GROWTH AND DEVELOPMENT

VEGETATIVE GROWTH AND DEVELOPMENT

- Shoot and Root Systems

- Root functions
  - Anchor
  - Absorb
  - Conduct
  - Store

As the shoot system enlarges, the root system must also increase to meet demands of leaves/stems

MEASURING GROWTH

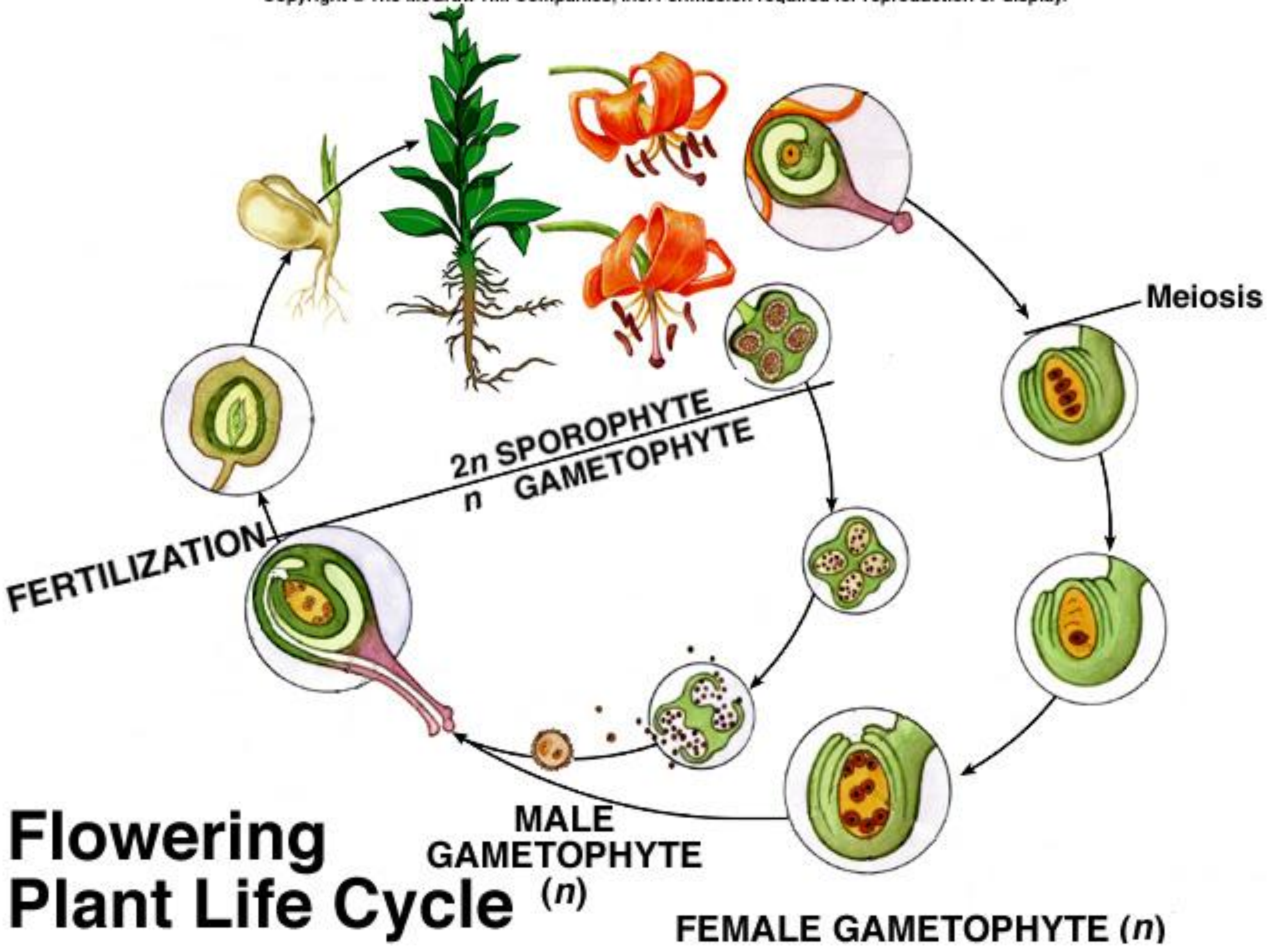
- Increase in fresh weight
- Increase in dry weight
- Volume
- Length
- Surface area

MEASURING GROWTH

- Classifying shoot growth
  - **Determinate** – flower buds initiate terminally; shoot elongation stops; e.g. snap beans
  - **Indeterminate** – flower buds born laterally; shoot terminals remain vegetative;

SHOOT GROWTH PATTERNS

- Annuals
  - Herbaceous (nonwoody) plants
  - Complete life cycle in ***one growing season***



Flowering Plant Life Cycle

SHOOT GROWTH PATTERNS

- Biennials
  - Herbaceous plants
  - Require ***two growing seasons*** to complete their life cycle (not necessarily two full years)
  - Stem growth limited during first growing season; see fig. 9-4; Note vegetative growth vs. flowering e.g. celery, beets, cabbage, Brussels sprouts

SHOOT GROWTH PATTERNS

- Perennials
  - Either herbaceous or woody
  - **Herbaceous** roots live indefinitely (shoots can)
    - Shoot growth resumes in spring from adventitious buds in crown
    - Many grown as annuals
  - **Woody** roots and shoots live indefinitely
    - Growth varies with annual environment and zone
    - Pronounced diurnal variation in shoot growth; night greater

ROOT GROWTH PATTERNS

- Variation in pattern with species and season
- Growth peaks in spring, late summer/early fall
  - Spring growth from previous year's foods
  - Fall growth from summer's accumulated foods
- Some species roots grow during winter

HOW PLANTS GROW

- Meristems
  - Dicots
    - Apical meristems – vegetative buds
      - shoot tips
      - axils of leaves
    - Cells divide/redivide by mitosis/cytokinesis
    - Cell division/elongation causes shoot growth
    - Similar meristematic cells at root tips

HOW PLANTS GROW

- Meristems (cont)
  - Secondary growth in woody perennials
    - Increase in diameter
      - due to meristematic regions
    - vascular cambium
      - xylem to inside, phloem to outside
    - cork cambium
      - external to vascular cambium
      - produces cork in the bark layer

GENETIC FACTORS AFFECTING GROWTH AND DEVELOPMENT

- DNA directs growth and differentiation
  - Enzymes catalyze biochemical reactions
- Structural genes
  - Genes involved in protein synthesis
- Operator genes
  - Regulate structural genes
- Regulatory genes
  - Regulate operator genes

GENETIC FACTORS AFFECTING GROWTH AND DEVELOPMENT

- What signals trigger these genes?

  - Believed to include:
    - Growth regulators
    - Inorganic ions
    - Coenzymes
    - Environmental factors; e.g. temperature, light

    - Therefore . . .
      - Genetics directs the final form and size of the plant as altered by the environment

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light
- Temperature
- Water
- Gases

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light
  - Intensity
  - Quality
  - Duration

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light (cont)

  narrow band affects plant photoreaction processes

  PAR (Photosynthetically Active Radiation)

  400-700nm

  stomates regulated by red (660nm), blue (440nm)

  – **photomorphogenesis** – shape determined by light
    - controlled by pigment **phytochrome**
    - phytochrome absorbs red (660nm) and far-red (730nm) but not at same time

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light (cont)
  - importance of phytochrome in plant responses
    - plants detect ratio of red:far-red light
    - red light – full sun
      - yields sturdy, branched, compact, dark green plants
    - far-red light – crowded, shaded fields/greenhouses
      - plants tall, spindly, weak, few branches; leaves light green

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

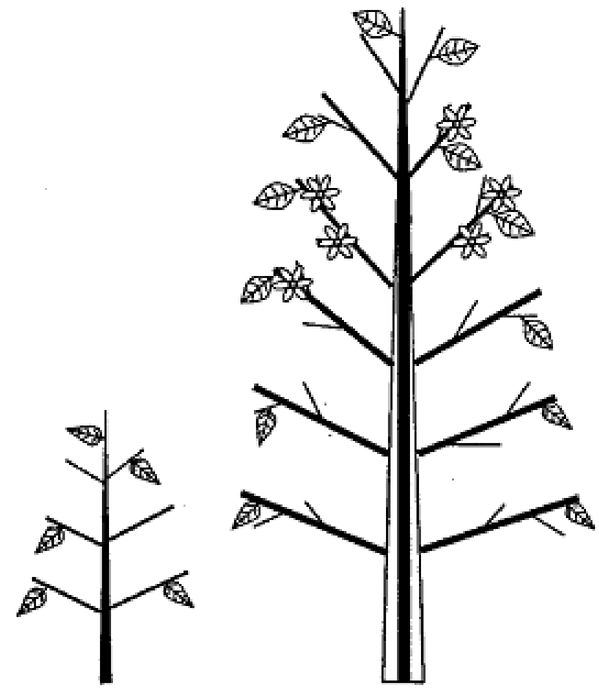
- Light (cont)
  - **Phototropism** – movement toward light
    - hormone auxin accumulates on shaded side
    - cell growth from auxin effect bends plant
    - blue light most active in process
    - pigment uncertain

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light (cont)
  - **Photoperiodism** – response to varying length of light and dark
    - shorter days (longer nights)
      - onset of dormancy
      - fall leaf color
      - flower initiation in strawberry, poinsettia, chrysanthemum
      - tubers/tuberous roots begin to form
    - longer days (shorter nights)
      - bulbs of onion begin to form
      - flower initiation in spinach, sugar beets, winter barley

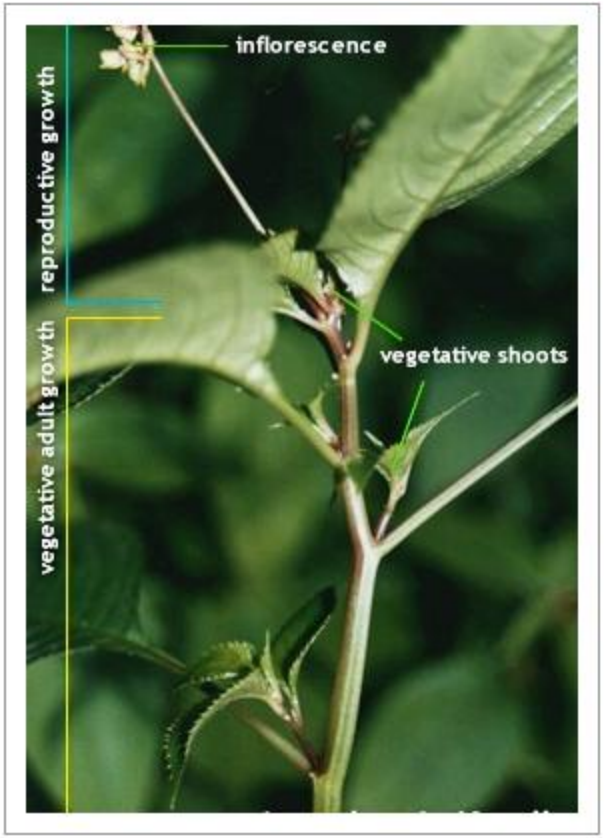
PHASE CHANGE: JUVENILITY, MATURATION, SENESCENCE

- Phasic development
  - embryonic growth
  - juvenility
  - transition stage
  - maturity
  - senescence
  - Death



- The shoot apical meristem (and therefore plants) undergo three distinct phases:
- Juvenile
- Adult vegetative
- Adult reproductive

Meristems in the juvenile phase have no ability to produce reproductive structures (cones or flowers) so are described as having no **competence**. Adult meristems are competent because they can now produce reproductive structures (ie. will respond to stimuli which trigger this), but the actual production of these will depend on environmental stimuli.



PHASE CHANGE: JUVENILITY, MATURATION, SENESCENCE

- Juvenility
  - terminated by flowering and fruiting
  - may be extensive in certain forest species
- Maturity
  - loss or reduction in ability of cuttings to form adventitious roots
- Physiologically related
  - lower part of plant may be oldest chronologically, yet be youngest physiologically (e.g. some woody plants)
  - top part of plant may be youngest in days, yet develop into the part that matures and bears flowers and fruit

AGING AND SENESCENCE

- Life spans among plants differ greatly
  - range from few months to thousands of years
    - e.g. bristlecone pine (over 4000 years old)
    - e.g. California redwoods (over 3000 years old)
  - clones should be able to exist indefinately
- Senescence
  - a physiological aging process in which tissues in an organism deteriorate and finally die
  - considered to be terminal, irreversible
  - can be postponed by removing flowers before seeds start to form

REPRODUCTIVE GROWTH AND DEVELOPMENT

- Phases
  - Flower induction and initiation
  - Flower differentiation and development
  - Pollination
  - Fertilization
  - Fruit set and seed formation
  - Growth and maturation of fruit and seed
  - Fruit senescence

REPRODUCTIVE GROWTH AND DEVELOPMENT

- Flower induction and initiation
  - What causes a plant to flower?
    - Daylength (photoperiod)
    - Low temperatures (vernalization)
    - Neither

REPRODUCTIVE GROWTH AND DEVELOPMENT

- Photoperiodism
  - Short-day plants (long-night; need darkness)
  - Long-day plants (need sufficient light)
  - Day-neutral plants (flowering unaffected by period)
- Change from vegetative to reproductive

REPRODUCTIVE GROWTH AND DEVELOPMENT

- Low temperature induction
- Vernalization
  - Any temperature treatment that induces or promotes flowering
  - First observed in winter wheat; many biennials
  - Temperature and exposure varies among species
  - Note difference/relationship to dormancy

REPRODUCTIVE GROWTH AND DEVELOPMENT

- Flower development
  - Stimulus from leaves to apical meristem changes vegetative to flowering
  - Some SDPs require only limited stimulus to induce flowering; e.g. cocklebur – one day (night)
  - Once changed the process is not reversible
  - Environmental conditions must be favorable for full flower development