Grade 11 Biology

Plants – Anatomy, Growth and Function

Class 15

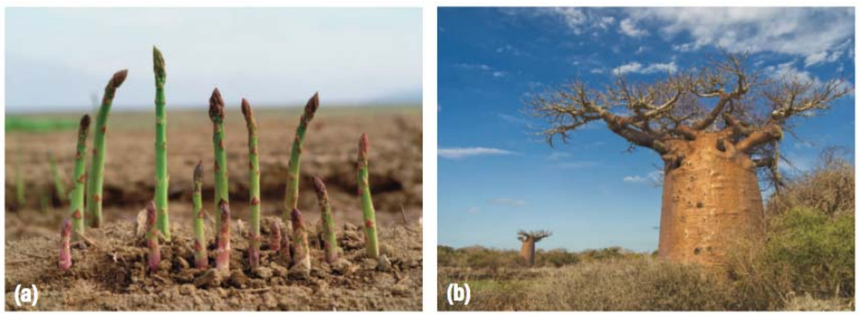
Stems

Functions:

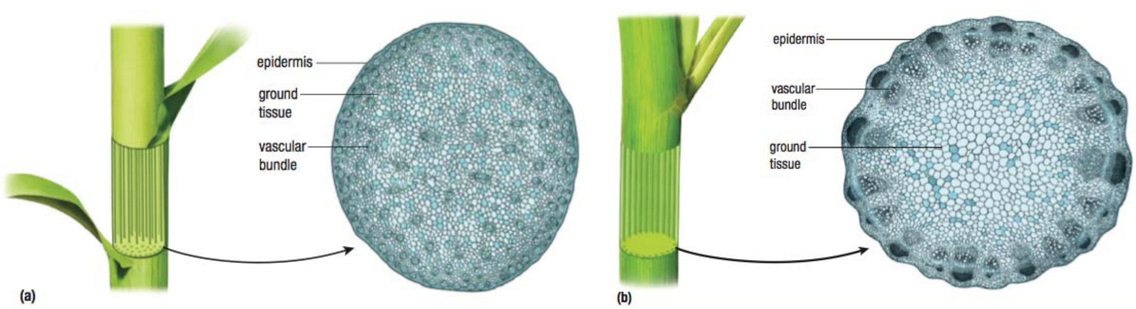
- Transport water and dissolved substances to from root to shoot
- Raise leaves, flower and cones to maximize their exposure to light and pollinators
- Store water and carbohydrates
- Perform photosynthesis
- Protection from herbivores with spikes

Structure:

- Two types:
  - – Herbaceous – stems that do not have wood; pliable with a thin epidermis and can carry out photosynthesis
  - – Woody – stems that contain wood; hard with bark and do not carry out photosynthesis



- Herbaceous stems have a vascular bundle, a long continuous strand of vascular tissue that consists of xylem and phloem



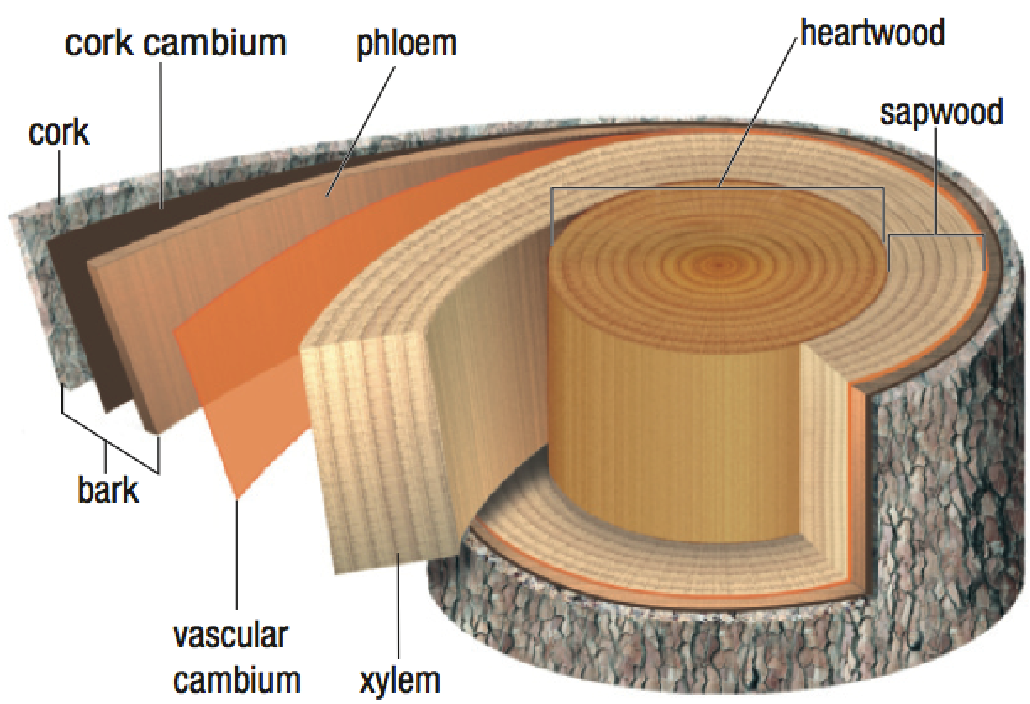
Monocot – Cross-section

- Vascular bundles are found throughout the ground tissue of the stem

Eudicot – Cross-section

- Vascular bundles form a ring around the ground tissue

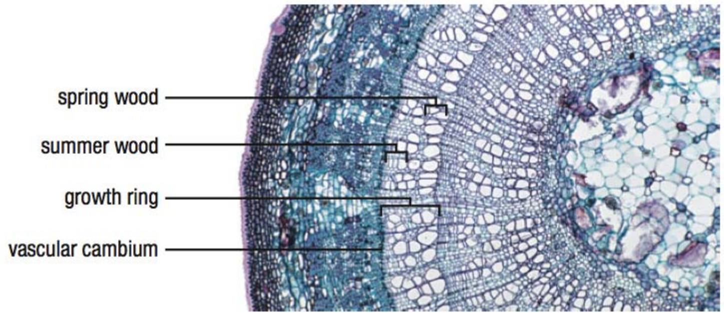
- Woody stems have vascular cambium, a layer of meristematic cells that divide to form new xylem and phloem cells
- Wood is actually many layers of xylem tissue filled up with resins and oils that no longer conduct water
  - Sapwood is younger xylem that allows water and minerals to be transported to the leaves
  - Heartwood is older xylem that is very rigid and helps support the tree



- Bark consists of all tissues found outside the vascular cambium (phloem, cork cambium and cork)
- Phloem transports sugars in the leaves throughout the plant
- Cork cambium produces cork to prevent water loss from the stem

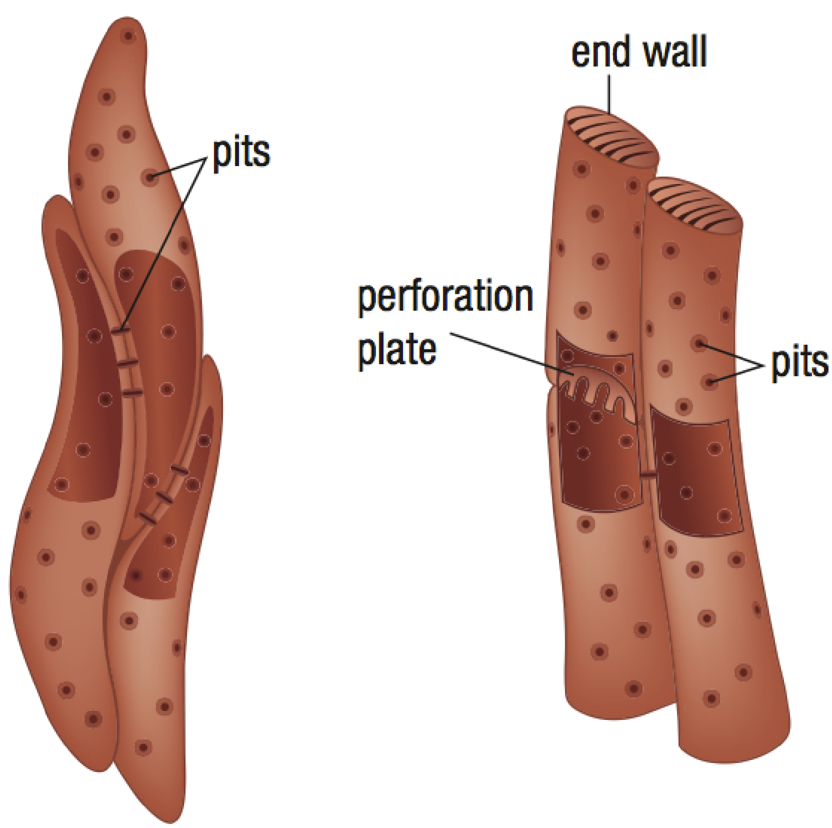
Growth Rings

- During the spring, vascular cambium grows rapidly producing a layer of lighter-coloured wood (spring wood)
- During the summer, a layer of darker-coloured wood (summer wood) is formed



Xylem Cell Types

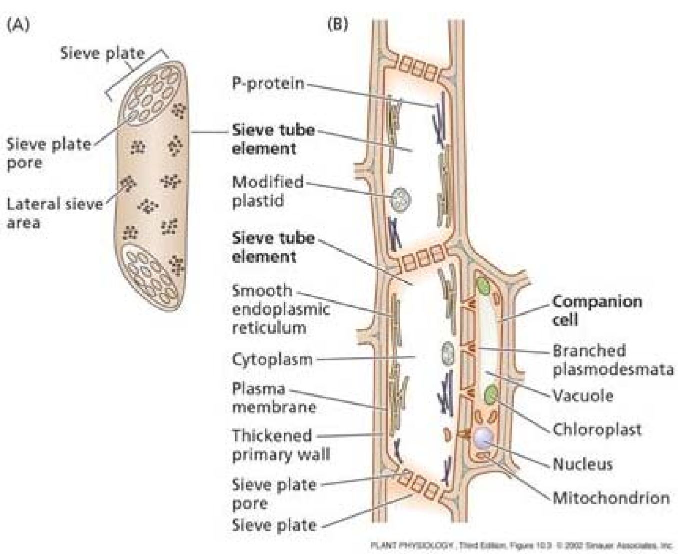
- Xylem cells are thick-walled and dead at maturity
  - Rich in lignin (carbohydrate)
- Types:
  - Tracheids – long, cylindrical cells with tapered ends and pits that allow water and solute to pass up or across to neighbouring xylem cells
  - Vessel elements – shorter and wider cell with less-tapered ends; have perforation plates to allow water and solutes to pass

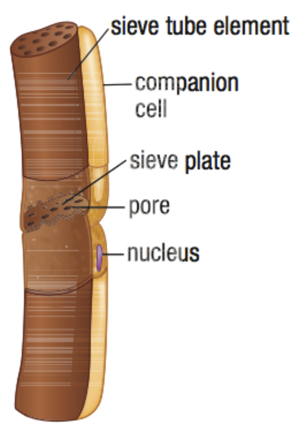


(a) tracheids **(b)** vessel elements

Phloem Cell Types

- Phloem cells are living at maturity and contain cytoplasm
- Types:
  - Sieve cells – cells with narrow pores in their cells walls; contains organelles and nucleus
  - Sieve tube elements – cells with cytoplasm but lack organelles and nucleus; have sieve plates to allow solutes to pass to neighbouring phloem cells
  - Companion cells – contains a nucleus and organelles; always associated with sieve tube elements





(c) sieve tube elements and companion cells

Table 1 Xylem and Phloem Cell Types in Gymnosperms and Angiosperms

Plant group	Xylem tissue cell types	Phloem tissue cell types
gymnosperms	tracheids	sieve cells
angiosperms	tracheids vessel elements	sieve tube elements companion cells

- Some stems grow underground to store food and water and can give rise to a new plant

Figure 8 Underground stems: (a) potato tuber, (b) gladiolus corm, and (c) iris rhizome

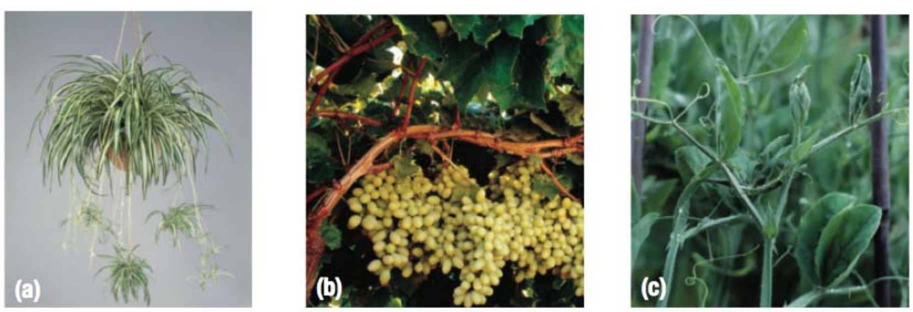


Figure 9 Above-ground modified stems are found on (a) spider plants, (b) grape vines, and (c) sweet peas.

- Stolons are modified stems that grow along the soil instead of upright (ex: spider plants)
- Vines have modified stems that uses other objects to raise and support their leaves
  – Can be herbaceous (sweat pea stems)
  – Can be woody (grape stems)

Human Uses of Stems

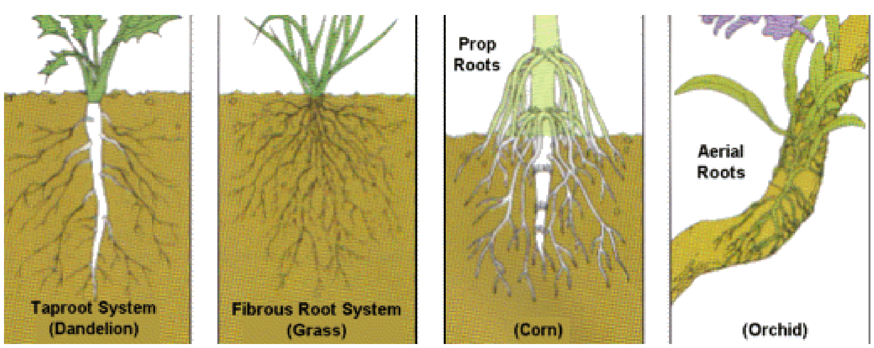
Table 2 Some Uses of Plant Stems

Use	Examples	Use	Examples
fuel	• ethanol • wood	dyes	• indigo, used to dye jeans • hematoxylin, a stain used to prepare microscope slides
food	• sugar cane • potatoes • yams • maple syrup • asparagus	other chemicals	• tannin, an ingredient in wood stains • turpentine, a solvent • latex rubber, used for many products, including gloves, tubing, and erasers
textiles	• flax (used to manufacture linen) • hemp (used to produce textiles) • bamboo (used to make clothing; often blended with other natural fibres such as cotton)	medicine	• salicylic acid, a pain reliever made from willow bark • taxol, an anti-cancer drug made from the bark and needles of yew trees

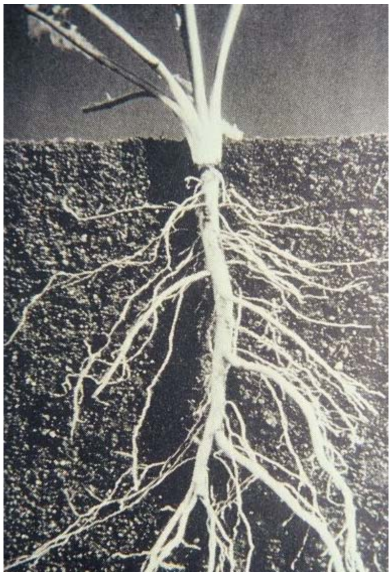
Roots

Functions:

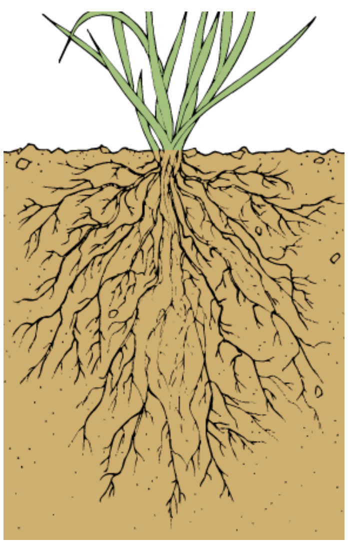
- Anchor the plant and provide structure
- Absorb water and nutrients
- Store water and carbohydrates



Types of Root Systems



- Taproot System – large, thick, main root called a taproot that grows straight downward
  - May contain lateral roots branching from it with root hairs
  - Gymnosperms and angiosperm eudicots have taproot systems

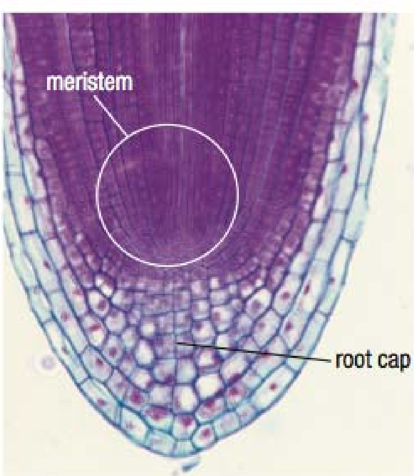


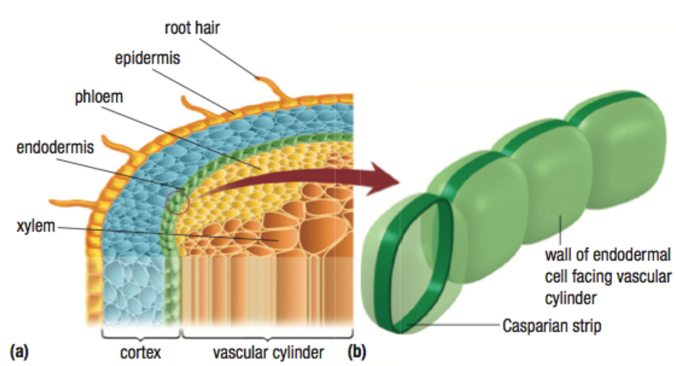
- Fibrous Root System – contains many small roots with lateral roots and root hair
  - Occurs in angiosperm monocots
  - Shallower than taproots

Structure:

- Root cap – thick layer of cells that produces a sticky substance to help penetrate the soil and minimize damage to the root cells
- Meristem – produces new cells to increase the length of the root
- Root cortex – beneath the epidermis that stores carbohydrates and transports water from the epidermis to the xylem
- Endodermis – the innermost layer of cells in the root cortex

- Casparian strip – the wax-like strip that runs through the cell wall of an endodermal cell





- Vascular cylinder – the central portion of a root that contains the xylem and phloem
  - In gymnosperms and eudicots, the centre of the root contains xylem cells forming an “X” shape
  - In monocots, the centre of the root contains parenchyma cells surrounded by a ring of xylem and phloem cells

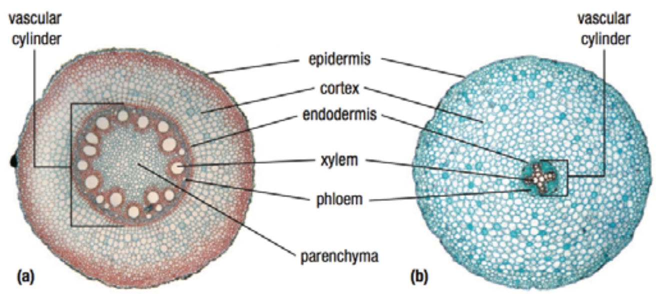


Figure 5 Cross-sections of (a) a monocot root and (b) a eudicot root. In monocots, the centre of the vascular cylinder has parenchymal cells. In eudicots xylem cells are at the centre of the root.

- Over 80% of plants have a mutualistic relationship with mycorrhizal fungi
  - Fungi provides water and nutrients for the plant; plants provides carbohydrates for the fungi
- Plants also have a mutualistic relationship with nitrogen-fixing bacteria
  - Bacteria provide plants with nitrates and nitrites; plant provides bacteria with carbohydrates

- Some taproots (carrots, beets) are specialized for carbohydrate storage
- Some lateral roots (yams, cassava, sweet potatoes) are tuberous roots that contain carbohydrates

- Some roots produce toxins to prevent being eaten and to reduce competition
  - Ex: Black Walnut root secretes a toxin that inhibits the growth of other plants nearby to reduce competition for resources
- Some roots grow adventitious roots that grow somewhere other than the root apical meristem for additional support

Human Uses of Roots

- Food and beverages
  – Parsnips, turnips, beets, taro, sweet potatoes
- Chemicals
  – Beets provide the red dye colour for textiles
  – Rotenone is a natural pesticide produced in the pea family
- Erosion Control
  – Prevent soil erosion due to water and wind

Figure 10 Chemicals in the roots of (a) ipecacuanha, (b) kava kava, and (c) valerian have medicinal uses that have been verified by scientific studies.

- Medicinal Purposes
  – Ipecac from the ipecacuanha plant induces vomiting
  – Kava kava root reduces anxiety
  – Valerian is a sedative that relieves insomnia

Transport in Vascular Plants

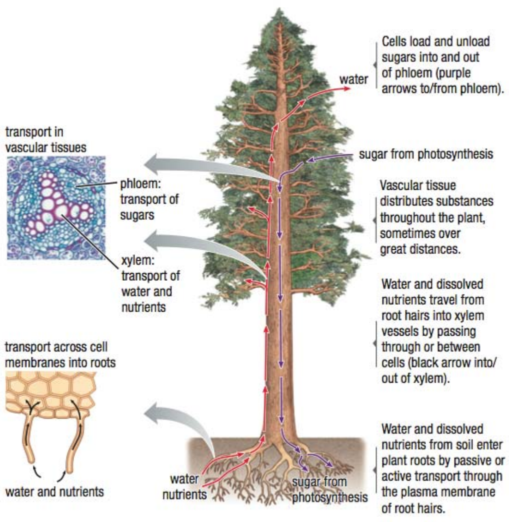


Figure 2 Overview of transport routes in plants

- Water and nutrients move into the plant via three stages:
  - From soil into the roots
  - From roots to the stem
  - From stem to the leaves

Transport into the Root

- Water enters the roots cells by osmosis and move toward the vascular cylinder
- Plant cells use active transport to move nutrients from the soil into the roots cells toward the endodermis
- Water and nutrients encounter the Casparian strip that prevents the substances from leaking back to the cortex
- Once inside the vascular cylinder, nutrients are actively pumped across cell membranes into the xylem

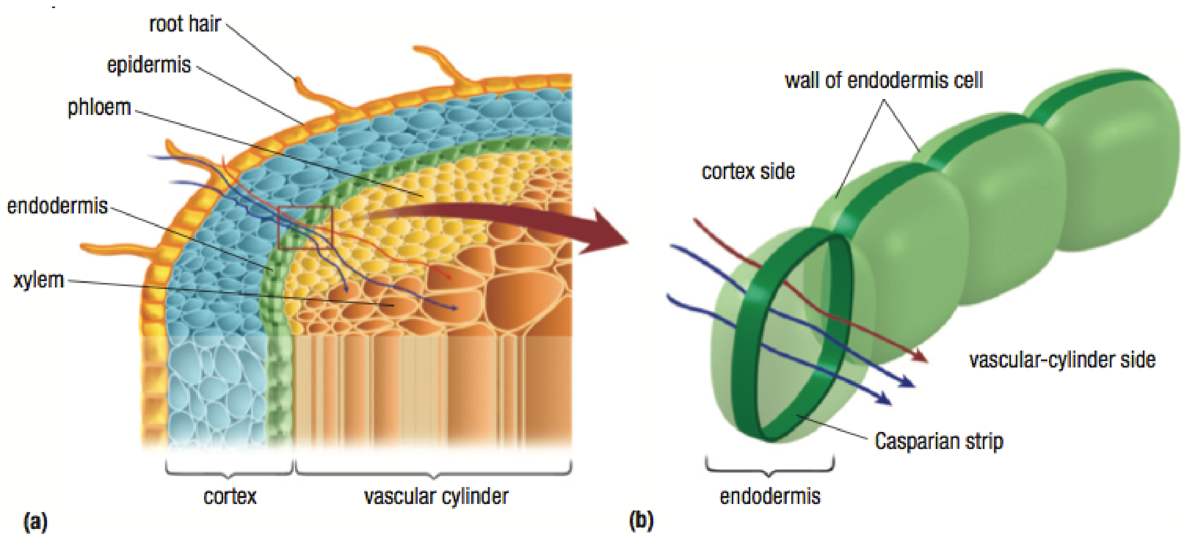


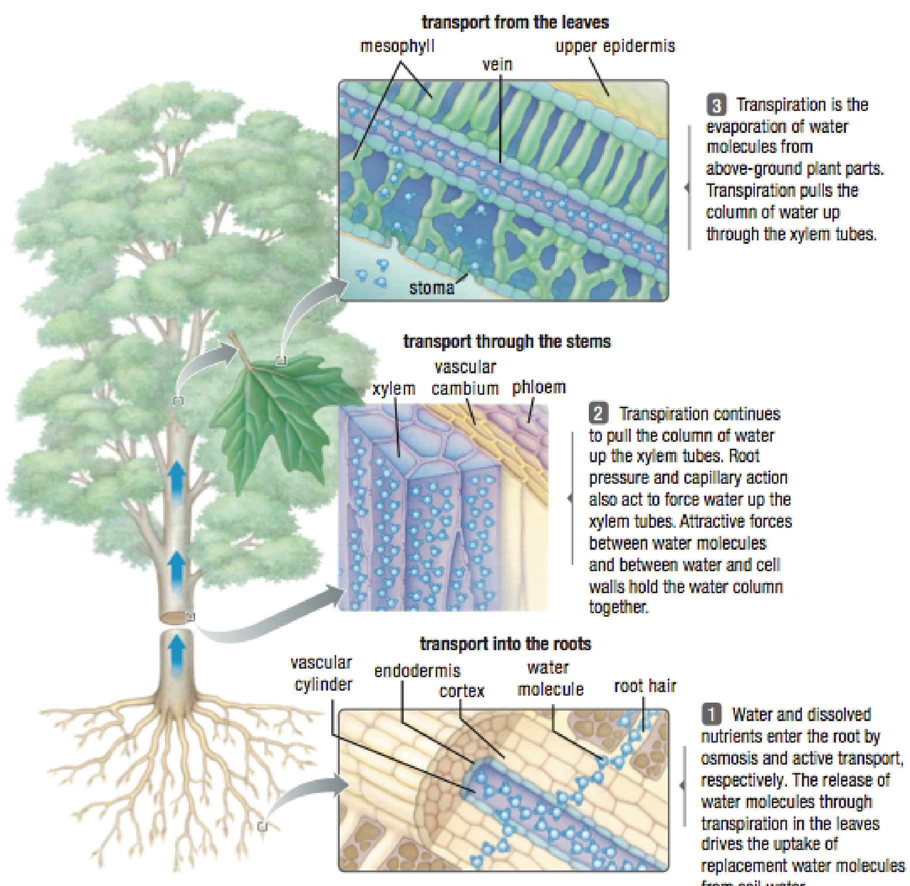
Figure 3 (a) Water moves through the cortex by two routes (blue arrows): it either flows between the cells or enters the cells by osmosis and then moves from cell to cell. Nutrients are taken in by active transport and move from cell to cell (red arrow). (b) At the endodermis, the Casparian strip prevents substances from passing between the endodermal cells and forces them to pass through the cell membrane instead. Nutrients enter the xylem by active transport.

Transport into the Stem

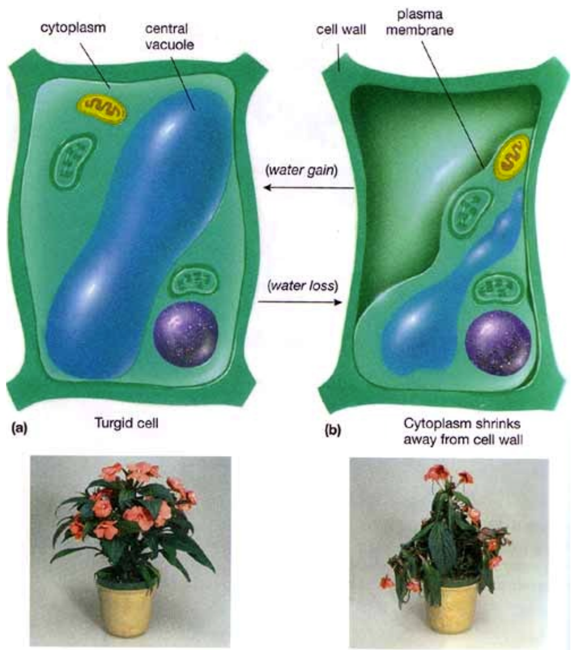
- Once inside the xylem, the liquid is called the xylem sap
- As more nutrients are pumped into the xylem, the concentration increases and water follows by osmosis creating increased root pressure
- Root pressure and capillary action allow the xylem sap to move up through the xylem tube and across through xylem pits

Transport to the Leaves

- Transpiration from the leaves causes water vapour to evaporate through the stomata
- Due to the attractive forces between water molecules, when a water molecule moves up, it pulls a neighbouring water molecule with it
- This water column is the main driving force of transport to the leaves



Turgor Pressure



- Plant cells store water and dissolved substances inside the central vacuole
- Full vacuoles exerts turgor pressure against the cell wall
- Turgor pressure supports the plant and prevents wilting

Transport of Sugars

- Source – a plant cell with a high concentration of sugars and other solutes; a leaf cell
- Sink – a plant cell with a low concentration of sugars due to rapid usage
- Sugars can move up or down the plant and are generally transported from a source to a sink
- Location of sources and sinks can change with the seasons

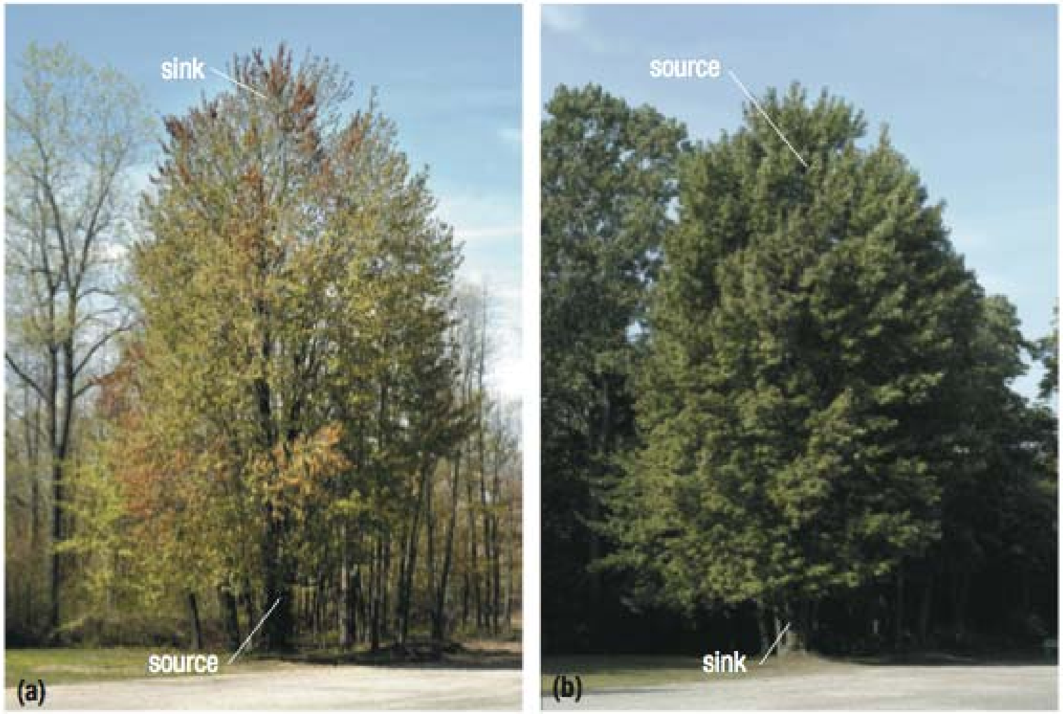


Figure 7 (a) In early spring, phloem sap moves mainly upward from the roots to the growing shoots. (b) In summer, phloem sap moves mainly downward from mature leaves to the stems and roots.

- Sugar transport has three stages:
  - Transport from source cells to phloem cells
  - Transport through the phloem
  - Transport from phloem cells to sink cells

Transport from Source to Phloem

- Involves active transport since the sugar moves against its concentration gradient
- As concentration of phloem sap increases, water is drawn in by osmosis to increase turgor pressure near the source cells

Translocation

- Transport of sugars quickly through the phloem driven by the difference in turgor pressure between the source cells and sink cells

Transport from Phloem to Sink

- Sugars move down its concentration gradient into the sink cells by passive transport
- Water returns to the xylem from the phloem by osmosis and allows recirculation of the water

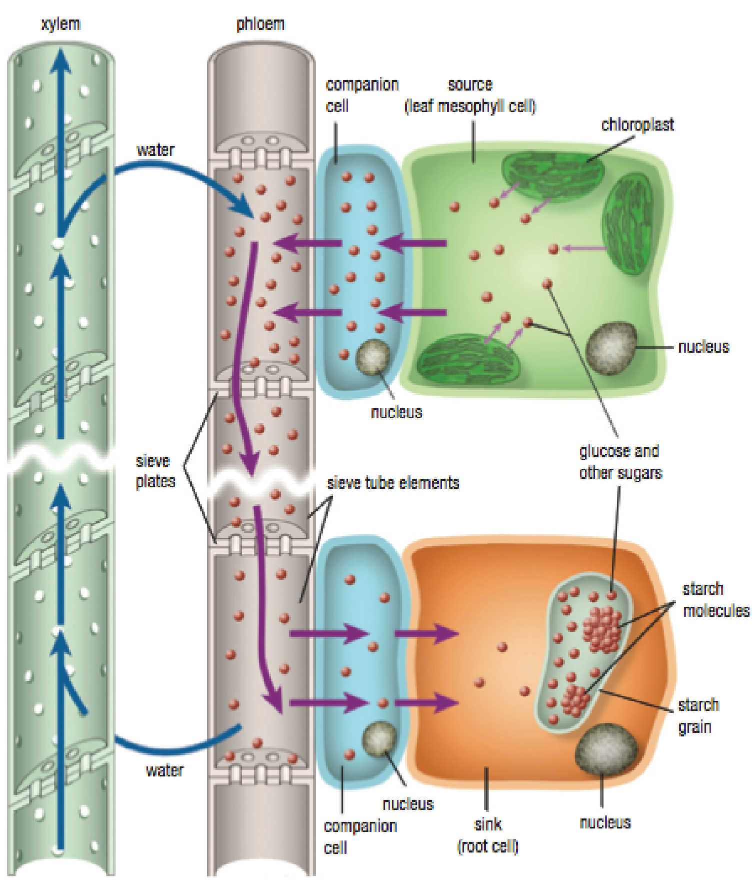
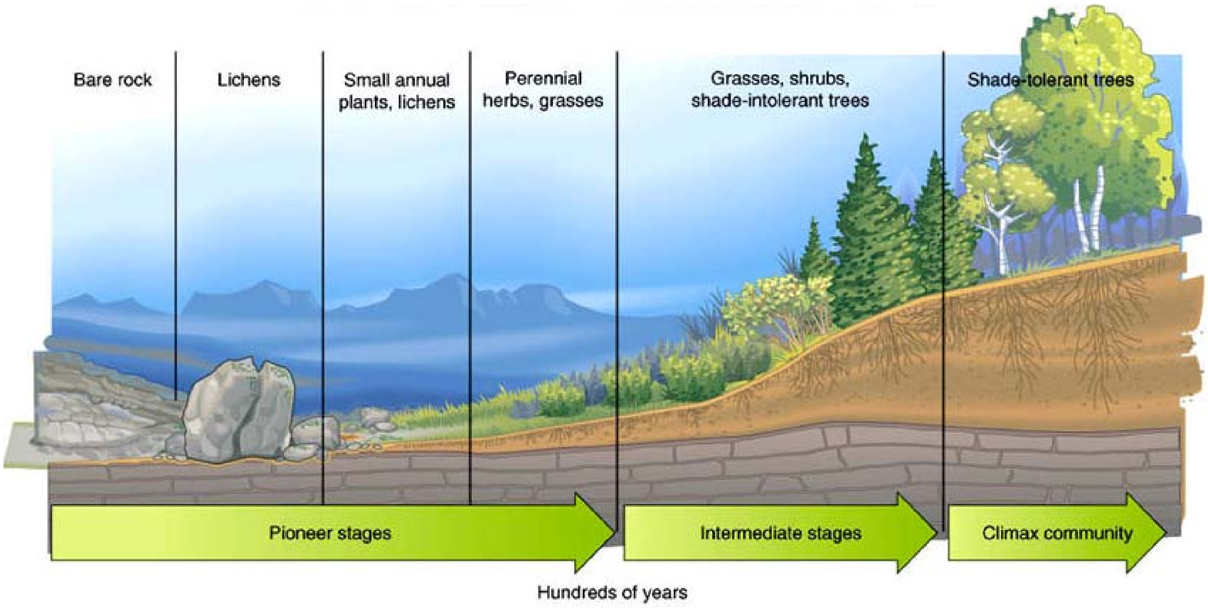


Figure 9 Transporting sugars from a source to a sink cell involves both passive and active transport.

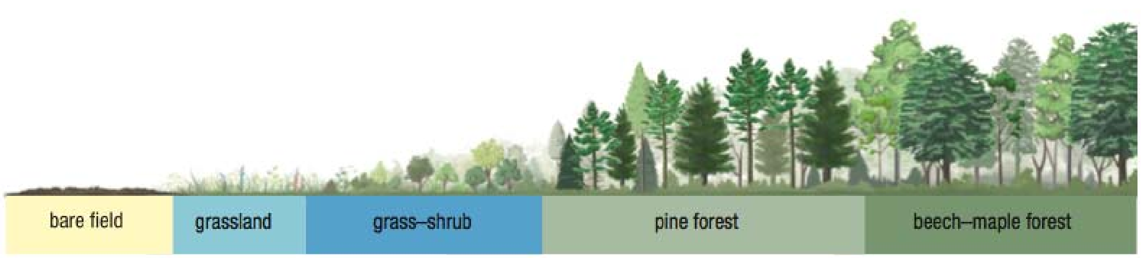
Succession

- The gradual change in the species composition of a community over time
- **Primary succession** – succession that takes place on completely barren rock, mineral deposits, lifeless surfaces
  - Colonized by pioneer species (usually lichens that can obtain nutrients by eroding rock)
  - Animals that eat lichen add droppings to the developing soil layer

  - Mosses and small plants colonize the area and retain water and stabilize the soil; insects, birds and some small animals feed on the small plants
  - Small herbaceous plants outcompete the mosses and continue to add nutrients to the soil below attracting more insects, worms and animals
  - Soil layer thickens and is able to support more plants and animals
  - Different plants and larger plants provide shelter and shade for a wide range of animal species
  - Eventually a stable community is formed



- **Secondary Succession** – occurs after an existing community has been disturbed by a natural event (forest fires, violent storms) or human activity (deforestation, construction)
- Plant communities establish more quickly than in primary succession



Human Activity and Succession

- Succession creates stable, diverse communities that can withstand environmental change
- Human activity often prevents succession and reduce plant and animal biodiversity
- Strategies can be used to minimize our effects on succession
  - Ex: selectively cutting, introducing native plants to lawns and gardens, naturalization

Asexual Reproduction in Seed Plants

- The production of offspring by a single parent
- Structure for Asexual Reproduction:
  - Rhizomes – modified stems that include corms, stolons and the eyes on tubers
  - Modified leaves
  - Modified roots

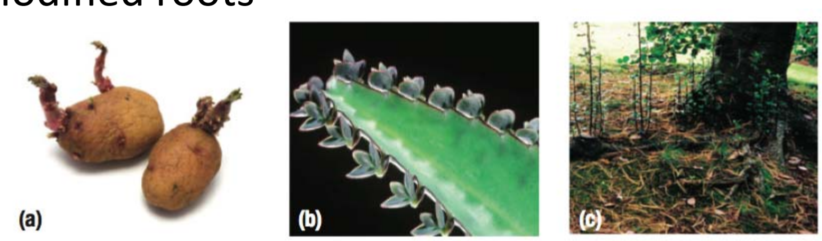


Figure 3 New plants can arise from (a) tubers, (b) leaves, and (c) roots.

- Costs and benefits of asexual reproduction

Benefits	Costs
• All offspring will have the same genetic traits as its parent • No need to produce specialized reproductive structures • Only one plant is needed • Plantlets formed by asexual reproduction have a higher survival rate	• Genetically identical offspring creates a monoculture that can be susceptible to diseases, environmental damage, etc.

Human Uses of Asexual Plant Reproduction

- Farmers can use asexual reproduction to produce copies of plants that had desirable characteristics

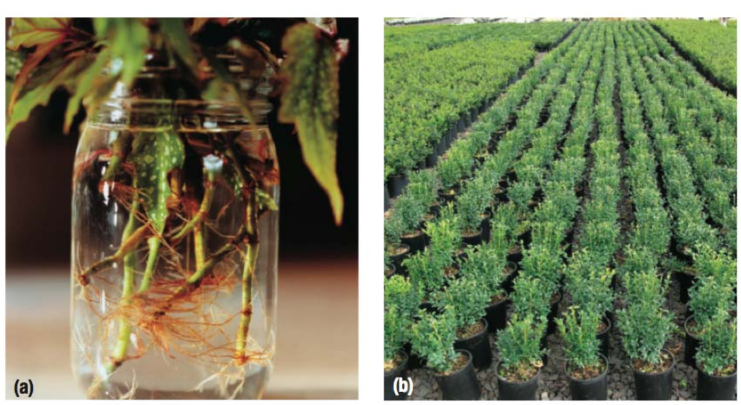
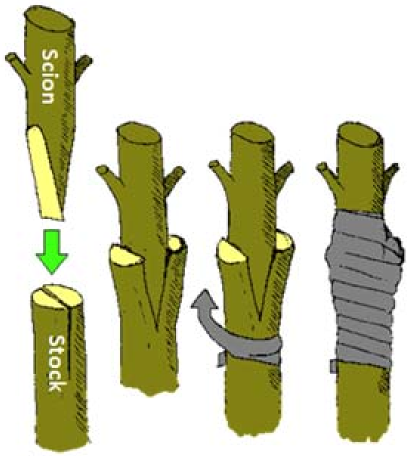


Figure 4 (a) Roots form on a cutting. (b) Commercial nurseries produce genetically identical plants grown from cuttings.

- Grafting – involves cutting a young branch (scion) from a plant and attaching it to the stem of another plant (stock)
  - Cambium of the scion and the stock grow together and vascular tissue fuses



Sexual Reproduction in Seed Plants

- Seeds protect and nourish the enclosed embryo and carries the embryo to a new location
- Seeds are dispersed primarily by wind or animals


(a)


(b)

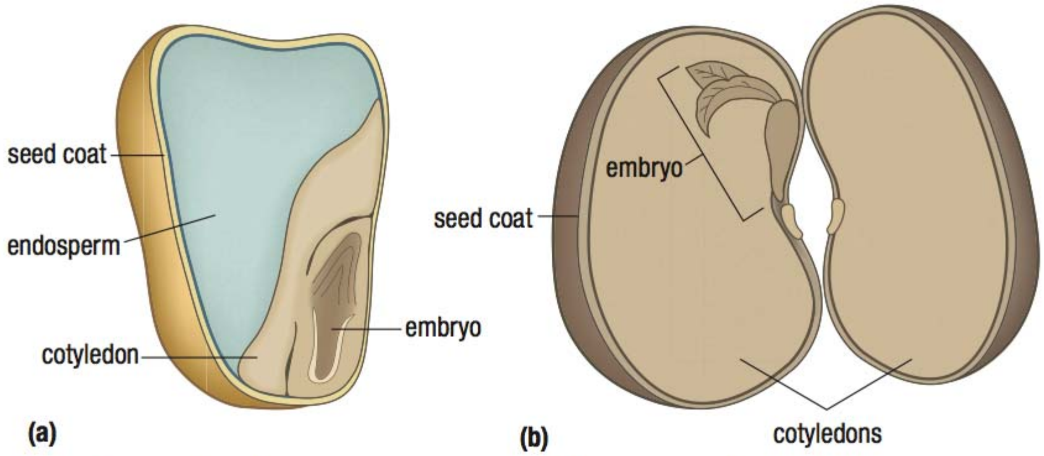


Figure 3 General seed structure in angiosperms. (a) A monocot and (b) a eudicot

- Seeds contain an embryo, nutritive tissue and a protective seed coat
- In angiosperms, the nutritive layer is called the endosperm and the seed is contained in fruits

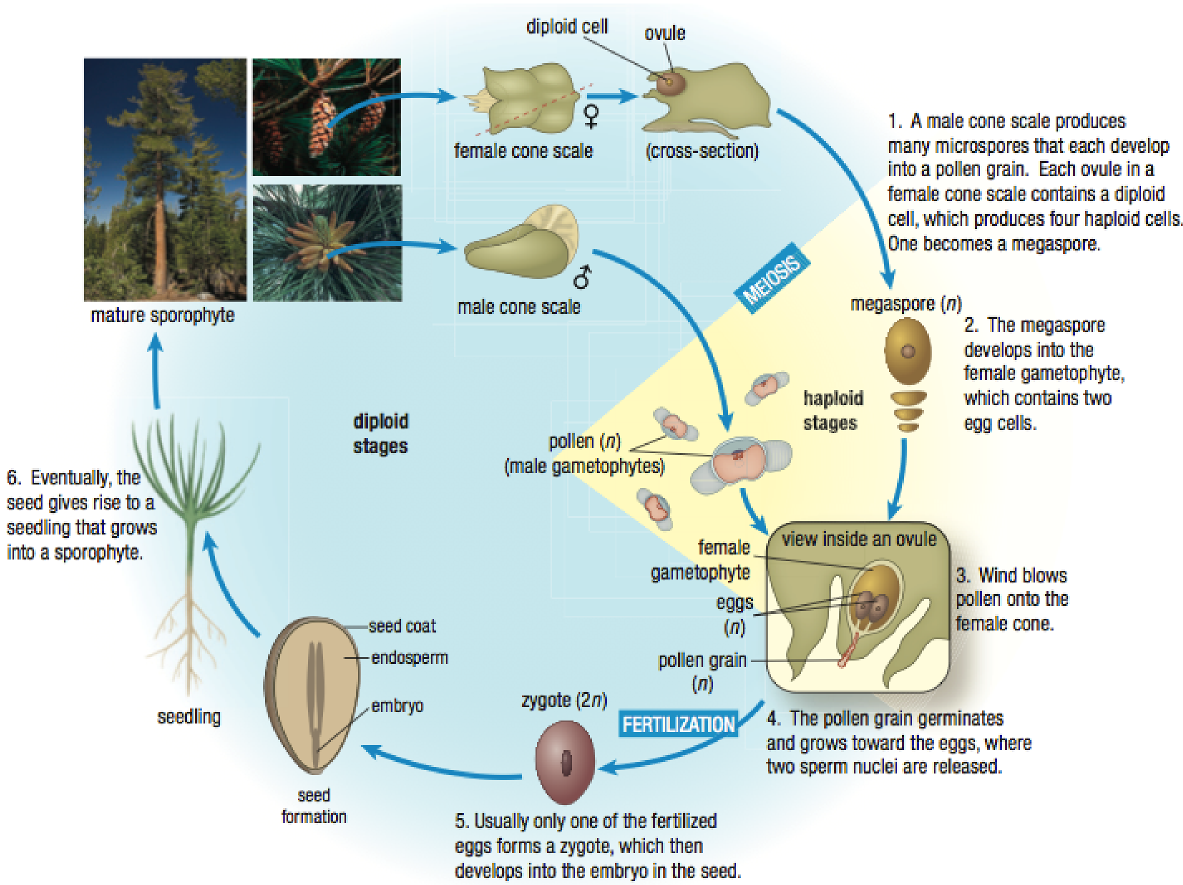
- Costs and benefits of sexual reproduction

Benefits	Costs
• High level of genetic diversity allowing for higher chances of survival • Seeds can be dispersed away from the parent so seedlings have less competition for resources • Seeds can remain dormant for long periods and germinate only when conditions are favourable	• Require energy to create specialized reproductive organs

Sexual Reproduction in Gymnosperms

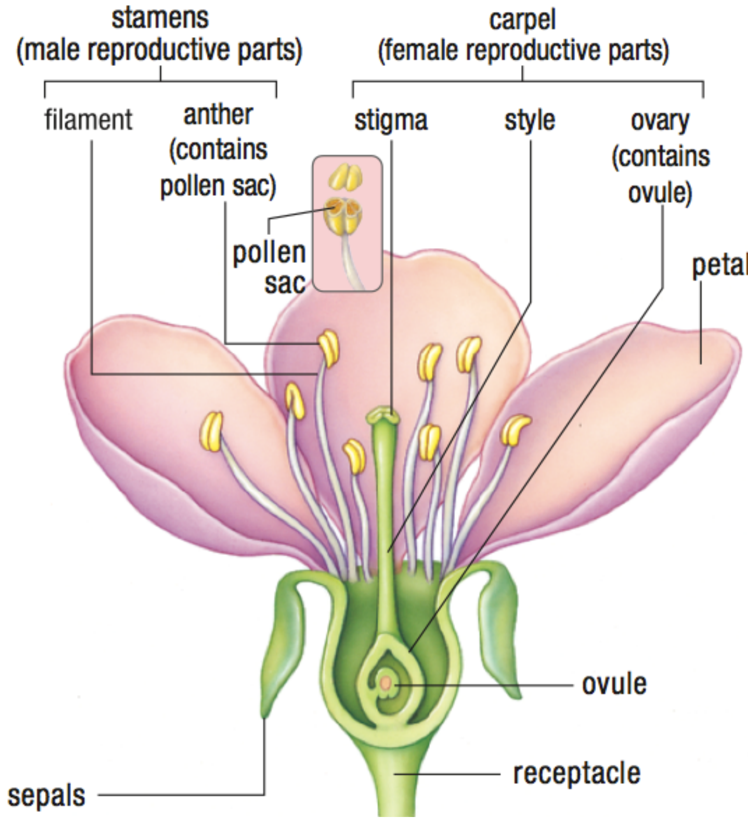
- Conifers produce both male and female cones
- Microspores are produced by meiosis within male cones that lead to a pollen grain containing a male gametophyte
- Megaspores are produced in female cones that lead to egg-producing female gametophytes
- Pollen grain transfers to the female cone by wind dispersal and grows a pollen tube that extends to the ovule

- As pollen tube grows, its haploid nucleus divides by mitosis produce two sperm nuclei
  - One sperm fertilizes the egg to form a diploid zygote; the other sperm degrades
- Zygote develops into the embryo and eventually a mature sporophyte



Sexual Reproduction in Angiosperms

- Stamens make up the male reproductive flower parts
  - Anther produces pollen grains
  - Filament raises the anther above the female organs
- Carpel makes up the female reproductive flower parts
  - Stigma is the sticky surface for the pollen grains
  - Style is the tube-like structure that leads to the ovary
  - Ovary contains ovules that can form seeds when fertilized



- Monocot flowers always have petals and stamens in multiples of three
- Eudicot flowers have petals and stamens in multiples of four or five

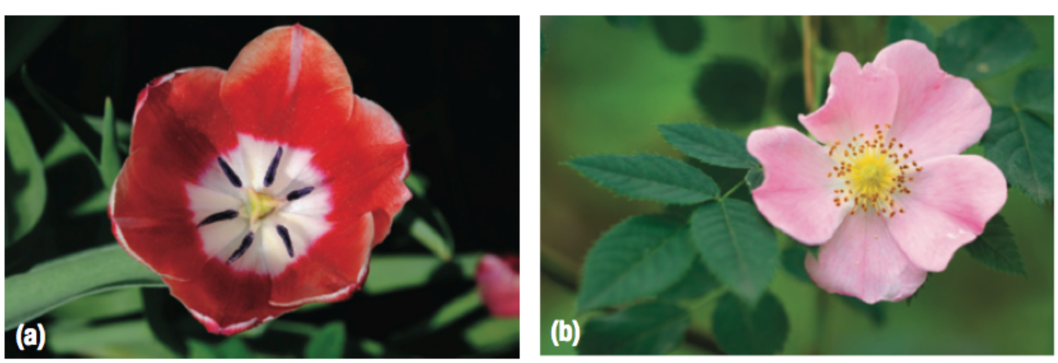
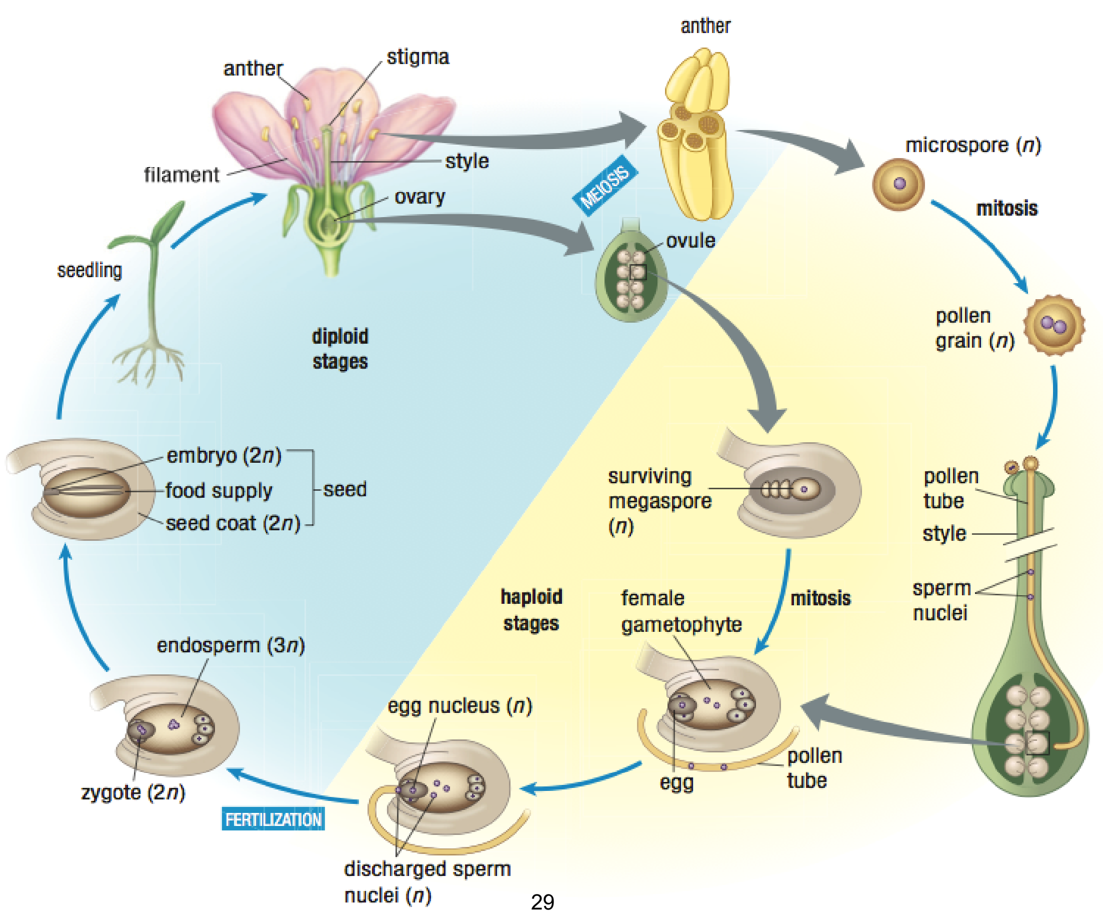


Figure 8 (a) The floral parts of monocots, such as this tulip, are always in groups of three or in multiples of three. (b) The floral parts of eudicots, such as this rose, are always in groups of four or five, or multiples of these.

- Pollination in angiosperms occur by wind or animals (birds, insects and bats)
- Most species can only cross-pollinate; some plants can self-pollinate
- Pollen grain grows a pollen tube when it sticks to the stigma until it reaches the ovary
- Double fertilization occurs at the ovary
  - One sperm nucleus fertilizes the egg to form a diploid zygote
  - The other sperm fuses with two polar nuclei in the ovule forming a triploid cell that develops into the endosperm



Fruit Formation

- Once fertilized, the ovary wall develops a fruit wall called the pericarp (fleshy or dry)
- Fruit helps to protect and disperse the seed
- Fruit does not provide nutrients to the seed
- Any structure that is formed from a ripened ovary is called "fruit"

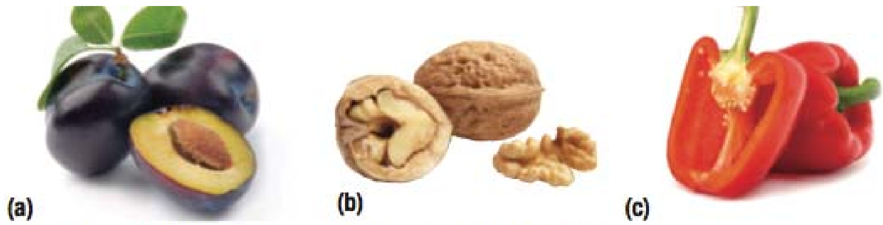


Figure 12 (a) Plums, (b) walnuts, and (c) red peppers are all fruits.