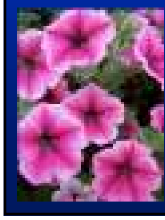
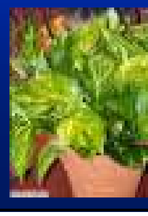



Propagation of Horticultural Plants





What is Plant Propagation?

- Multiplication of plants and preservation (maintaining) their unique qualities for human use
- Purposeful act of reproducing plants via sexual and asexual reproduction
  - ✓ <u>Sexual</u>: seed germination, some variation, not always identical to parent plant

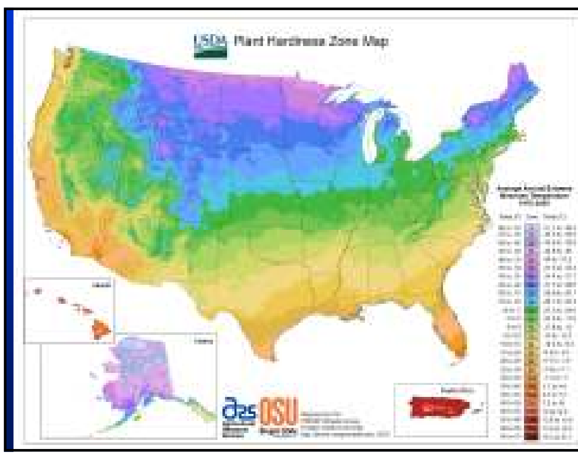

Plant Propagation History

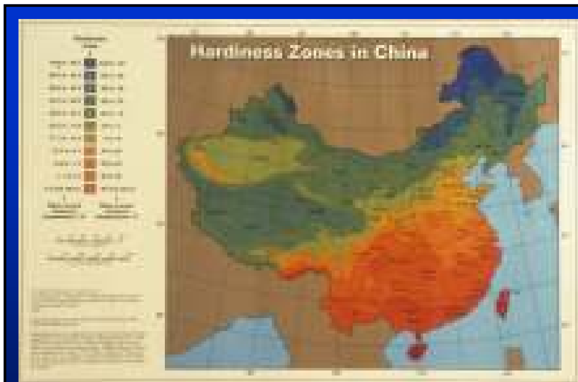
- Practiced for over 10,000 years
  - ✓ Hunters and gatherers
  - ✓ Domestication of animals & plants for food production
  - ✓ Population growth and need for consistent food supply
  - ✓ Herbals and medicinal plants for curing illnesses
  - ✓ Fiber, building materials (wood), food, forage for animals, pharmaceuticals and ornamental crops (flowers, trees, shrubs, evergreens, houseplants)

Woody Plant Crop Improvement

- Crop improvement
  - ✓ Find related crops in native area to use in breeding
- New crop for area not previously grown
  - ✓ Improved growth rate of forest species
  - ✓ Increased drought or heat tolerance
  - ✓ Less susceptible to insects and diseases
  - ✓ More ornamental than native species
  - ✓ Better quality fruit production/yield
  - ✓ Production of less invasive species/hybrids

Where do these great plants come from that we grow in our gardens?





China Cold Hardiness Zone Map

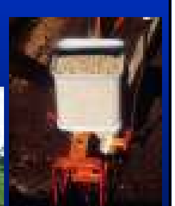
China, Korea, and Japan over U.S. map

Europe Cold Hardiness Zone Map

The Propagation Environment

- Rooting media
- Containers
- Physical Structures
- Greenhouse Lighting
- Temperature Control
- Humidity/Moisture Control
- Gas exchange
- Mineral Nutrition

Sexual Reproduction: Seeds



Why Use Seed Propagation over Asexual?

- Advantages:
  - ✓ Inexpensive, much cheaper than any other propagation method
  - ✓ Easy to handle, store, ship and use
  - ✓ Juvenile characteristics of seedlings can be a benefit
  - ✓ Genetic variability may be desirable: improved ornamental characteristics, great tolerance to environmental conditions
  - ✓ Germplasm preservation of endangered plants
  - ✓ Production of virus-free material for fruit and ornamental crops

Why Use Seed Propagation over Asexual

- **Disadvantages:**
  - Genetic variability may be not be desirable, not uniform
  - May have dormancy issues that must be satisfied before germination
  - Some non-viable seed, no embryo, empty, i.e. paperbark maple, triploid plants are sterile
  - Longer time for reproductive maturity, can take decades before plant flowers/fruits
  - Takes longer to produce a larger plant than asexual propagation

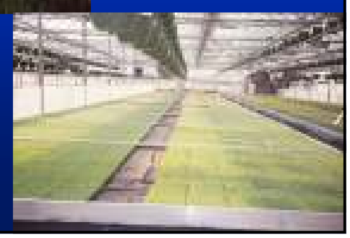
Reproductive Structures: Seed

- **Seed**: matured, ripened ovule located inside a fruit (ovary)
- Contains an embryo, storage reserve tissue and protective outer coating (seed coat)
  - **Embryo**: resulted from union of male and female games during fertilization, develops into the new plant
    - **Cotyledons**: "seed leaves" produced during germination, these fall off and the "true" leaves are formed afterwards
    - **Monocots**: produce only one cotyledon, i.e. grasses
    - **Dicots**: produce two or for gymnosperms up to 15 cotyledons, i.e. annuals, perennials, trees, vegetables, etc.

Germination Process

Germination: radicle (root) emergence from the seed, then the shoot, which produces a seedling plant

- **Conditions required for germination:**
  - Seed must be viable with a live embryo, capable of germination
  - Seed placed in proper environmental conditions for germination: available water, proper temperature, supply of oxygen, sometimes light
  - Seeds must be pathogen free
  - Any dormancy present within the seed must be overcome



Scarification to Relieve External Dormancy

- **Scarification**: treatment that alters the seed coverings to allow water to penetrate hard coated seeds; can be physical, chemical (acid) or high temperatures
  - **Mechanical scarification**: tumbles seeds in drums against an abrasive material or rub large seeds with sandpaper or metal file
  - Can store afterwards or proceed to germination
  - Only need to nick seed so can see white inner seed to allow water to penetrate

Scarification to Relieve External Dormancy

- **Chemical scarification**: dry seed placed into glass jars containing 2 parts concentrated sulfuric acid to one part seed, very dangerous, not for homeowners
- Soak seed for 10 min. up to 6 hours, species dependent
- Acid poured off and seeds rinsed in colander with water for 10 minutes to get rid of all sulfuric acid that can damage emerging radicle

Scarification to Relieve External Dormancy

- High temperature scarification: place seeds on moist or dry sand at 95° F (35° C), temp. OR soak seeds in very hot water, but not boiling for several minutes
  - Time required varies with each species
  - Can be used instead of mechanical or acid scarification, but is quite variable and often does not work on very hard seed coats
  - Nature: scarification occurs naturally with alternating freezing and thawing cycles in soil, gradually breaks down the seed coat
  - Birds and mammals that eat seed and pass through its digestive system, stomach acids scarify the seeds and come out in their excrement
  - Fire can work as well as microorganisms in soil can break down seed coat over time

Stratification to Relieve Internal Dormancy

- Stratification: period of moist-chilling or moist-warm conditions that satisfies dormancy in embryo, seeds must be imbibed first!
  - Seed moisture should remain constant during stratification as dehydration stops the process, seeds revert to secondary dormancy
  - Temperatures similar to outdoor winter temperatures but usually above freezing 1-7° C (33-45° F), use refrigerator
  - Below freezing temperatures will not work for stratification
  - For tropical and some temperate species, temperatures are above 25° C (77° F)
  - Some plants have double dormancy and require both moist-chilling followed by moist-warm stratification

Stratification to Relieve Internal Dormancy

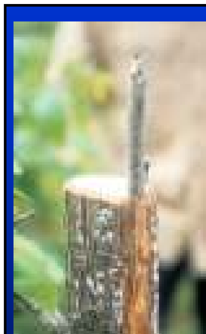
- Stratification: period of moist-chilling or moist-warm conditions that satisfies dormancy in embryo, seeds must be imbibed first!
  - Successful stratification requires seeds placed in moist, aerated medium at chilling temperatures for certain period of time, dependent on species
  - Medium should not be wet, just moist, otherwise, mold will form on seeds and kill seeds
  - Can plant directly in field or place fully imbibed seeds (soak for 12-24 hrs.) in refrigerator with medium
  - Medium: well-washed sand, peat moss, sphagnum moss, vermiculite, moistened and allowed to drain for 24 hrs.
  - Seeds mixed with 1-3 times their volume of medium in poly bags

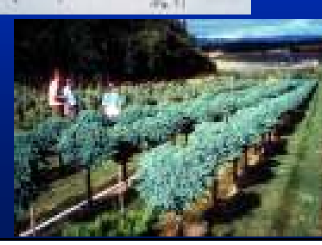
Asexual Propagation: Grafting, Budding, Layering, Micropropagation, Cuttings

What is Asexual Plant Propagation?

- Asexual reproduction of plants
  - Asexual (cloning): get exact same genotype in each new plant; involved inducing replacement of missing parts (roots, shoots, and/or buds)
    - Cuttings: stem, leaf, leaf-bud, root
    - Grafting and budding: parts of two plants joined together
    - Layering: roots form on stem while still attached to parent plant
    - Specialized stems and roots, division (separation)
    - Micropropagation (tissue culture): sterile culture

Grafting

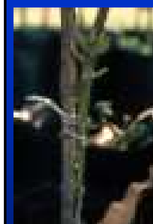




History of Grafting

- One of the oldest methods of propagation
- Dates back 3000 years ago in China, ancient Greece and Rome
- Started with olive, fruit, nut trees and grapes
- Now, primary way of propagating clonal shade and fruit trees, conifers, and hard to root plants

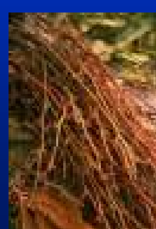
Definitions



- Grafting: art of joining two plants or plant parts together in a specific manner that they unite and continue to grow as one plant, contains several buds
- Budding: form of grafting, scion is reduced in size, contains only one bud with small sliver of stem

Definitions

- Scion: short stem piece with two or more dormant buds, part of graft which develops into the top (shoot) of plant
  - Budding: scion reduced to single bud with thin slice of wood



Definitions

- Understock, stock, or rootstock: lower part of graft, becomes the root system
  - Can be seedling or clonal material (cutting, layered, or tissue cultured plant)
  - May consist of roots, trunk, and scaffold branches if done high up in tree (topworking)

Definitions

- Graft Union: juncture where scion and rootstock have successfully united
  - Cambium of scion placed in close contact with cambium of rootstock

Requirements for Successful Graft Union Formation

1. Lining up of vascular cambiums of rootstock and scion
   - Scion and rootstock held together via wrapping, tying, etc.
   - Cut surfaces and scion buds protected from desiccation with wax or tree paint
2. Wounding response and callus formation
   - Callus formation: undifferentiated parenchyma cells
     - ✓ Fills void (space) between the two
3. Production and interlocking of parenchyma cells (callus bridge) by the scion and rootstock
4. Differentiation of vascular cambium cells across callus bridge into wound repair xylem and phloem
5. Production of secondary xylem and secondary phloem from the new vascular cambium in callus bridge

Budding

Budding

- Utilizes only one bud with small section of bark with or without wood
- Usually has to be done when bark is slipping
  - Exception is chip budding
- Common means of propagating cultivars onto roses, fruit and shade trees
- Usually young plants budded or smaller branches of larger plants
- Dormant or latent vegetative buds used
  - Smaller, pointed versus flower buds

Advantages of Budding

- Faster and easier than grafting
- May result in stronger graft union than grafting
  - Less likely to blow over in strong winds
- Usually high success rates
- Efficient and economical use of scion wood
  - Multiple buds per stem piece versus one graft

Micropropagation (Tissue Culture)

Tissue Culture

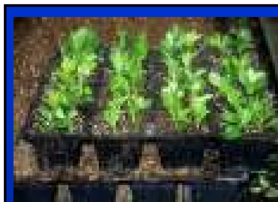
Tissue Culture:
- Establish and maintain plant organs (leaves, shoots, roots, embryos, etc.) and plant tissues (cells, callus, protoplasts) in aseptic culture

Tissue Culture

Micropropagation:
- Form of tissue culture used to propagate new plants in controlled environments
- Very small pieces of plant grown in artificial medium under aseptic conditions
- Accelerated form of clonal, asexual propagation
- Superior method to propagate slow to multiply plants
- Used for plants that cannot be propagated clonally by other asexual methods
- Used to regenerate genetically modified (transformed) plants via biotechnology

Tissue Culture Facilities and Equipment

Cuttings



Advantages of Using Cuttings

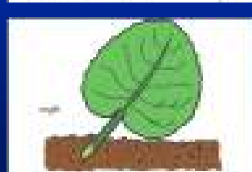
- Most important method of propagating a wide range of horticultural plants
- Many new plants started in limited space from a few stock plants
- Inexpensive, rapid, simple, no specialized technique required
- No incompatibility problems between root stock and scion (problem in grafting)
- Greater uniformity, less variation than seed
- Parent plant reproduced exactly with no genetic changes (identical clones), unless mutation occurs

Types of Cuttings

- A) Classified by nature of the wood stage (tissue maturity):
  - ✓ Hardwood: dormant, mature wood taken in late fall, winter or early spring before budbreak
  - ✓ Semi-hardwood: taken after a growth flush when wood is partially mature (during growing season)
  - ✓ Softwood: taken from soft, succulent growth just as it is about to harden, bendable
  - ✓ Herbaceous: taken from succulent, herbaceous (non-woody) plants
  - ✓ For some plants, rooting success or failure depends on the growth stage cuttings are taken

Types of Cuttings

- B) Classified based on where the cutting is taken:
  - Stem cuttings:
    - ✓ Produce a new root system, shoot/buds already present
  - Leaf cuttings:
    - ✓ Produce new adventitious bud/shoot (harder to develop)
    - ✓ Produce new adventitious root systems (easier to develop)



Types of Cuttings

- B) Classified based on where the cutting is taken:
  - Leaf-bud cuttings:
    - ✓ Produce new root system since potential shoot system is already present due to axillary bud
  - Root cuttings: must produce new roots and shoots
    - ✓ Produce new shoot system from an adventitious bud first
    - ✓ Develop new root system at base of new adventitious shoot
    - ✓ Or take stem cutting off of new shoot system

Physiological Basis of Root Initiation in Cuttings: Terms

- **Adventitious**: appearing in an unusual place such as a root developing from a shoot or shoot developing from a root

Factors influencing formation and survival of adventitious structures (roots and shoots)

- Plant genotype: life cycle, habitat, ecology
- Polarity
- Phase state of stock plant: adult vs. juvenile
- Type of wood selected for cuttings: current or past season growth, terminal or lateral, presence of leaves or buds on cuttings, flowering vs. vegetative stems
- Time of year cuttings taken: hardwood, softwood, semi-hardwood
- Etiolation, blanching or banding
- Girdling
- Wounding
- Physiological condition of stock plant: water stress, pests, carbohydrate status, mineral nutrition
- Hormones, rooting co-factors and rooting inhibitors
- Treatment of cuttings after removal from stock plant
- Environmental conditions during rooting: water, temp., light, media
- Survival of cuttings after rooting: hardening off

Factors influencing formation of adventitious structures (roots and shoots)

- ✓ **Wounding:**
  - ✓ Light wound: strip leaves off of the base of a cutting
  - ✓ Or use one or two equally spaced vertical cuts on lower portion of base just penetrating the bark, but not deep enough to split the stem
    - ✓ Still green on sides of wound
    - ✓ Firs and junipers require this for rooting

Factors influencing formation of adventitious structures (roots and shoots)

- ✓ **Why are cuttings treated with synthetic auxins?**
  1. Increase % of cuttings that root
  2. Speed up root initiation
  3. Increase the number and quality of roots produced
  4. Increase uniformity of rooting so well-developed root system