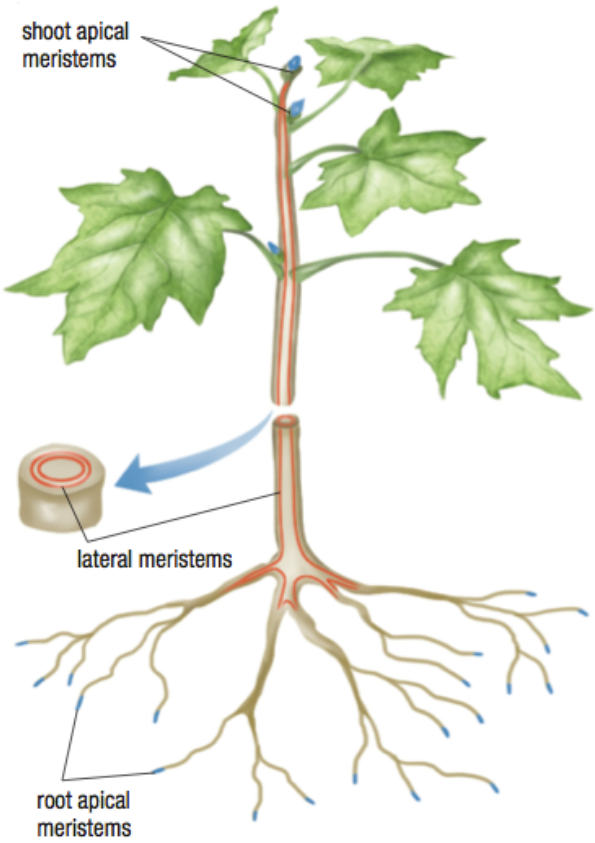
Grade 11 Biology

Plants – Anatomy, Growth and Function

Class 16

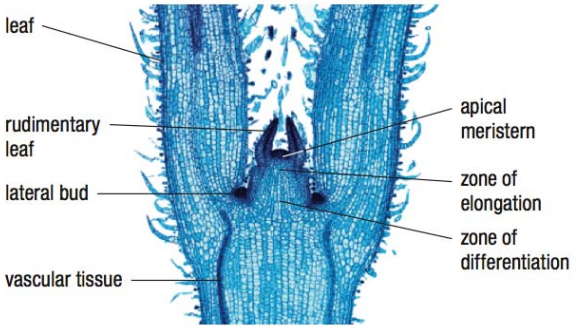
Plant Growth and Development

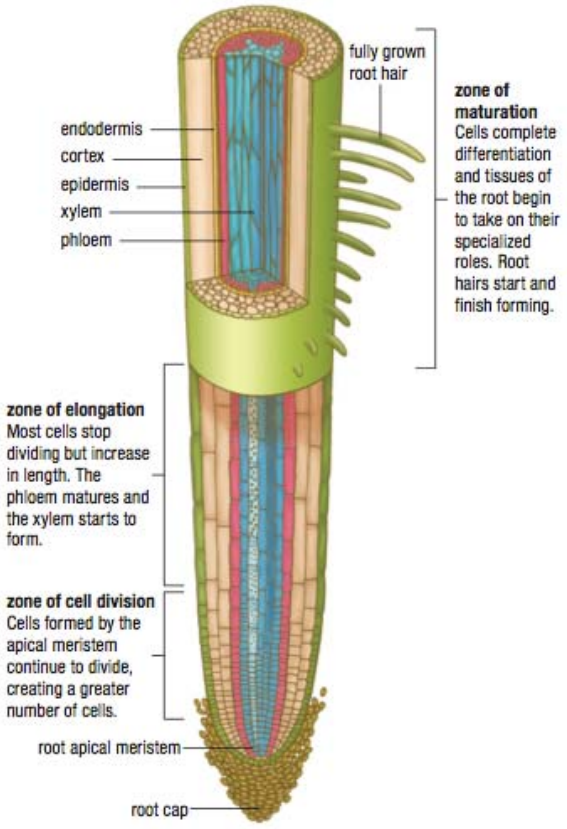
- Growth – the process of increasing in size
- Differentiation – the cell becomes specialized to perform a particular function
- Types of Growth
  - **Primary Growth** – increases the height of a plant from apical meristems; regions of actively dividing cells found at the tips of plants
  - **Secondary Growth** – increases the width of a plant from lateral meristems; regions of actively dividing tissues in the stems and roots



Primary Growth

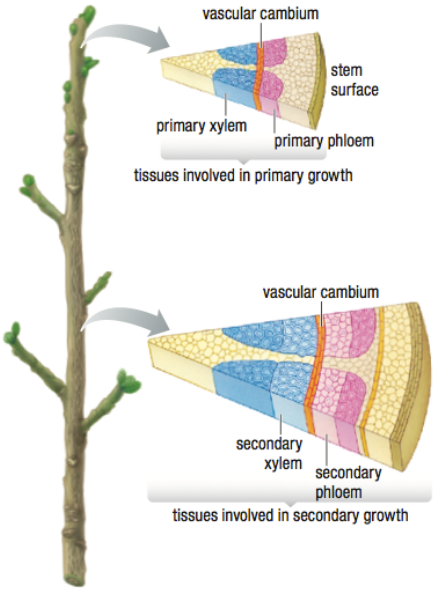
- Increases the length of a plant shoot or root
- Apical meristems divide by mitosis, each cell grows longer and becomes specialized into different cell types





- Shoot apical meristem produces tissues that forms stems, leaves and sexual reproductive organs
- Root apical meristem produces cells of the root cap and other cells in the root
- Apical meristems produces primary phloem and xylem

Secondary Growth



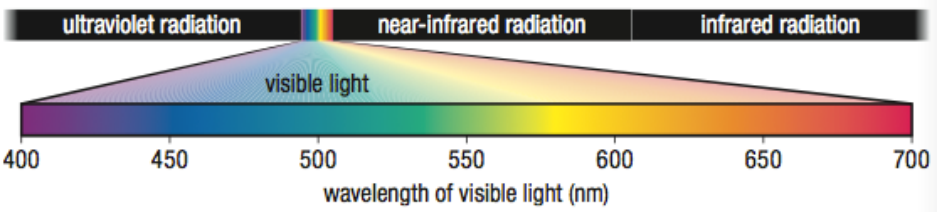
- Increases the width of the plant
- Only happens in woody species after the plant's first year
- Arises from lateral meristems in the cork cambium (forms bark) and the vascular cambium (forms secondary phloem and xylem)

- Vascular cambium produces new secondary xylem and phloem every year
- Secondary vascular tissue eventually crushes the primary phloem
- Amount of growth depends on the environmental conditions
- Thin ring = dry conditions
- Thick ring = rainy conditions

Factors that Affect Plant Growth

Light – contains a spectrum of different wavelengths, each with a different energy level

- Photoreceptors – molecular that reacts differently to different wavelengths



- As day length changes due to the seasons, the ratio of red light (660nm) to far-red light (730nm) changes
- Photoperiodism – a plant's response to changing day length
  - Short-day plants – plants that flower when days are under 12 hours (ex: tulips and chrysanthemums)
  - Long-day plants – plants that flower when days are longer than 12 hours (ex: spinach)
  - Day-neutral plants – plants that are not affected by day length (ex: tomato and rose plants)

Nutrients – two categories

- Macronutrients – nutrients that are needed in larger quantities (more than 1000mg/kg of dry mass)
  - Ex: Nitrogen, phosphorus and potassium
- Micronutrients – nutrients that plants need in small amounts (less than 100mg/kg of dry mass)
  - Ex: Boron, chlorine, copper, iron, manganese, molybdenum, nickel and zinc
  - Involved in chlorophyll synthesis, cell division and enzyme production

Table 1 Plant Macronutrients and Their Functions

Element	Commonly absorbed forms	Some known functions	Some deficiency symptoms
carbon (C)	CO_2	synthesis of all organic compounds	rarely deficient; available from the atmosphere
hydrogen (H)	H_2O	synthesis of all organic compounds	available from water; incapable of growth without it
oxygen (O)	CO_2, H_2O, O_2	release of energy through cellular respiration	available from the atmosphere and as a product of photosynthesis; cells die without it
nitrogen (N)	NO_3^-, NH_4^+	production of proteins, nucleic acids, chlorophyll	stunted growth, chlorosis
phosphorus (P)	$H_2PO_4^-$, HPO_4^{2+}	production of nucleic acids, membranes	purplish veins, stunted growth, fewer seeds or fruit
potassium (K)	K^+	activation of enzymes, cellular transport mechanisms	reduced growth, curled or spotted older leaves, burned leaf edges
calcium (Ca)	Ca^{2+}	formation and maintenance of cell walls; membrane transport mechanism	deformed leaves, poor root growth, death of buds
sulfur (S)	SO_4^{2-}	production of proteins	pale green leaves or chlorosis, slow growth
magnesium (Mg)	Mg^{2+}	production of chlorophyll; activation of enzymes	chlorosis, drooping leaves

Temperature – all plants grow best at certain temperature ranges

- Transpiration is highest on hot sunny days when stomata are open
- If temperature is above or below the plant's optimum range, the plant will grow more slowly

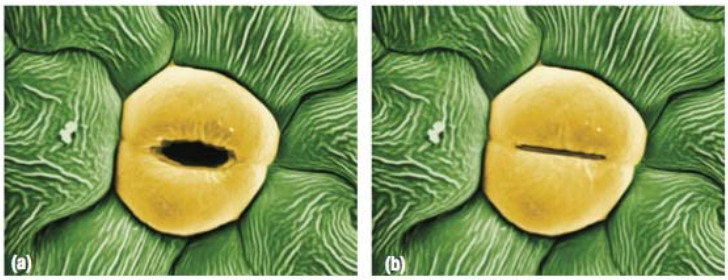
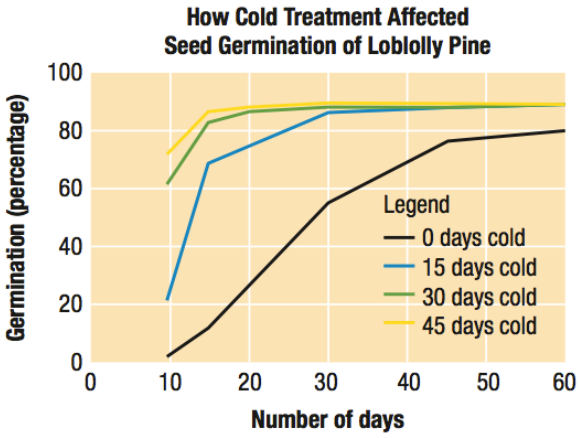


Figure 12 (a) An open stoma allows water vapour to leave the leaf. (b) A closed stoma prevents transpiration from occurring.



- Temperature can also act as a signal to begin a developmental stage
  - Ex: The loblolly pine seeds will germinate only after undergoing a period of cold treatment to increase the changes that the seed will germinate in the spring

Soil – plays three roles

1. Provides medium for plants roots to anchor
2. Retains water in which nutrients are dissolved
3. Provides the roots with air

- Sandy soil does not hold water well and dries out quickly
- Soil with too much clay does not have enough air spaces and holds too much water that can drown the plant

- Soil must have sufficient humus – organic matter made up of partially decomposed remains of organisms
- Soil pH determines whether the macronutrients and micronutrients will be dissolved in the soil water and uptaken by plant roots
  - Most plants prefer mildly acidic soil

Climate Change

- Earth's average temperature has increased due to human activity
- For every 1°C increase, flowering of angiosperm occurs 5 days earlier on average
- Earlier flowering can break the link between the flowering date and the appearance of insect of bird pollinators

Control of Plant Growth

- Plant growth regulators – a chemical produced by plant cells that regulates growth and differentiation
- Tropism – a directional change in growth or movement in response to stimulus
  - Phototropism – change in the direction of growth in response to light

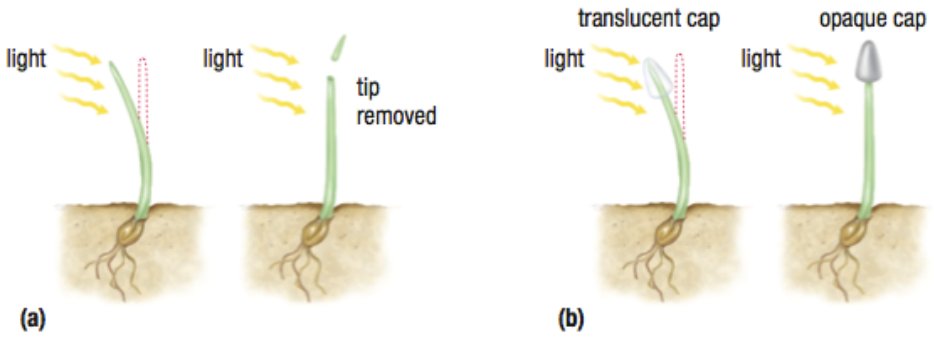


Figure 3 Darwin's phototropism experiments led him to hypothesize that plants produce substances that regulate their growth. (a) Plants with intact tips bend toward light, while plants with tips removed do not. (b) When the tip is covered with an opaque cap that blocks light, the seedling does not bend. When the cap is translucent and allows light to pass through to the tip, the seedling bends.

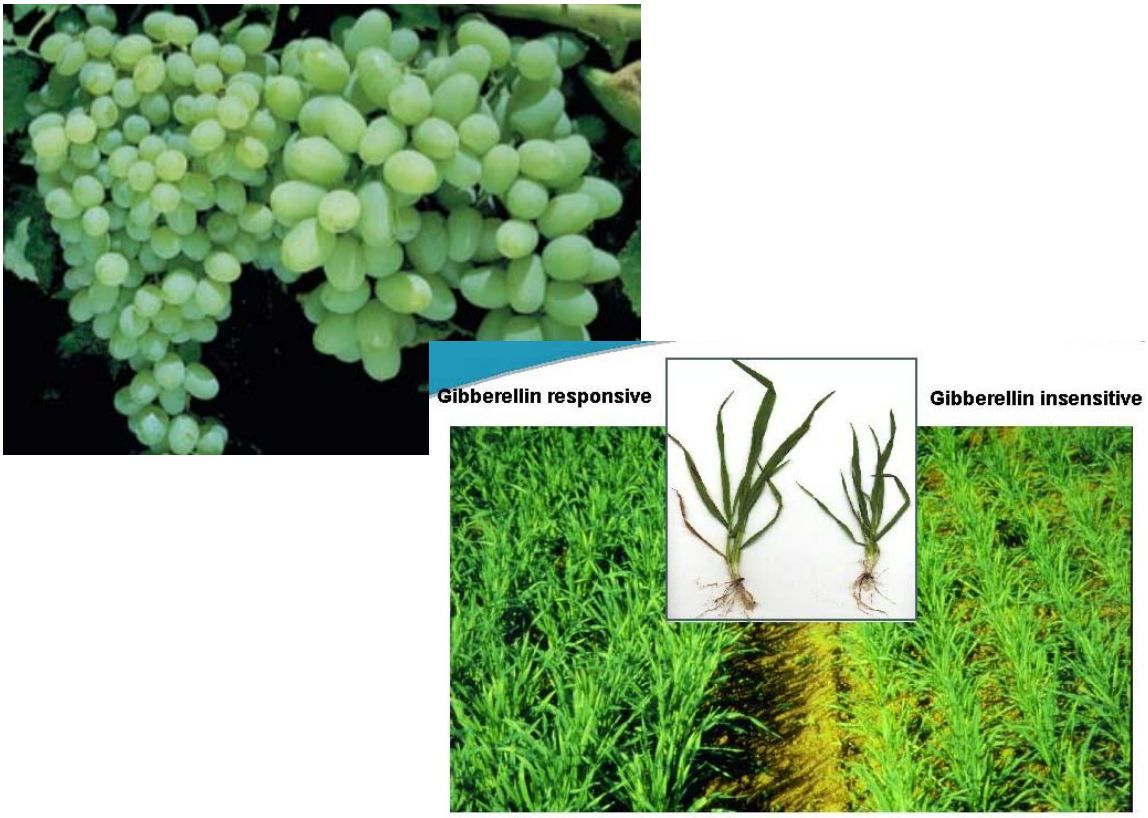
- Darwin and his son concluded that the tip produces a substance in response to light since when removing it and putting an opaque cap over it, the plant did not bend towards the light

- Gravitropism – change in the direction of growth in response to gravity
  - Causes the root to grow downward and the emerging shoot to grow upward
- Thigmotropism – change in the direction of growth in response to contact
  - Climbing vines such as beans and peas exhibit thigmotropism

- **Auxins** – promotes cell elongation; side closest to light contains less auxin than the shaded side so the shaded side elongates and bends toward light

- Auxins are used as an herbicide so that rapid growth outstrip the plant of their carbohydrate supply
- Synthetic auxins are used to artificially synchronize fruit ripening
- Auxins can inhibit cell division in some tissues
  - Apical dominance – cell division occurs in the apical bud but is inhibited in the lateral buds due to high levels of auxin in the apical meristem
  - Growers stop apical dominance by cutting off the apical bud allowing lateral buds to develop

- **Gibberellins** – promote cell division and cell elongation; dwarf plants produce low levels of gibberellins
- Make stored carbohydrate reserves available to the growing embryo
- Help the plant respond to temperature changes
  - Cabbage and lettuce plants bolt and go to seed when experiencing cold temperatures
  - Bolting is the rapid stem elongation that happens prior to flowering



- **Cytokinins** – promote cell division and slow cell aging in certain plant organs by inhibiting protein breakdown and stimulating protein synthesis
- **Ethylene** – induces changes that protect a plant against environmental stress, regulates growth of roots and shoots around obstacles, regulates fruit ripening, shoot and growth differentiation, flower opening, leaf and fruit drop and flower and leaf senescence

- Fruit release ethylene gas when they ripen which can cause spoilage
- Producers ship fruit in well-ventilated trucks with ethylene-absorbing filters
- Ethylene is released in a chamber to ripen all the fruit at the same time

- **Abscisic Acid (ABA)** – inhibits growth and maintains dormancy in leaf buds and seeds
- Dormant plants are less vulnerable to damage than actively growing plants
- ABA applied to plants before they are shipped from nurseries to garden centres
- ABA is produced under dry conditions and induces guard cells in the stomata to close allowing leaves to conserve water