Plant Propagation
Learning Objectives

• Define sexual and asexual plant propagation.
• Describe various techniques for propagating plants.
• Identify the environmental factors affecting plant propagation.
Plant Propagation …

Plant multiplication

- Sexual: from seed
- Asexual: from vegetative parts
SEXUAL (SEED) PROPAGATION
Sexual Propagation

**Advantages:**
- Major source of genetic diversity (new or improved cultivars)
- Large numbers of plants can be reproduced easily and inexpensively
- May be only technique for a species (ex: some palms)
- Long-lived seeds are easily stored.
Sexual Propagation

Disadvantages:

- Genetic variability
- Seed may require special treatment to break dormancy
- Some species slow to flower and fruit
- Some diseases are seed-borne
Plant Propagation from Seed

Plant multiplication

- Sexual: from seed (pollination and fertilization with zygote formation)
- Apomixis: asexual seed production (cloning, no meiosis – citrus, mango, daisy, grasses and roses)
- Polyembryony (asparagus, tulip, beets, Swiss chard)
Seed Types

• Orthodox: maturation drying
• Recalcitrant: do not dry (avocado, mango, citrus, lychee, cocoa< 5%)
• Intermediate: share characteristics (non-orthodox: 10% - 15%, e.g Salix and Cuphea)
• Vivipary: germinate while still attached (Mangroves). Zinnia and tomato seeds can start to grow.
Seed Development

- **Histodifferentiation**: begins at fertilization and formation of zygote from the two haploid gametes
- **Cell expansion** (and food reserves)
- **Maturation drying**: can lose up to 90% plus of water
Parts of a Seed

- Seed coat
- Endosperm: stored nutrients
- Embryo: tiny plant
  - Cotyledons (seed leaves)
    Monocots = 1, Dicots = 2
  - Radicle (embryonic root)
  - Plumule (embryonic shoot)
Seedling Emergence

- Epigeous: hypocotyl hook like beans
- Gypogeous: shoot tip emerges first
- Hypogeous: epicotyl emerges and cotyledons remain inside seed coat
Purchasing Seed

- Look for percent germination and packaging date
- Select species adapted to your area
- Follow package info
Purchasing Seed

- Purchased seed is often treated with a pesticide
- Wash hands after handling
Collecting Seed

- Collect open-pollinated seeds (true-to-type)
- Determine seed maturity by size, shape, weight, and color
- Viability may be short or long
- Seeds from fleshy fruits should be cleaned
Don’t Collect Seeds from...

- F1 hybrids
- Plants that cross pollinate (ex: squash); next generation of seed will not be “true-to-type”
- Diseased plants
Testing Seed Viability

To check germination

• Rag doll test:
  - Place seeds in a moist paper towel
  - Place in plastic bag
  - Keep warm ~70°F
  - Check daily for germination

• Float test:
  - Non-viable seeds may float or sink more slowly (Ex: oaks, cycads)

• Many seeds are short-lived (Ex: onion and tropicals)

Credit: Colorado State University
Storing Seed

• Once dry, place seeds in an envelope marked with the name and date
• Store in an airtight container (plastic bag or jar)
• Store at 40-45°F and low relative humidity (~30-35%) (refrigerator)
Direct vs. Indirect Seeding

• Direct – seed sowed in permanent growing area
• Indirect – seed grown in temporary container and transplanted
Direct Seeding

- Easy to grow
- Poor transplant quality
- Must have good environmental conditions
- Right time of year
- Vegetables, flowers, turfgrass
- Seed coatings
- Moisture is critical
- Disease control
Indirect Seeding

- House vs. greenhouse
- Warm – then cooler w/bright light, overhead not window
- Try to time going outside
- Short, thick stemmed seedlings
- Pasteurized substrate, containers, etc.
- Disease control: damping off (Pythium, Rhizoctonia, Botrytis and Phytophthora)
## Which Vegetables to Transplant (TP)

<table>
<thead>
<tr>
<th>TP - easy</th>
<th>TP - okay</th>
<th>TP - difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet</td>
<td>Carrot</td>
<td>Bean</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Celery</td>
<td>Corn</td>
</tr>
<tr>
<td>Brussels sprouts</td>
<td>Eggplant</td>
<td>Cucumber</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Kale</td>
<td>Cantaloupe</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Kohlrabi</td>
<td>Mustard</td>
</tr>
<tr>
<td>Chard</td>
<td>Leek</td>
<td>Peas</td>
</tr>
<tr>
<td>Collards</td>
<td>Onion</td>
<td>Squash</td>
</tr>
<tr>
<td>Endive</td>
<td>Pepper</td>
<td>Turnips</td>
</tr>
<tr>
<td>Lettuce</td>
<td>Salsify</td>
<td>Watermelon</td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When to Start Transplants

- Count back from last frost date
- Add up days to germinate plus “hardening-off” time
Containers for growing TP

Should be:

- Sterile, well-drained, and 2” to 3½” deep
- Examples: flats, pots (plastic, clay, peat)
- To sterilize: clean with chlorox/water 1:9 dilution
Germination Medium

Any combination of below:
- Builders Sand (porous)
- Peat Moss (holds water)
- Shredded Sphagnum (holds water)
- Vermiculite (light weight material, holds water)
- Perlite (light material for air/drainage)
- Jiffy Mix (sphagnum, peat, vermiculite)

Examples: 50/50 Builders Sand/Peat Moss; or 50/50 peat/perlite
Germination Medium

- Sterile
- Moist, but well-drained (seeds/seedlings need O₂)
- No fertilizer (seed contains nutrients it needs)
- Particle size (fine-textured for small seeds)
Planting Seeds for TP

- Fill containers with moist growing medium.
- Gently press seeds onto surface (follow directions on seed package).
- Cover with plastic.
- Keep warm - 75°.
Planting Depth

Determined by Size of Seed (i.e., stored food)

- Small seed – scatter over surface and press into soil
- Medium seed – cover lightly
- Larger seed – 1 to 2 times the seed diameter
- Exception – cycad and coconut – level or just under surface
Germination Stages

Seed Germination Stages:

• Imbibition: two phases of water uptake
• Lag
• Radicle emergence
Stages of Seed Germination

- **Activation**: Water penetrates seed coat and endosperm swells.
- **Digestion/Cell Division**: Water dissolves nutrients in endosperm for embryo.
- **Growth**: Cell division and elongation.
Germination Parameters

• Germination percentage
• Germination rate or speed
• Germination uniformity
Environmental Factors

• Temperature (soil versus air)
  – Maximum, minimum or optimum
  – Thermoinhibition

• Water

• Gas: exchange between embryo and substrate (oxygen and CO$_2$ accumulation)

• Light: quality and photoperiod
  phytochrome Pr to Pfr (poinsettias Pfr to Pr)
Seeds with “Special Needs”

Seed remains dormant due to:
- Impermeable or hard seed coat
- Chemical that inhibits germination
- Immature embryos
- Double dormancy
# Days to Germinate – Varies with Species

<table>
<thead>
<tr>
<th>Examples</th>
<th>Days to Germ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>7-10</td>
</tr>
<tr>
<td>Cabbage</td>
<td>4-10</td>
</tr>
<tr>
<td>Cucumber</td>
<td>6-10</td>
</tr>
<tr>
<td>Eggplant</td>
<td>6-10</td>
</tr>
<tr>
<td>Lettuce</td>
<td>6-8</td>
</tr>
<tr>
<td>Melons</td>
<td>6-8</td>
</tr>
<tr>
<td>Onion</td>
<td>7-10</td>
</tr>
<tr>
<td>Pepper</td>
<td>9-14</td>
</tr>
<tr>
<td>Squash</td>
<td>4-6</td>
</tr>
<tr>
<td>Tomato</td>
<td>6-12</td>
</tr>
<tr>
<td>begonia</td>
<td>2-3</td>
</tr>
<tr>
<td>impatiens</td>
<td>8</td>
</tr>
<tr>
<td>coleus</td>
<td>10</td>
</tr>
<tr>
<td>vinca</td>
<td>14-21</td>
</tr>
</tbody>
</table>
Care of Transplants

- When seeds sprout, remove cover & place in bright light.
- Water as needed but do not overwater (causes rot and disease).
- Fertilize when 2\textsuperscript{nd} set of “true leaves” appear (use water soluble fertilizer at half-strength; gradually increase over time.)
“Harden Off” Seedlings

• Gradually acclimate plants to outdoor conditions.
• Process takes 1 to 2 weeks before putting into garden.
• Set outside for a few hours each day in semi-shade (not below 45°F).
• Gradually increase time outdoors and sunlight.
• Transplant late afternoon or on a cloudy day, or add protection.
Seeds with “Special Needs”

Treatments:

- **Scarification**: process that weakens or removes the hard seed coat
  - chemical (acid treatments)
  - mechanical (file, sand paper, hammer, etc.)
  - hot water (170-210°F) - softens seed coat
  - Ex: Zamia, camellia, redbud, peaches

- **Stratification**: imbibed seeds are subjected to prolonged chilling or heat to allow the embryo to develop.
  - seeds are layered in a moist medium
  - can be accomplished outdoors or in refrigerator (1-4 months)
  - Ex: dogwood, holly, magnolia; palms (warm)

- **Double Dormancy**: cold-warm-cold stratifications; scarification followed by stratification, etc. Ex: fringe tree
ASEXUAL (VEGETATIVE) PLANT PROPAGATION
Asexual Propagation

• Advantages:
  – Progeny are identical to parent plant (clones)
  – Uniformity
  – Shorter time to mature (flower/fruit)
  – May be only way to propagate a plant
  – New cultivars can be multiplied quickly
  – Can combine plants (grafting/budding)

• Disadvantages
  – No variation or evolutionary advances
  – More expensive per plant than seeding
Main Methods of Asexual Propagation

• Cuttings
• Layering
• Separation/Division
• Grafting/Budding
• Micro-propagation/Tissue culture
Plant Sale Hints

- PCGC
- Shorten time between harvest and stick
- Correct sized cuttings
- Consistent number of cuttings
- Use correct hormone (IBA auxin)
- Reduce water loss in cutting
Plant Sale Hints

- Use right size containers, repotting?
- Consistent substrate
- Final appearance at propagation
- Follow headspace line
- Fertilize after rooting until September
- Pinch when appropriate
- Roots, shoots and flowers (pinch flowers early on)
Cuttings – Common Techniques

Part of Plant:
- Stem cuttings
- Leaf-bud cuttings
- Leaf cuttings
- Root cuttings
Stem Cuttings

- No uptake
- Healing
- Balancing act: water management and stored energy
- Time of day
- Photosynthesis
- Polarity: proximal and distal
- Preformed roots vs. de novo roots (competency vs. determinism)
We ask a lot of a cutting!

It must regenerate roots under adverse conditions:
- Loss of water supply
- Loss of nutrient supply
- Excessive wounding
Stem Cuttings

Defined by maturity of plant tissue:

- **Softwood and Herbaceous**
  - Current season’s growth
  - Plant tissue bends easily
  - Taken 3-4 weeks after growth flush

- **Semi-Hardwood**
  - Current seasons growth
  - Still green, but not woody
  - Plant tissue snaps when bent

- **Hardwood**
  - Usually last year’s growth
  - Springs back when bent
  - Take just before or during dormant season
Softwood/Herbaceous Stem Cuttings

- Cuttings collected from succulent new growth.
- Tip and subterminal cuttings
- Quick to root; < 8 weeks
Semihardwood Stem Cuttings

- Taken late spring to midsummer
- Tissue is mature, but not woody
Hardwood Stem Cuttings

- Taken from last season’s growth
- During or just before dormant season
- Tissue springs back when bent
Stem Cutting Types

- Single node (eye): vines, no polarity
- Double node: polarity, commercial
- Multiple node: polarity and usually contains apical bud
- Stem vs. tip cutting
Cutting Considerations

- Stem cutting angle: slanted vs. straight
- Reduction of leave surface area
- Sanitation$^3$
Leaf-bud Cuttings

- Leaf, petiole, and ½”-1” stem
- Mark which end is “up” or cut one end straight and angle the other.
Leaf Cuttings
Leaf Cuttings

• Snake plant
Leaf Cuttings

• Begonia
Cane Cuttings
Root Cuttings
Adventitious Roots

• Successful cutting propagation relies on the formation of adventitious roots.
• Adventitious roots grow from areas of the plant other than the root zone.
• Root growth is stimulated by interruption of downward movement of carbohydrates, hormones, and other materials.
• Initiate from preformed root initials or a wound.
Adventitious Roots from Preformed Root Initials

- Develop naturally on stems while they are still attached to the parent plant
- May or may not emerge prior to severing the stem
- Plants with preformed root initials generally root rapidly (Ex: Coleus).
Adventitious Roots from Wounds (de novo)

• Develop after the cutting is made.

• Steps:
  - wound seals
  - callus forms
  - adventitious roots are initiated
Harvesting Stem Cuttings

• Select most vigorous and healthy plants.
• Turgid leaves (not wilted)
• Free of insects and diseases
• Take cuttings from higher light area vs. shade.
• Take cuttings in morning and place in moist plastic bag or bucket of water.
Auxins

Auxins (plant hormones-IAA, IBA, NAA) stimulate root initiation and development
- Produced naturally in plants
- Also synthetically produced (NAA, IBA).
Propagation Container

- Direct stick vs. indirect stick
- Propagation flat spacing
- Proportion of cutting to salable container
- Bumping up advantages during process (space, materials and substrate moisture)
- Order of desired growth: roots, shoots, and flowers
Rooting: Choose a container

It must be deep enough to keep cuttings out of saturation zone
Rooting: Choose a medium

- Use a mix of organic and inorganic materials such as peat & perlite 1:1
- Coarse vermiculite
Prepare the cuttings

• Take cutting 4-6 inches long (or shorter).
• Free of flowers, and fruit
• Remove leaves from lower 1/3.
• Cut just above a bud in most cases.
Prepare the cuttings
Transfer a small amount of rooting hormone to another container to avoid contaminating the entire bottle.
Place cuttings in media

Left—Cutting too deep
Right—Cutting at proper depth
Polarity

- Mark which end is “up” or cut one end straight and angle the other
We ask a lot of a cutting!

It must regenerate roots under adverse conditions:

• Loss of water supply
• Loss of nutrient supply
• Excessive wounding
Environmental Conditions

- Substrate
- Sand, perlite, vermiculite, bark, peat-based mixes (not water)
- Well-drained substrate
- Correct-sized container
- Lower light and high humidity
- Warmer substrate temperature and lower air temperature
- Mist tent or bag
Key to Success: A Favorable Environment

- 100% relative humidity
- 70°-80°F
- Diffused light
- Moist medium
Mist System

See instructions online for building a small mist unit

...or a more elaborate one!
Simple Enclosed Systems

Aluminum pans and plastic covers

Covered aquarium

Pot and a clear plastic bag
Once Roots Develop

• Apply soluble fertilizer – $\frac{1}{2}$ rate
• “Hardening off” cuttings - gradually alter environment
  – Increase light level
  – Reduce mist or RH level
Critical Factors

• Healthy stock plants
• Well-drained substrate (gas exchange)
• Correct-sized container
• Hormones
• Lower light and high humidity
• Warmer substrate temperature and lower air temperature
• Don’t overwater
• Mist tent or bag
### Cuttings – in review

**Stem cuttings**
- Hardwood
  - Deciduous
  - Narrow-leaved evergreen
- Semi-hardwood
- Softwood
- Herbaceous

**Leaf-bud cuttings**
- Single node stem cuttings

**Leaf cuttings**
- Leaf
- Leaf & petiole

**Cane cuttings**

**Root cuttings**
Layering

- Air
- Simple Tip
- Mound
- Serpentine
Steps in Air Layering Dicots

Materials needed: moist sphagnum moss, sharp knife, rooting hormone, plastic wrap, 2 twist ties, healthy plant, aluminum foil

- Remove ½ - 1” ring of bark with knife.
- Use a small paint brush to dust the wound with rooting hormone.
- Wrap wounded area with moist sphagnum moss.
- Cover with plastic and secure with twist ties.
- Wrap with aluminum foil.
- When roots are visible through the plastic, cut the plant stem below the layer and pot in container.
- “Baby” the plant until roots are well established.
Plants that air layer easily (among others):

- Fiddle-leaf fig
- Rubber plant
- Croton
- Hibiscus
- Camellia
- Azalea
- Magnolia
- Oleander

Credit: The University of Maine
Tip-Layer

- Bend a low stem to the ground.
- Wound the lower side of the stem.
- Cover with soil leaving 6-12 inches exposed.
- Anchor if necessary.
- Best time is spring.
- Ex: climbing roses, jasmine, abelia, pyracantha, oleander, azalea
Mound (Stool) Layering

- Cut plant back heavily prior to spring.
- Lightly wound emerging new shoots and mound soil over them.
- Ex: Japanese magnolia, croton, tibouchia
Division/Separation

- Useful for clumping plants with more than one crown…
- …or underground storage structures like rhizomes, bulbs, tubers.
- Do not divide when flowering.
- Ex: ferns, orchids, daylilies, liriope, amaryllis
Division/Separation

- Plant structures

  - bulb

  - tuber

  - rhizome

  - plantlet
Budding/Grafting

• Joining of 2 or more plant parts as one plant.
• Scion – a piece of shoot with dormant buds that will produce the new stem and branches.
• Rootstock – provides the new plant’s root system and lower stem.

Inverted T cut (left); cutting a bud (right)
Requires Four Conditions:

1. Scion and rootstock must be compatible.
2. Each must be at the proper physiological stage.
3. Cambial layers of each must meet.
4. Union must be kept moist until joined.
Budding/Grafting

- Method used to:
  - reproduce “true” types;
  - decrease time to flowering/fruiting;
  - provide a hardier root system (Ex: cold and nematode tolerance);
  - dwarf plants.
- Requires more skill than most methods.
Tissue Culture / Micropropagation

New-age clonal propagation: Growing tiny plant pieces in test tubes under stringent conditions
For More Propagation Information:

**Landscape Plant Propagation Info**
http://hort.ifas.ufl.edu/database/lppi/sp185.shtml

**Table 1a. Propagation Methods for Some Common Florida Landscape Plants.**

<table>
<thead>
<tr>
<th>Botanical Common Name</th>
<th>Seed</th>
<th>Layering</th>
<th>Division</th>
<th>Cuttings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calliandra haematocarpa Powderpuff</td>
<td>germinate readily</td>
<td>*air, mound</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Callistemmon spp. Bottlebrush</td>
<td>collect seed when mature; pretreat at 40°F for 2 months; much seedling variability</td>
<td>---</td>
<td>---</td>
<td>*semi-hardwood, tip, early summer; hardwood in fall or winter</td>
</tr>
<tr>
<td>Camellia spp.</td>
<td>scarification of seed coat necessary</td>
<td>air</td>
<td>---</td>
<td>*semi-hardwood, tip, early summer; grafting and budding</td>
</tr>
<tr>
<td>Carissa macrocarpa Natal Plum</td>
<td>clean and sow when ripe; slow to germinate</td>
<td>---</td>
<td>---</td>
<td>*semi-hardwood, tip, early summer</td>
</tr>
</tbody>
</table>

**Plant Propagation for the FL Gardener**
http://edis.ifas.ufl.edu/mg108
References

• Plant Propagation Techniques for the Florida Gardener
  http://edis.ifas.ufl.edu/mg108

• Landscape Plant Propagation Information
  http://hort.ifas.ufl.edu/lppi/

• Nursery Propagation
  http://edis.ifas.ufl.edu/topic_nursery_propagation

• Plant Propagation – Concepts and Laboratory Exercises
  by Beyl & Trigiano

• Plant Propagation Principles and Practices by Hartmann
  and Kester
Acknowledgements

Terry DelValle, UF/IFAS-Duval County Extension
Sydney Park Brown, CLCE – 2018 revision