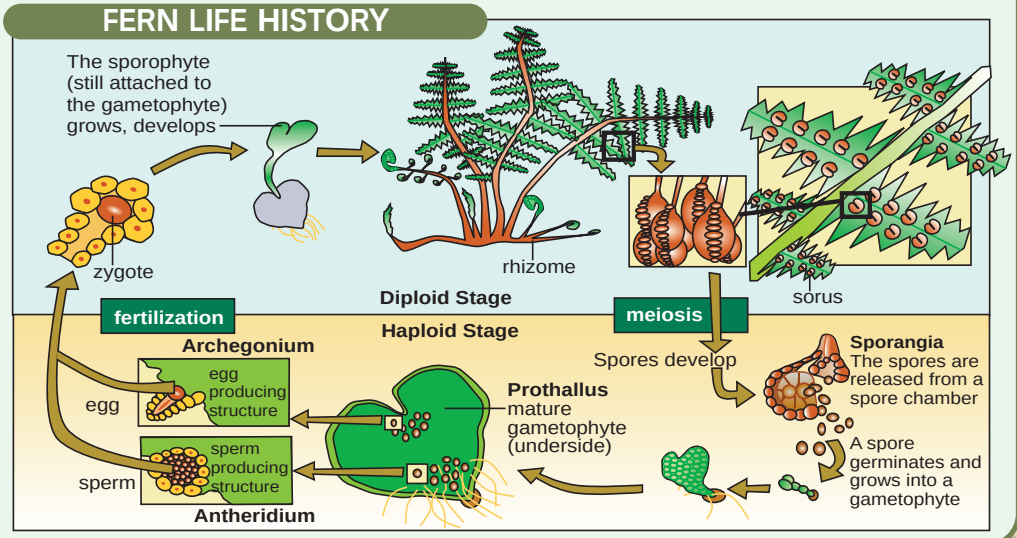
- Terrestrial adaptations of seed plants.
  - Gametophytes protected in moist sporophytic, reproductive tissues.
  - Pollination replaced swimming for sperm delivery to egg.
  - The seed evolved - a dormant embryo with surrounding nutrients protected from environmental conditions. Seeds replaced spores as dispersal agents, using wind, water or animals.
- **The seed - a fertilized egg**
  - Inside an ovule.
  - Integument, megasporangium → megaspore 'gametophyte → egg sperm



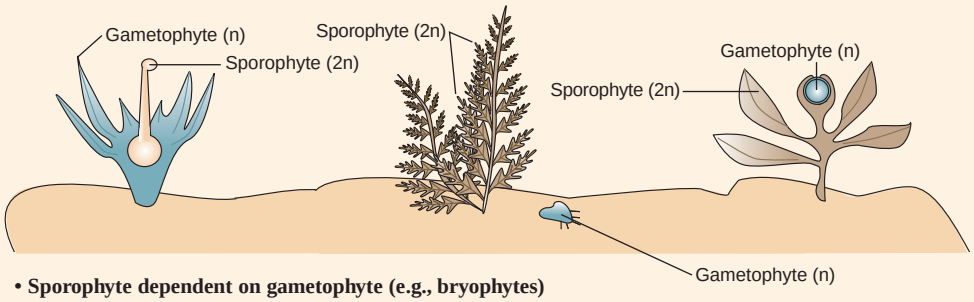
OVULE TO SEED



FERN LIFE HISTORY



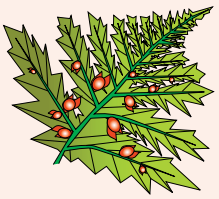
TRENDS IN ALTERNATION OF GENERATIONS



- **Sporophyte dependent on gametophyte (e.g., bryophytes)**
- **Large sporophyte and small, independent gametophyte (e.g., ferns)**
- **Reduced gametophyte dependent on sporophyte (seed plants)**

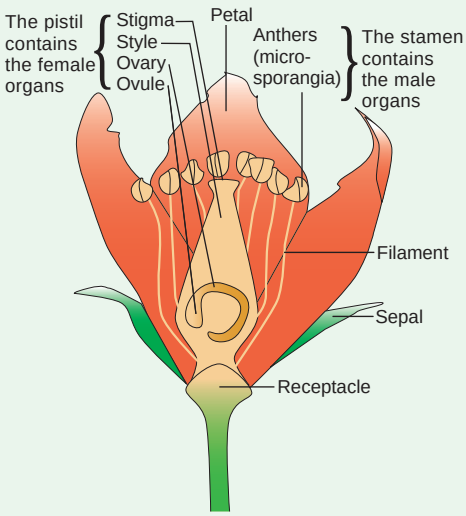
SEED "Ferns"

Extinct fossil forms that may show transition from seedless vascular plants (e.g., ferns) to vascular seed plants (e.g., gymnosperms and angiosperms).



FLOWERS

- Most plants are angiosperms and thus produce flowers with both male and female reproductive structures.
- **Flower anatomy**
  - Sepals, petals
  - **Stamen** (Male Portion): Anther, filament
  - **Pistil** (Carpel, Female Portion): Stigma, style, ovary, ovule

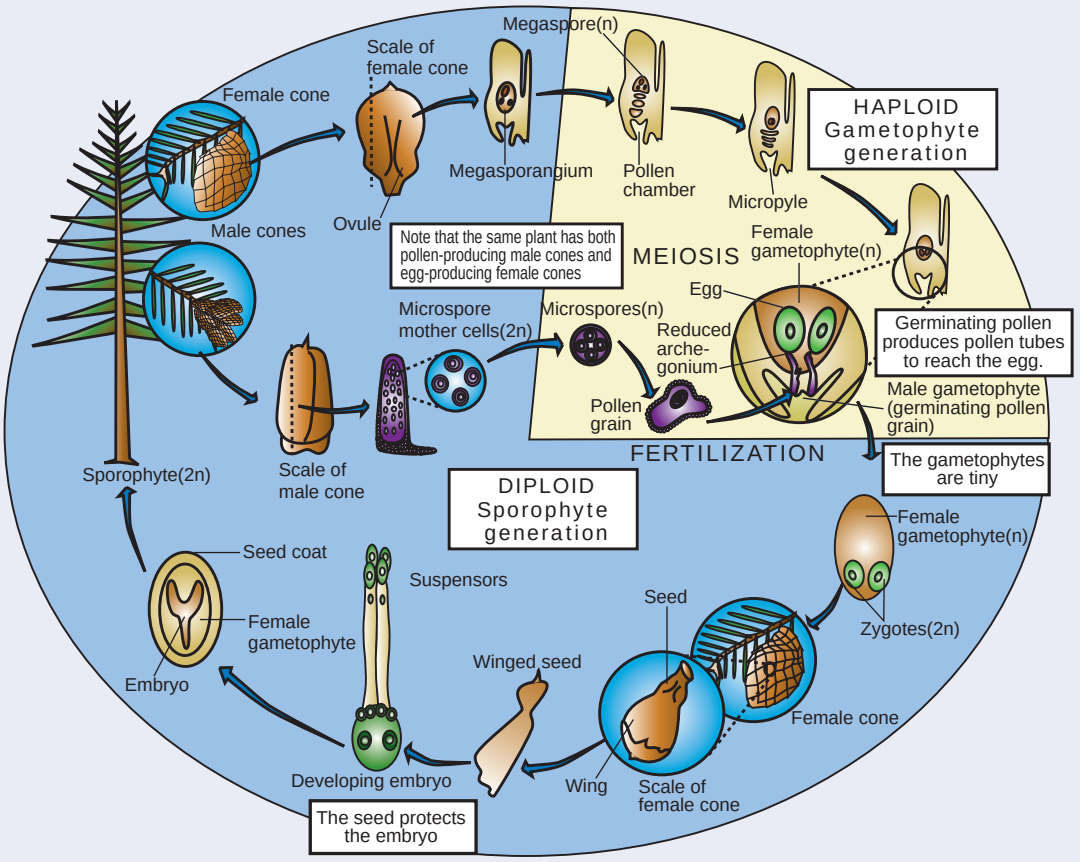


- Angiosperms have dominated the plant scene since the demise of dinosaurs and many gymnosperms (Cenozoic era, 65 mya to present).
- Seed in a protective container or cotyledon
- **Angiosperm life cycle:**
  - Microspore mother cell → microspores → pollen grain (male gametophyte)which includes tube cell and generative cell (sperm)
  - Megaspore mother cell → megaspore → embryo sac with 7 cells and 8 nuclei (female gametophyte) → egg
  - Two sperm move through the pollen tube and engage in a double fertilization (where one sperm fuses with the egg to form a zygote/embryo, and the other sperm fuses with a large, central cell to form endosperm/nutrient reserve for the embryo) until it can produce its first leaves and begin photosynthesis.
  - Pollination and fertilization occur within hours to days, making angiosperms quick reproducers, compared to gymnosperms.
- Flowers ensure pollination by insects, birds and mammals.
  - Flowers and pollinators co-evolved.
- **Seed dispersal**
  - Important because plants may drop seeds close by, but new individuals will possibly compete with parent plants.
  - Wind, water and animals are common dispersal agents.
  - Fruits can entice animals to aid in dispersal.
- **Fruits** – ripened ovary **(see fig.)**
- **Monocots and Dicots** - two major groups of angiosperms **(see fig. for differences)**
  - Monocots include grasses, corn, sugar cane, palm trees, lilies and orchids.
  - Dicots include most trees, vines, shrubs and cacti.

THE GYMNOSPERMS - "naked seed" plants

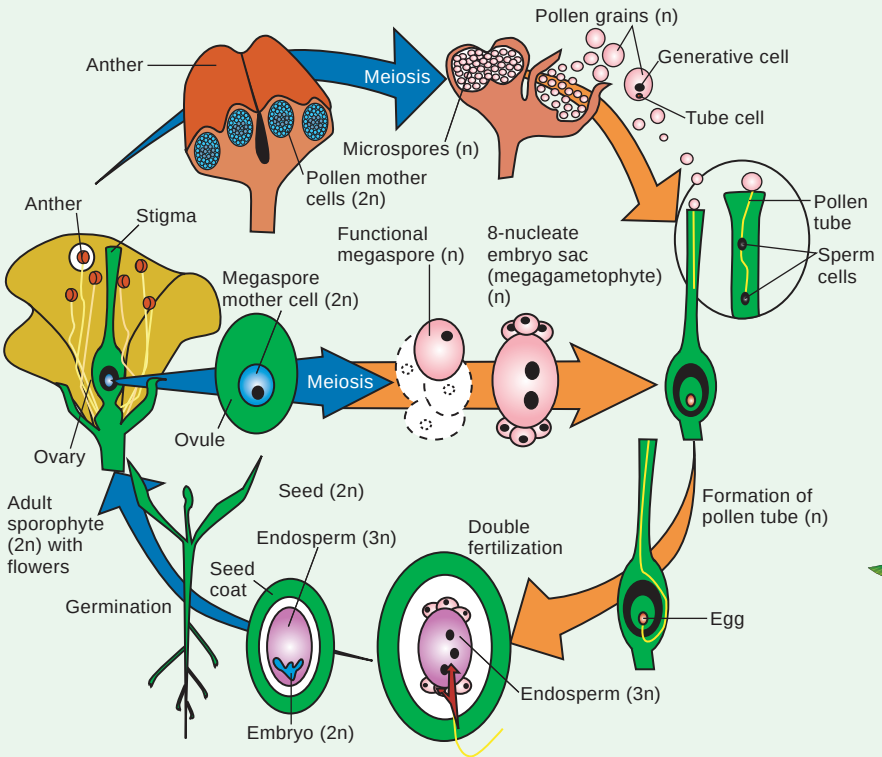
- Dominant plant when dinosuars ruled (Mesozoic era, 220 - 65 mya).
- Do not produce flowers.
- Ovules/seeds exposed.
- **Division Cycadophyta**
  - Slow-growing palm-like trees found primarily in tropics and sub-tropics.
  - **Division Ginkgophyta**
    - Only one living member.
    - Ginkgo biloba (common diet supplement)
- **Division Gnetophyta**
  - Closest living relatives of angiosperms
  - Ephedra
  - Drug ephedrine originally derived from this plant.
  - Cells resemble xylem vessel cells of angiosperms.
  - Cone clusters resemble flowers.
- **Division Coniferophyta** (Conifers, Evergreens)
  - Oldest, tallest, most massive plants (e.g., 380 ft. tall Redwood tree).
  - Leaves form needles, which slow desiccation and are resistant to grazing by herbivores.
  - Important economically as wood/paper source, resin, turpentine and Christmas trees
- **Pine life cycle:**
  - Ovulate cone = megastrobilus with megas-porophylls (scales) - Micropyle, where pollen lands on ovulate cone.
  - Pollen cone = microstrobilus with microsporphylls
  - The process from pollination to fertilization can take over a year, which proved slow once the angiosperms evolved.

GYMNOSPERM LIFE CYCLE

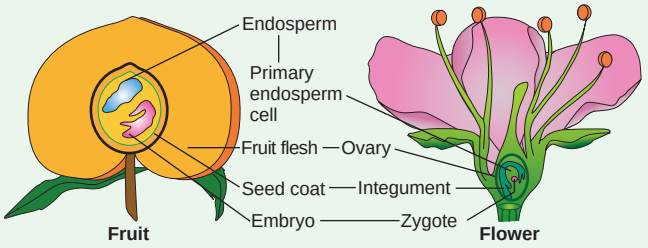


THE ANGIOSPERMS - "enclosed seed" plants

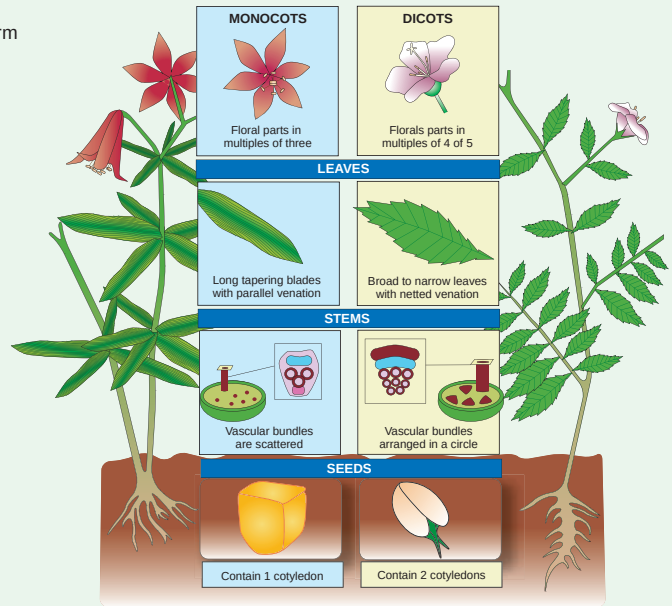
ANGIOSPERM LIFE CYCLE



FRUIT DEVELOPMENT

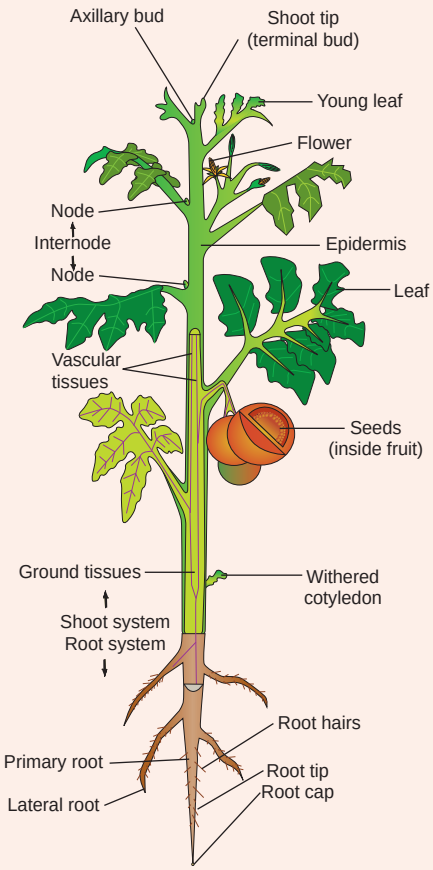


MONOCOTS VS DICOTS



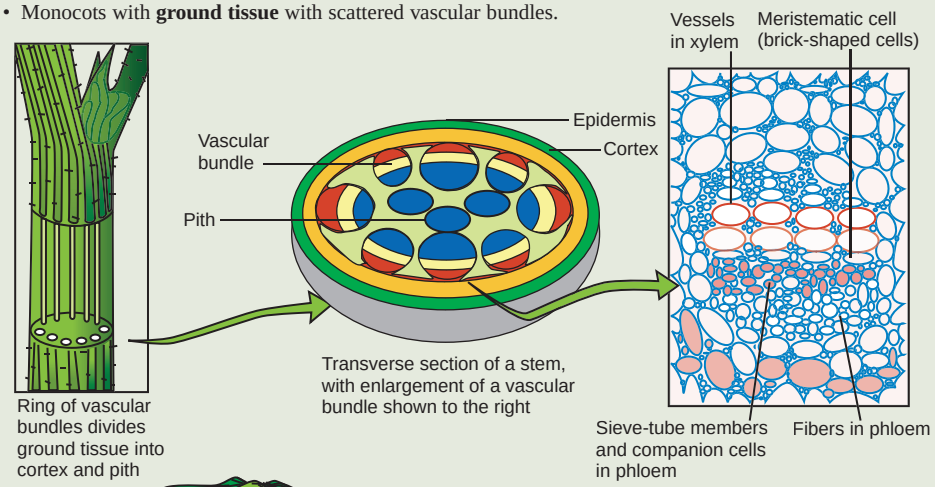
PLANT ARCHITECTURE

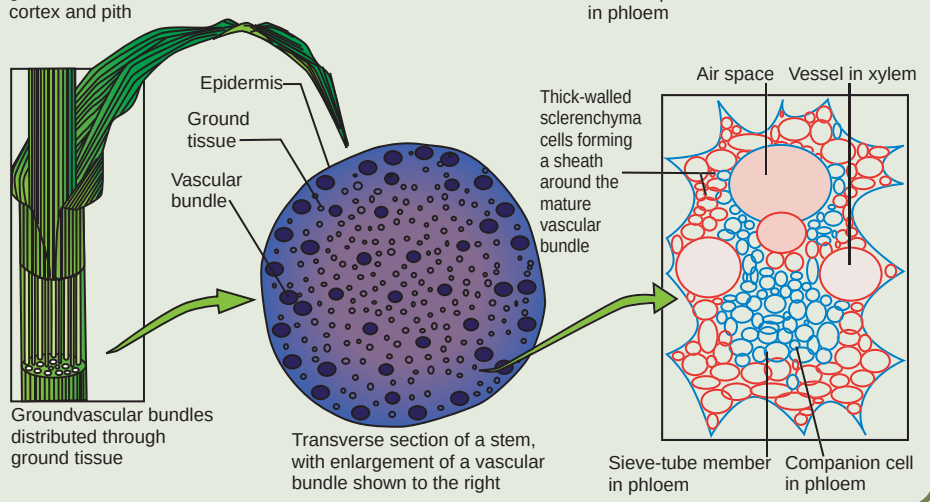
- Plant needs and solutions:
  - **Leaves** - Collection and conversion of solar energy
  - **Stems** - Positioning and support of leaves
  - **Roots** - Anchorage and absorption
  - **Vascular system** - Transport



STEM STRUCTURE

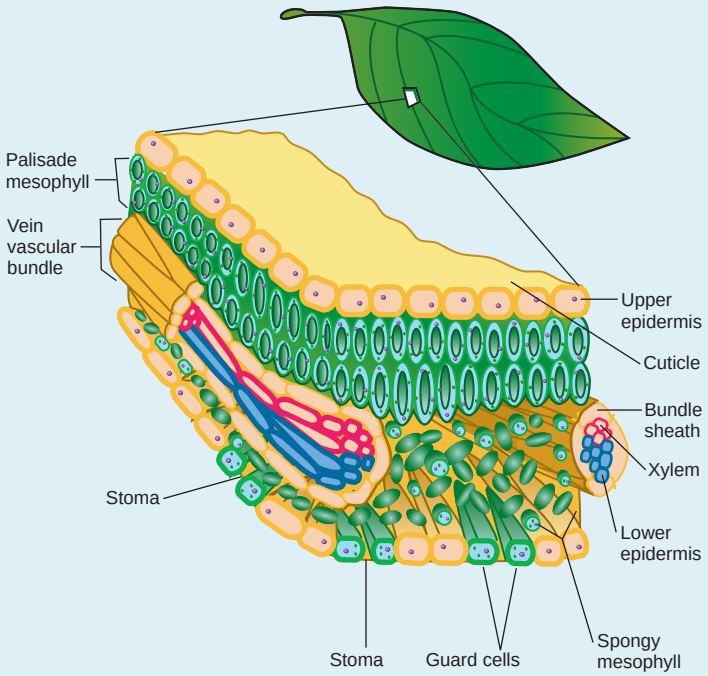
- **Cellulose-based cell walls** for support and growth toward sunlight
- **Epidermis**
- Dicots with **cortex** and **pith** separated by ring of vascular bundles.
- Monocots with **ground tissue** with scattered vascular bundles.



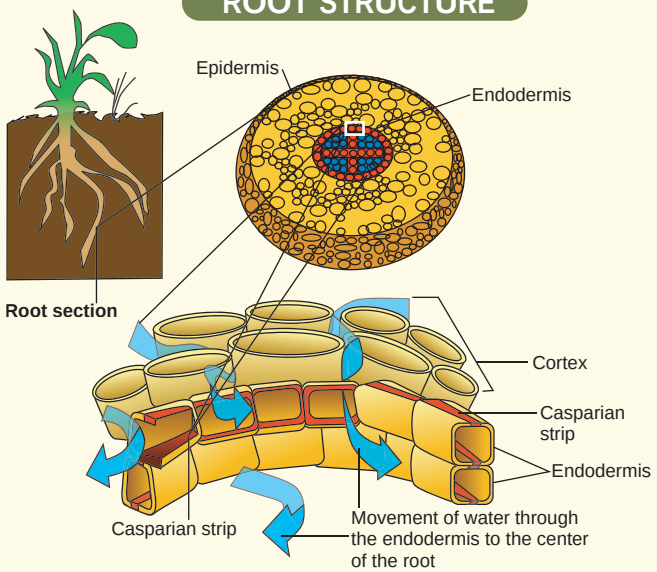


LEAF STRUCTURE

- **Epidermis**
- **Cuticle** with wax to resist desiccation (produced by epidermis).
- **Guard cells** with stomata to regulate gas exchange.
- **Mesophyll** - Photosynthetic layer.
- Dicots with palisade and spongy layers; monocots with one layer.
- **Vein** - Vascular bundle for transport of materials.



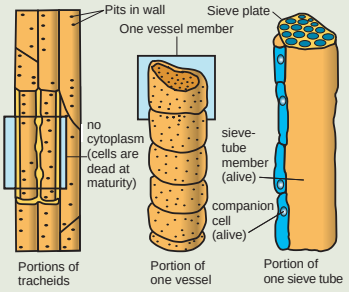
ROOT STRUCTURE



- **Epidermis** - Has root hairs for increased absorption area for water/minerals.
- **Cortex**
- **Endodermis** - With casparian wax strips
- **Stele** - Central cylinder with vascular tissues inside
- **Apoplastic pathway** vs. **symplastic pathway**: Water enters through root epidermis and passes in the spaces "between" cortex cells apoplastically unti reaching the endodermis. Casparian strips prevent water from passing between endodermal cells. Thus, water is forced through the cell membranes symplastically where it is filtered before reaching the vascular tissues within the stele. In this way, potentially harmful substances might be removed by the selectively-permeable membranes of the endodermal cells.

VASCULAR TISSUES

- **Xylem**, used for water/mineral transport.
  - **Tracheids** - Thin, hollow, dead cells with perforated, tapered ends.
  - **Vessel members (element)** - Thick, hollow, dead cells with large holes on end.
- **Phloem** used for sugar/food transport.
  - **Sieve tube members (element)**, hollow, living cells with perforated ends.
  - **Companion cells**, living cells that help keep sieve tube member cells alive.

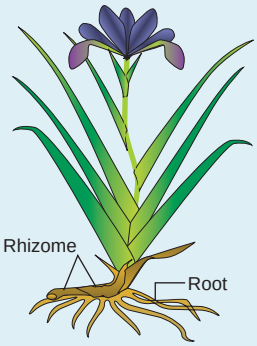


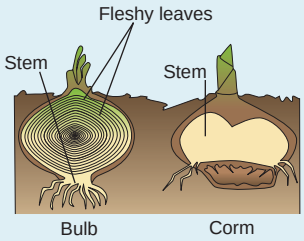
IMPORTANT SYMBIOSES WITH PLANTS

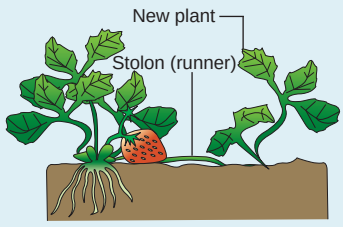
- **Root nodules & bacteria**
  - Bacteria fix nitrogen and are housed in root nodules to supply "fertilizer," thus allowing the plant to thrive, even in soils that are nutrient poor.
- **Mycorrhizae**
  - Most plants today have an association between their roots and fungi in the soil. This association, or mycorrhizae, is critical in aiding water/mineral uptake by the plant.

VEGETATIVE (asexual) REPRODUCTION

Plants typically produce new parts/structures without sexual reproduction, thus allowing the quick spread of the plant into the immediate habitat.







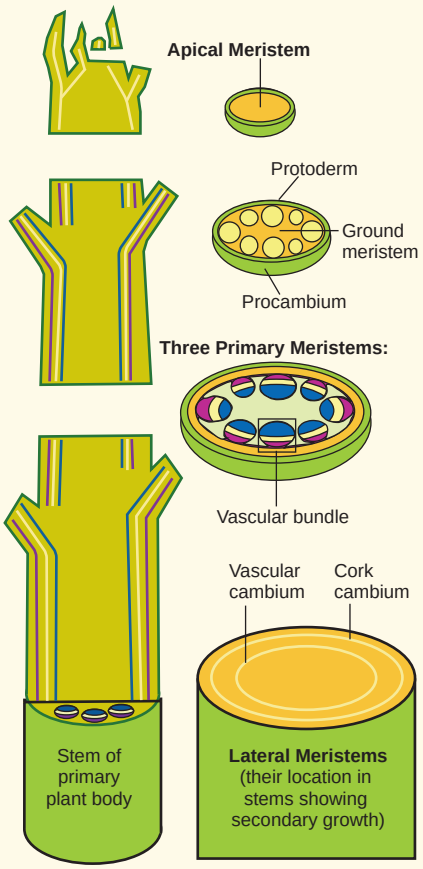
Asexual Reproductive Modes of Flowering Plants

Mechanism	Representative	Characteristics
Vegetative reproduction on modified stems		
Runner (stolon)	Strawberry	New plants arise at nodes on an above ground horizontal stem
Rhizome	Bermuda grass	New plants arise at nodes of underground horizontal stem
Corm	Gladiolus	New plant arises from axillary bud on short, thick, vertical underground stem
Tuber	Potato	New shoots arise from axillary buds on tubers (enlarged tips of slender underground rhizomes)
Bulb	Onion lily	New bulb arises from axillary bud on short underground stem
Parthenogenesis	Orange tree, rose	Embryo develops without nuclear or cellular fusion (e.g., from unfertilized haploid egg; or develops adventitiously, from tissue surrounding embryo sac)
Vegetative propagation	Jade plant, African violet	New plant develops from tissue or organ (e.g., a leaf) that drops or is separated from plant
Tissue culture propagation	Orchids, lily, tulip, wheat, rice, corn	New plant induced to arise from cell of a parent plant that is not irreversibly differentiated

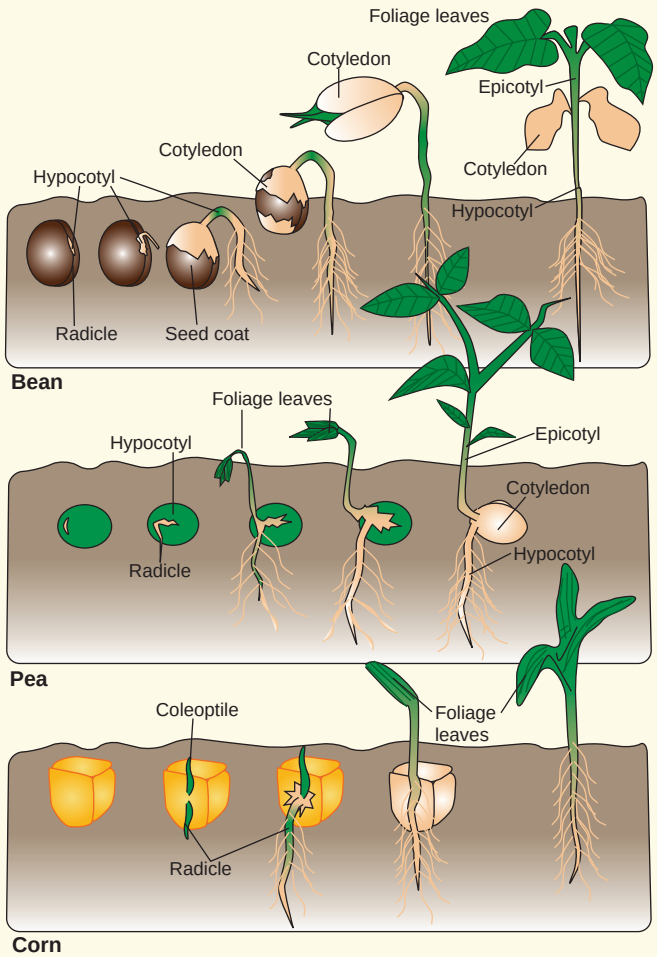
PLANT DEVELOPMENT

MERISTEMATIC TISSUES

- Growth after germination
- **Upward growth**
  - Epicotyl or Coleoptile
  - **Phototropism** - Plant growth and movement in response to light.
- **Downward growth**
  - Radicle or hypocotyl
  - **Gravitropism** - Plant growth response to gravity via statolith sensors.
- Meristematic tissues form all tissues of adult plant (similar to germ tissues of animals).
- **Apical meristems**
  - Responsible for increase in plant height.
- **Lateral meristem**
  - Responsible for increase in plant diameter (girth).
- **Three primary meristems**:
  - **Protoderm** - Epidermis
  - **Ground meristem** - Cortex and ground tissues
  - **Procambium** - Vascular bundles with xylem and phloem.



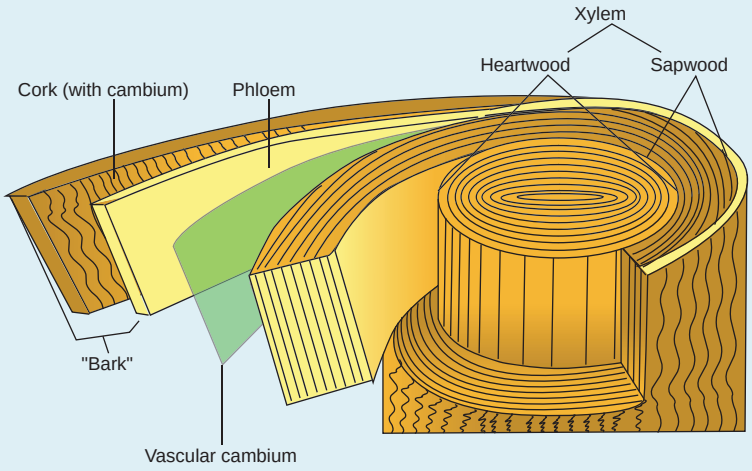
SEEDLING DEVELOPMENT



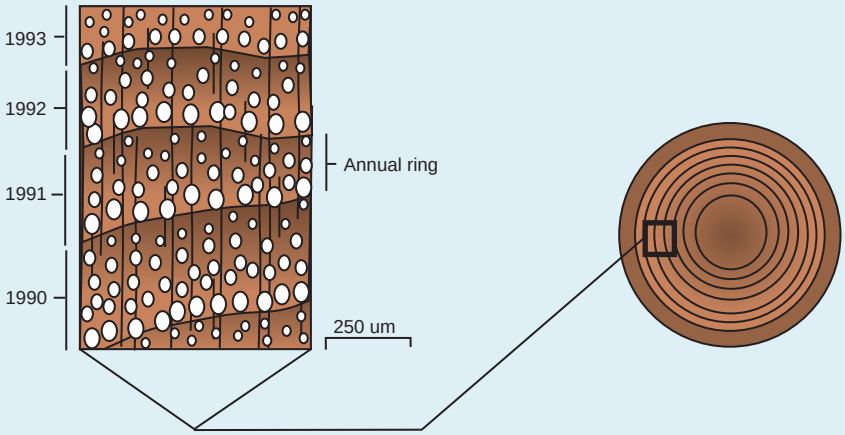
Plant development continued:

- **Vascular cambium** - Produces xylem inward and phloem outward
- **Cork cambium** - Cork
- Wood is produced from xylem:
  - **Annual rings (see fig.)**
  - Heartwood vs. sapwood **(see fig.)**
  - Heartwood - Clogged xylem, little water transport
  - Sapwood - Newer xylem, free flowing water transport
- **Bark** is produced from phloem, cork cambium, cork
  - Lenticels are cracks in the bark to facilitate gas exchange.
  - "Girdling plants" or cutting a horizontal band around the circumference of the plant, can be deadly because the vascular cambium, in which nutrients and water travel vertically, can be damaged. Lawn equipment (especially weed whackers) is a potential source of this kind of plant damage.
- **Exchange and Transport**
  - Plants obtain gases, nutrients, minerals and water via internal fluids.
  - Gas exchange- stomata, roots, lenticels
  - Internal transport- xylem and phloem
  - Fluids move in xylem via adhesion, cohesion, evaporation and osmosis.
- **Theories of upward movement:**
  - **Capillary action** - Some water moves up small vascular cells naturally.
  - **Root pressure** - Solutes inside the root tissues draw some water up.
  - **Transpiration pull** (cohesion-adhesion-tension)- The main motive force for transporting water up to the top of a plant (sometimes several hundred feet).
  - Essentially, as water evaporates from the leaf surface, the cohesive and adhesive properties of water pull water molecules from below, establishing a water tension/pressure. One drawback is it requires loss of water from the plant. In dry conditions or arid environments, this water loss for vertical transport can be critical to plants – thus, a replenishing water supply in the roots is vital.
- **Fluid movement in phloem (see fig.)**
  - Sugars produced by the leaves via photosynthesis must be distributed to the rest of the plant. Gravity can assist this basically downward movement. However, getting the sugars into the cells of the phloem requires energy (i.e. active transport). Sometimes large quantities of sugars/starch are stored in special vegetative structures (e.g., tubers).

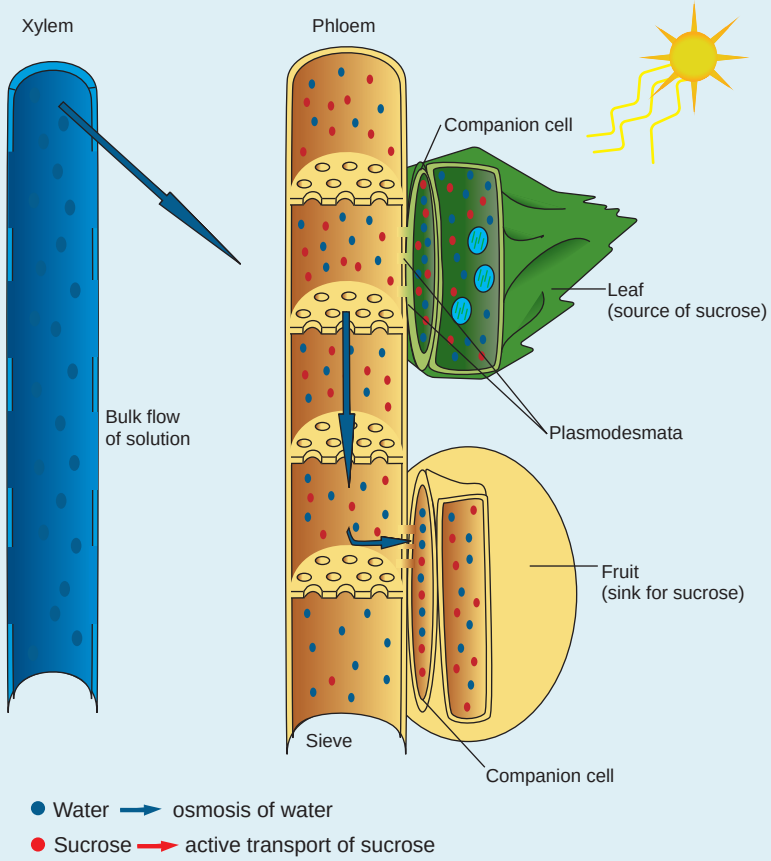
SECONDARY GROWTH



ANNUAL RINGS



INTERNAL TRANSPORT IN PHLOEM



CREDITS
Author: Randy Brooks, PhD.
Layout: Dale Nibbe

PRICE
U.S. $5.95
CAN. $8.95

ISBN-13: 978-142320405-3
ISBN-10: 142320405-0

9 781423 204053 50595

6 54614 00405 5