Chapter 4

PLANT PROPAGATION

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Chapter 4
Plant Propagation

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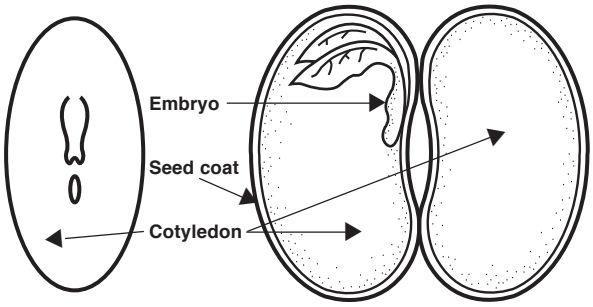
I. Sexual Propagation

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm (cotyledon), which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate, or begin active growth. In the following section, seed germination and transplanting of seeds will be discussed.

A. Seed

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to provide the size, color, and habit of growth desired. Choose varieties adapted to your area that will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than nonhybrids and sometimes have specific disease resistance or other unique cultural characteristics. Disadvantages of hybrids: seed cannot be saved as they do not breed true, and they may have a higher fertility requirement.



Bean seed with interior parts indicated

Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Good seed will not contain seed of any other crop, weed seeds, or other debris. The seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, germination percentage you may typically expect, and notes of any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Do not freeze seed. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly-closed containers and maintained near 40°F in low humidity.

Some gardeners save seed from their own gardens, however, such seed is the result of random pollination by insects or other natural agents and may or may not produce plants typical of the parents. Open pollinated varieties are best for seed saving. Vegetable seeds are discussed in Chapter 19.

B. Germination

Four environmental factors affect germination: water, light, oxygen, and heat.

1. Water—The first step in the germination process is absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process begins, a dry period will cause the death of the embryo.
2. Light—Light is known to stimulate or to inhibit germination of some seed. The

light reaction involved here is a complex process. Some crops that have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, centaurea, annual phlox, verbena, and vinca will germinate best in the dark (Table 1). Many other plant seeds are not specific in their light or dark requirements.

Seed catalogs and seed packets often list germination or cultural tips for individual varieties. When sowing light-requiring seed, do as nature does and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day.

Table 1. Seed requirements.

Plant	Approximate time to seed before last spring frost	Approximate germination time (days)	Optimum germination temperature (°F)	Germination in light (L) or dark (D)
Begonia	12 weeks or more	10 to 15	70	L
Browallia		15 to 20	70	L
Geranium		10 to 20	70	D
Larkspur		5 to 10	55	D
Pansy (Viola)		5 to 10	65	D
Vinca		10 to 15	70	D
Dianthus	10 weeks	5 to 10	70	—
Impatiens		15 to 20	70	L
Petunia		5 to 10	70	L
Portulaca		5 to 10	70	D
Snapdragon		5 to 10	65	L
Stock		10 to 15	70	—
Verbena		15 to 20	65	D
Ageratum	8 weeks	5 to 10	70	L
Alyssum		5 to 10	70	—
Broccoli		5 to 10	70	—
Cabbage		5 to 10	70	—
Cauliflower		5 to 10	70	—
Celosia		5 to 10	70	—
Coleus		5 to 10	65	L
Dahlia		5 to 10	70	—
Eggplant		5 to 10	70	—
Head lettuce		5 to 10	70	L
Nicotiana		10 to 15	70	L
Pepper		5 to 10	80	—
Phlox		5 to 10	65	D
Aster	6 weeks	5 to 10	70	—
Balsam		5 to 10	70	—
Centaurea		5 to 10	65	D
Marigold		5 to 10	70	—
Tomato		5 to 10	80	—
Zinnia		5 to 10	70	—
Cucumber	4 weeks or less	5 to 10	85	—
Cosmos		5 to 10	70	—
Muskmelon		5 to 10	85	—
Squash		5 to 10	85	—
Watermelon		5 to 10	85	—

(—) means no specific light or dark requirements.

3. Oxygen—In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.
4. Heat—A favorable temperature is another important requirement of germination (Table 1). It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperature, whereas others require a narrow range. Many seed have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50°F and a maximum temperature of 95°F, but an optimum germination temperature of about 80°F. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65° to

75°F is best for most plants. This often means the germination flats may have to be placed on radiators, heating cables, or heating mats to maintain optimum temperature. The importance of maintaining proper soil temperature to achieve maximum germination percentages cannot be over-emphasized.

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones or auxins to initiate the process.

C. Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

1. Seed scarification—Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds.
   a. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted.
   b. Another scarification method is mechanical. You may file seeds with a metal file, rub them with sandpaper, or crack them with a hammer to weaken the seed coat.
   c. Hot water scarification involves putting the seed into hot water (170° to 212°F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted.
   d. You also may try warm, moist scarification. In this case, seeds are stored in nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.
2. Seed stratification—Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they overwinter. This so-called "after-ripening" may be accomplished artificially by a practice called stratification.
   a. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with 1/2-inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator (not freezer). Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag and pot from the refrigerator. Remove the bag and set the pot in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 2 inches tall, transplant them into pots to grow until it is time to set them outside.
   b. Another procedure for starting seeds uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will be successful. After 10 to 12 weeks, remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off.

c. Temperatures in the range of 35° to 45°F are effective for stratification. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

D. Starting Seeds

1. Media—A wide range of materials can be used to start seeds, from plain vermiculite or mixtures of soilless media to the various amended soil mixes. With experience, you will learn to determine what works best under your conditions. However, keep in mind what makes a good germinating medium. It should be rather fine and uniform, yet well-aerated and loose. It should be free of insects, disease organisms, and weed seeds. It should also be of low fertility or total soluble salts and capable of holding and moving moisture by capillary action. One mixture that supplies these factors is a combination of 1/3 sterilized soil, 1/3 sand or vermiculite or perlite, and 1/3 peat moss. Do not use garden soil by itself to start seedlings; it is not sterile, it is often too heavy, and it will not drain well.

   a. The importance of using a sterile medium and container cannot be overemphasized. The home gardener can treat a small quantity of soil in an oven. Place the slightly moist soil in a heat-resistant container in an oven set at about 250°F. Use a candy or meat thermometer to ensure that the mix reaches a temperature of 180°F for 30 minutes. Avoid over-heating as this can be extremely damaging to the soil. Be aware that the soil will release very unpleasant odors in the process of sterilization. This treatment should prevent damping-off and other plant diseases, as well as eliminate potential plant pests.

   b. An artificial, soilless mix also provides the desired qualities of a good germination medium. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, lightweight, and produce uniform plant growth. "Peat-lite" mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge.

2. Containers—Flats and trays can be purchased or you can make your own from scrap lumber. A convenient size to handle would be about 12 to 18 inches long and 12 inches wide with a depth of about 2 inches. Leave cracks of about 1/8-inch between the boards in the bottom or drill a series of holes to ensure good drainage.

   a. You can also make your own containers for starting seeds by recycling such things as cottage cheese containers, the bottoms of milk cartons, or bleach containers and pie pans, as long as good drainage is provided. Wash growing containers and implements to remove any debris, then rinse in a solution of one part chlorine bleach to nine parts water. At least one company has developed a form for shaping newspaper into pots, and another has developed a method for the consumer to make and use compressed blocks of soil mix instead of pots.

   b. Clay or plastic pots can be used and numerous types of pots made of compressed peat are also on the market. Plant bands and plastic cell packs are also available. Each cell or minipot holds a single plant that reduces the risk of root injury when transplanting. Peat pellets, peat or fiber-based blocks, and expanded foam cubes can also be used for sowing.

3. Seeding—The proper time for sowing seeds for transplants depends upon when plants may safely be moved out-of-doors in your area. This period may range from 4 to 12 weeks before transplanting, depending upon the speed of germination, the rate of growth, and the cultural conditions provided. A common mistake is to sow the seeds too early and then attempt to hold the seedlings back under poor light or improper temperature ranges. This usually results in tall, weak, spindly plants that do not perform well in the garden.
   a. After selecting a container, fill it to within 3/4-inch of the top with moistened growing medium. For very small seeds, at least the top 1/4-inch should be a fine, screened mix or a layer of vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.
   b. For medium and large seeds, make furrows 1 to 2 inches apart and 1/8- to 1/4-inch deep across the surface of the container using a narrow board or pot label. By sowing in rows, good light and air movement results, and if damping-off fungus does appear, there is less chance of it spreading. Seedlings in rows are easier to label and handle at transplanting time than those that have been sown in a broadcast manner. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if they require darkness for germination. A suitable planting depth is usually about two to three times the diameter of the seed.
   c. Do not plant seeds too deeply. Extremely fine seeds such as petunia, begonia, and snapdragon are not covered, but lightly pressed into the medium or watered in with a fine mist. If these seeds are broadcast, strive for a uniform stand by sowing half the seeds in one direction, then sowing the remaining seed the other direction to form a crossed pattern.
   d. Large seeds are frequently sown into a small container or cell pack that eliminates the need for early transplanting. Usually two or three seeds are sown per unit and later thinned to allow the strongest seedling to grow.
4. Seed tape—Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-to-handle seeds. However, tapes are much more expensive per seed. Seed tapes allow uniform emergence, eliminate overcrowding, and permit sowing in perfectly straight rows. The tapes can be cut at any point for multiple-row plantings, and thinning is rarely necessary.
   a. A homemade "seed tape" can be fashioned from 2-ply toilet paper and paste made with flour and water. Separate the two paper layers, then use a toothpick with a dab of flour paste on it to pick up and place seeds on one of the paper layers. Once all seeds are placed, put the two layers back together while the paste is still wet and roll the "tape" up for later use. The toilet paper, once covered with soil, will rapidly decay leaving no trace.
5. Pregermination—Another method of starting seeds is pregermination. This method involves sprouting the seeds before they are planted in pots or in the garden. This reduces the time to germination, as the temperature and moisture are easy to control. A high percentage of germination is achieved since environmental factors are optimum.
   a. Lay seeds between two paper towels or on a layer of vermiculite in a shallow pan. Keep them moist and in a warm place. When roots begin to show, place the seeds in containers or

plant them directly into the garden. While transplanting seedlings, be careful not to break off tender roots. Continued attention to watering is critical.

b. When planting seeds in a container that will be set out in the garden later, place one seed in a 2- to 3-inch container. Plant the seeds at only one-half the recommended depth. Gently press a little soil over the sprouted seed and then add about 1/4-inch of milled sphagnum peat or sand to the soil surface. These materials will keep the surface uniformly moist and are easy for the shoot to push through. Keep the seedlings in a warm place and care for them as for any other newly transplanted seedlings.

c. A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. You can make a gel by blending cornstarch with boiling water to a consistency that is thick enough so the seeds will stay suspended. Be sure to cool thoroughly before adding seeds. Place the gel with seedlings in a plastic bag with a hole in it. Squeeze the gel through the hole along a premarked garden row. Spacing of seeds is determined by the number of seeds in the gel. If the spacing is too dense, add more gel; if too wide, add more seeds. The gel will keep the germinating seeds moist until they establish themselves in the garden soil.

5. Watering—After the seed has been sown, moisten the planting mix thoroughly. Use a fine mist or place the containers in a pan or tray that contains about 1 inch of warm water. Avoid splashing or excessive flooding, which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.

   a. Ideally, seed flats should remain sufficiently moist during the germination period without having to add water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering. The plastic should be at least 1 inch from the soil. Placing a popsicle stick or pencil in the middle of the flat will hold the plastic off the soil and plants. Keep the container out of direct sunlight, otherwise the temperature may rise to the point where the seeds will be harmed. Many home gardeners cover their flats with panes of glass instead of using a plastic bag. Be sure to remove the plastic or glass cover as soon as the first seedlings appear. Surface watering can then be practiced.

   b. Lack of uniformity, overwatering, or drying out are problems related to manual watering. Excellent germination and moisture uniformity can be obtained with a low-pressure misting system or subirrigation (watering from below). Flats or pots must not sit in water constantly as the soil may absorb too much water, and the seeds will rot due to lack of oxygen.

6. Temperature and light—Several factors for good germination have already been mentioned. The last item, and by no means the least important, is temperature. Since most seeds will germinate best at an optimum temperature that is usually higher than most home night temperatures, special warm areas must be provided. The use of thermostatically controlled heating cables is an excellent method of providing constant heat (see Germination section on page 3-2).

   a. After germination and seedling establishment, move the flats to a light, airy, cooler location, at a 55° to 60°F night temperature and a 65° to 70°F day reading. This will prevent soft, leggy growth and minimize disease. Some crops, of course, may germinate or grow best at a different constant temperature and must be handled separately from the rest of the plants. Read as much as you can about the plants you are trying to grow.

   b. Seedlings must receive bright light after germination. Place them in a window facing south, if possible. If a

large, bright window is not available, place the seedlings under a fluorescent light. Use two 40-watt, cool-white fluorescent tubes or special plant growth lamps. Position the plants 6 to 8 inches from the tubes and keep the lights on for 14 to 16 hours each day. As the seedlings grow, the lights should be raised.

E. Transplanting and Handling

If the plants have not been seeded in individual containers, they must be transplated to give them proper growing space. One of the most common mistakes made is leaving the seedlings in the seed flat too long. The ideal time to transplant young seedlings is when they are small as there is less danger from transplant shock. This is usually about the time the first true leaves appear above or between the cotyledons (the cotyledons sometimes called "seed leaves" are not true leaves). Avoid letting plants get hard, stunted, or tall and leggy.

1. Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble houseplant fertilizer at the rate recommended by the manufacturer, about every 2 to 3 weeks after the seedlings are established. Remember that young seedlings can easily be damaged by too much fertilizer, especially if they are under moisture stress.
2. To transplant, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Gently ease them apart in small groups that will make it easier to separate individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not by their delicate stems. Punch a hole in the medium into which the seedling will be planted. Make it deep enough so that the seedling can be put at the same depth it was growing at in the seed flat. After planting, firm the soil and water gently. Keep newly transplanted seedlings in the shade for a few days, or place them under fluorescent lights. Keep them away from direct heat sources. Continue watering and fertilizing as in the seed flats.
3. Most plants transplant well and can be started indoors, but a few plants are difficult to transplant. These are generally directly seeded outdoors or sown directly into individual containers indoors. Examples include zinnias and cucurbits, such as melons and squash.
4. Containers for transplanting—There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Small plastic pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.
   a. Many types of containers are available commercially. Those made out of pressed peat can be purchased in varying sizes. Individual pots are inexpensive and can be planted directly into the garden. When setting out plants grown in peat pots, be sure to cover the pot completely. If the top edge of the peat pot extends above the soil level, it may act as a wick and draw water away from the soil and roots. To avoid this, tear off the top lip of the pot and then plant.
   b. Compressed peat pellets, when soaked in water, expand to form compact, individual pots. They waste no space, don't fall apart as badly as peat pots, and can be set directly out in the garden.
   c. In addition, many homeowners find a variety of materials from around the house to use for containers. These homemade containers should be deep enough to provide adequate soil and

have plenty of drainage holes in the bottom.

5. Hardening plants—Hardening off is the process of altering the quality of plant growth to withstand the change in environmental conditions that occurs when plants are transferred from a greenhouse to the garden. Severe sunscald or a stoppage in growth may occur if plants produced in the home are planted outdoors without a transition period. Hardening off is most critical with early crops, when adverse climatic conditions can be expected.
   a. Hardening off can be accomplished by gradually lowering temperature and relative humidity and reducing water. This procedure results in an accumulation of carbohydrates and a thickening of cell walls. A change from a soft, succulent type of growth to a firmer, harder type occurs.
   b. This process should be started at least 2 weeks before planting in the garden. If possible, plants should be moved to a 45° to 50°F temperature either indoors or outdoors in a shady location. A coldframe is excellent for this purpose. When put outdoors, plants should be shaded, then gradually moved into sunlight. Start with a 15- to 20-minute exposure. Each day gradually increase the length of exposure time to outside temperatures. Don't put tender seedlings outdoors on windy days or when temperatures are below 45°F.
   c. Reduce the frequency of watering to slow their growth, but don't allow plants to wilt. Even cold-hardy plants will be hurt if exposed to freezing temperatures before they are hardened. After proper hardening, however, they can be planted outdoors and light frosts will not damage them.
   d. The hardening off process is intended to slow plant growth. If carried to the extreme of actually stopping plant growth, significant damage can be done to certain crops. For example, cucumbers and melons will stop all growth, while cauliflower will make thumb-size heads and fail to develop further if hardened too severely.

II. Asexual Propagation

Asexual propagation is the best way to maintain some species, particularly an individual that best represents that species. Clones are groups of plants that are identical to their parent or mother plant. The Bartlett pear (1770) and the Delicious apple (1870) are two examples of clones that have been asexually propagated for many years. The major methods of asexual propagation are cuttings, layering, division, and budding/grafting. Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent plant and then severing it later; and budding and grafting is joining two plant parts from different varieties.

A. Cuttings

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part that is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.

1. Take cuttings with a sharp blade to reduce injury to the parent plant. Before using the knife to cut, dip the cutting tool into rubbing alcohol and allow it to dry or use a mixture of one part bleach to nine parts water to disinfect the blade and to prevent transmitting diseases. Remove flowers and flower buds from cuttings to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production.
   a. To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting a small amount in a separate container for immediate use. Do not dip cuttings directly into the original container.

b. If hormone powder is used, only a very light coating is necessary. Tap off any excess onto a sheet of paper.

2. Insert cuttings into a rooting medium such as coarse sand, vermiculite, sterilized soil, water, or a mixture of peat and perlite. A pencil can be used to make a hole in the medium for easier insertion and to prevent the removal of hormone powder from the cut surface.
   a. It is important to choose the correct rooting medium to get optimum rooting in the shortest time. In general, the rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress. Moisten the medium before inserting cuttings, and keep it evenly moist while cuttings are rooting and forming new shoots. Place stem and leaf cuttings in indirect light. Root cuttings can be kept in the dark until new shoots appear.
3. Stem cuttings—Numerous plant species are propagated by stem cuttings (Table 2). Some can be taken at any time of the year, but stem cuttings of many woody plants must be taken during the fall or in the dormant season. Tip, medial, cane, single and double eye, and heel are all examples of stem cuttings.
   a. Tip cuttings: Detach a 2- to 4-inch piece of stem with two or three nodes, including the terminal bud. Make the bottom cut 1/4-inch below a node. Remove lower leaves from the cutting that would be in contact with the medium. Dip the stem in rooting hormone if desired. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deeply enough into the media to support itself (about half way). At least one node must be below the surface.
   b. Medial cuttings: Make the first cut just above a node, and the second cut just below another node 2 to 4 inches down

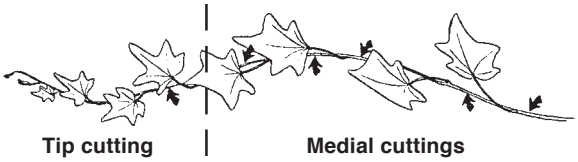
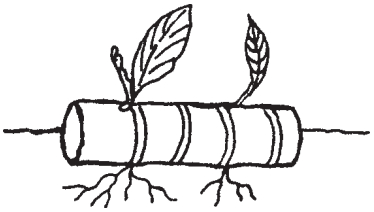


Table 2. Selected herbaceous plants that can be propagated from cuttings.

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	**Scientific name**		
African violet	*Saintpaulia* spp.	leaf	3 to 4
Aluminum plant	*Pilea* spp.	stem	2 to 3
Aloe	*Aloe* spp.	leaf	4 to 6
Aphelandra	*Aphelandra* sp.	stem	2 to 3
Arrowhead plant	*Syngonium podophyllum*	stem	2 to 3
Begonia	*Begonia* spp.	stem (fibrous rooted)	2
		whole leaf or leaf section (Rex)	4 to 5
Cactus	*Cephalocereus senilis*	stem	3 to 4
	Opuntia microdasys	stem	3 to 4
Chrysanthemum	*Chrysanthemum* spp.	stem	1 to 2
Carnation	*Dianthus* spp.	stem	2 to 3
Coleus	*Coleus blumei*	stem	1 to 2
Crown of thorns	*Euphorbia splendens*	stem	4 to 5
Dahlia	*Dahlia* spp.	stem or leaf-bud	3 to 4
Dieffenbachia (dumbcane)	*Dieffenbachia* spp.	stem	4 to 6
Dracaena	*Dracaena* spp.	stem	3 to 4
Echeveria	*Echeveria* spp.	stem or leaf	4 to 6
Euphorbia	*Euphorbia* spp.	stem	4 to 6
Fittonia	*Fittonia* spp.	stem	2 to 3
Fuchsia	*Fuchsia* spp. (also hybrids)	stem	1 to 2
Geranium	*Pelargonium* spp.	stem	1 to 2
Hoya	*Hoya* spp.	stem	3 to 4
Hydrangea	*Hydrangea* spp.	stem	2 to 3
Impatiens	*Impatiens* spp.	stem	2 to 3



Cane cuttings

Heel cuttings

Single eye (left) and double eye (right) cuttings

the stem. The terminal bud is not necessary for this kind of stem cutting. Prepare and insert the cutting as you would a tip cutting. Be sure to position right side up. Axial buds are always above leaves.

c. Cane cuttings: Cut cane-like stems into sections containing one or two "eyes" or nodes. Dust ends with fungicide or activated charcoal. Allow to dry several hours. Lay horizontally with about half of the cutting below the media surface, eye facing upward. Cane cuttings are usually potted when roots and new shoots appear. This method is used with dumbcane (Dieffenbachia).

d. Single eye cuttings: The eye refers to the node. This is used for plants with alternate leaves when space or stock material are limited. Cut the stem about 1/2 inch above and 1/2 inch below a node. Place cutting horizontally or vertically in the medium.

e. Double eye cuttings: This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about 1/2 inch above and 1/2 inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

f. Heel cuttings: This method uses plant material with woody stems. Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.

4. Leaf cuttings—Leaf cuttings are used almost exclusively for a few indoor houseplants. Leaves of most other plants will either produce a few roots but no plant, or they just decay. Covering leaf cut-

Table 2. (cont'd)

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	**Scientific name**		
Ivy	several genera and species	stem	2 to 3
Jade	*Crassula* spp.	stem or leaf	4 to 5
Kalanchoe (bryophyllum)	*Kalanchoe* spp.	stem or leaf	4 to 5
Lantana	*Lantana* sp.	stem	3 to 4
Monstera (Swiss cheese plant)	*Monstera deliciosa*	stem	4 to 5
Mint	*Mentha* spp.	stem	2 to 3
Peperomia	*Peperomia* sp.	leaf, leaf-bud or stem	4 to 6
	P. obtusifolia	leaf-bud or stem	4 to 6
	P. obtusifolia variegata	leaf-bud or stem	4 to 6
Periwinkle (myrtle)	*Vinca* spp.	stem	3 to 4
Petunia	Petunia hybrids	stem	2 to 3
Philodendron	*Philodendron* spp.	stem	2 to 4
Piggyback plant	*Tolmiea menziesii*	leaf with plantlet	3 to 4
Pothos	*Scindapsus aureus*	stem	2 to 3
Poinsettia	*Euphorbia pulcherrima*	stem	2 to 3
Sansevieria (snake plant)	*Sansevieria* spp.	leaf, leaf section	4 to 6
Velvet plant	*Gynura* spp.	stem	1 to 2
Wandering jew	*Tradescantia* spp. *Zebrina* spp.	stem	2 to 3

*The indicated time for rooting is only approximate and may be longer under some conditions. Where new shoots must develop in addition to roots, the time required for shoot development is often longer.

Source: Propagating Herbaceous Plants from Cuttings, PNW 151.

tings with a plastic bag will maintain moisture in the medium and humidity around the cutting.

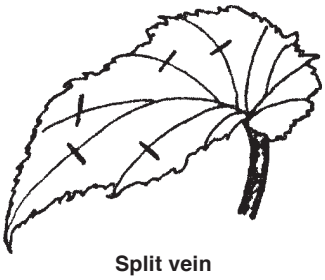
a. Whole leaf with petiole: Detach the leaf and up to 1 1/2 inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be severed from the new plants when they have their own roots, and the petiole reused. This method is used for African violets.

Whole leaf with petiole

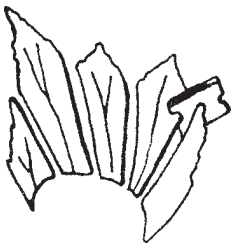
Whole leaf without petiole

b. Whole leaf without petiole: This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will form from the axillary buds. The leaf may be removed when the new plant has its own roots. This method is used with jade plants.

c. Split vein: Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay and pin the cutting, lower side down, on the medium. New plants will form at each cut. If the leaf tends to curl up, hold it in place by covering the margins with the rooting medium. This method is used with Rex begonias. A plastic bag around the container and leaf will help keep the leaf from drying out.



Split vein



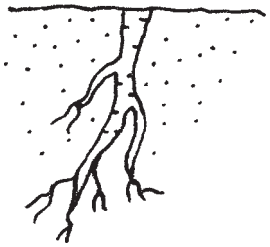
Leaf section

d. Leaf sections: This method is frequently used with snake plant (Sansevieria) and Rex begonias. Cut begonia leaves into wedges with at least one main vein. Lay leaves flat on the medium. A new plant will arise at the vein.

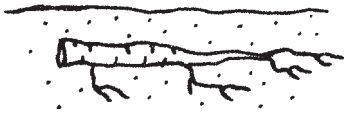
Cut snake plant leaves into 2-inch sections. Consistently make the lower cut slanted and the upper cut straight so you can tell which is the top. Insert the cuttings vertically into the medium. Eventually a new plant will appear at the base of the cutting. These and other succulent cuttings will rot if kept too moist. No plastic bag is needed around succulents.

5. Root cuttings—Root cuttings are usually taken from 2- to 3-year-old plants during their dormant season when they have a large carbohydrate supply. Root cuttings of some species produce new shoots, which then form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

a. Plants with large roots: Make a straight top cut and a slanted cut 2 to 6 inches below the first cut. This will help you determine what portion is the top. Store about 3 weeks in moist sawdust, peat moss, or sand at 40°F. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often used outdoors.



Plants with large roots



Plants with small roots

b. Plants with small roots: Take a 2- to 3-inch section of root. Insert the cutting horizontally about 1/2 inch below the medium surface. This method is usually used indoors or in a hotbed.

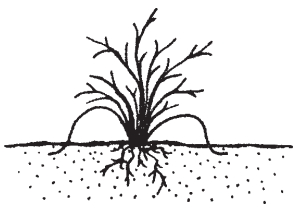
B. Layering

Stems still attached to their parent plants may form roots where they touch a rooting

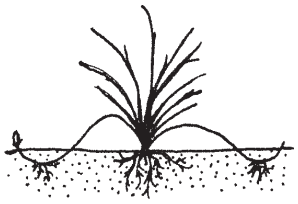
medium. Severed from the parent plant later, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents water stress and the loss of carbohydrate shortage that plagues cuttings.

Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering is enhanced by wounding one side of the stem or by bending it very sharply.

1. Tip layering—Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the tip layer from the mother plant and plant it in early spring or fall. Examples: purple and black raspberries and trailing blackberries.

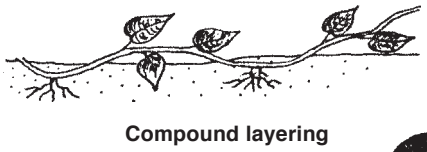


Tip layering

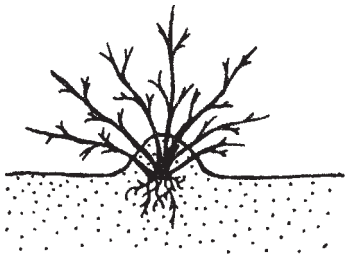


Simple layering

2. Simple layering—Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed. Bend the tip into a vertical position and stake it in place. The sharp bend will often induce rooting, but wounding the lower side of the branch may help. Examples: rhododendron and honeysuckle.
3. Compound layering—This method works for plants with flexible stems. Bend the stem to the rooting medium as for simple layering, but alternately cover and expose stem sections. Wound the lower side of stem sections to be covered. Examples: heart-leaf philodendron and pothos.
4. Mound (stool) layering—Cut the plant back to 1 inch above the ground during the dormant season. Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries and apple rootstocks.



Compound layering



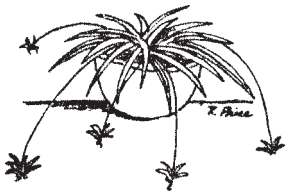
Mound layering

Air layering

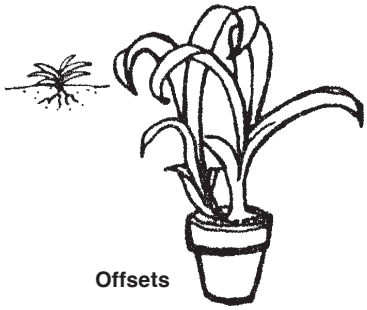
5. Air layering—Air layering is used to propagate some indoor plants with thick stems, or to rejuvenate them when they become leggy. Make an upward slanting cut one half way through the stem just below a node. Hold the slit open with a toothpick laid sideways or a bit of sphagnum moss. Surround the wound with wet, unmilled sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie it in place above and below the wound. When roots pervade the moss, cut the plant off below the root ball. Examples: dumbcane and rubber tree.

Note: The following propagation methods can all be considered types of layering, as the new plants form before they are detached from their parent plants.

6. Stolons and runners—A stolon is a horizontal, often fleshy stem that can root and produce new shoots where it touches the medium. A runner is a slender stem that originates in a leaf axil and grows along the ground or downward from a hanging basket, producing a new plant at its tip. Plants that produce stolons or runners are



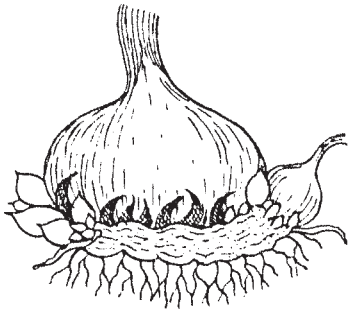
Stolons and runners



Offsets

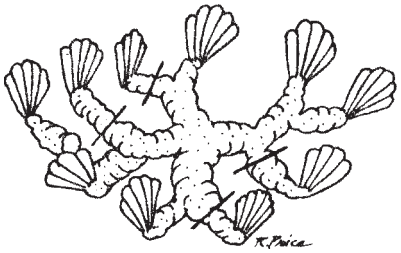
propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent, or detached and placed in a rooting medium. Examples: strawberry and spider plant.

7. Offsets—Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, while others may simply be lifted off of the parent stem. Examples: date palm, haworthia, bromeliads, and many cacti.
8. Separation—Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.
   a. Bulbs: New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb number. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replace them immediately so that their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Examples: tulip and narcissus.



Separation corms

   b. Corms: A large new corm forms on top of the old corm, and tiny cormels form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting time. Examples: crocus and gladiolus.



Division

C. Division

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not jointed, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: snake plant, iris, prayer plant, and day lilies.

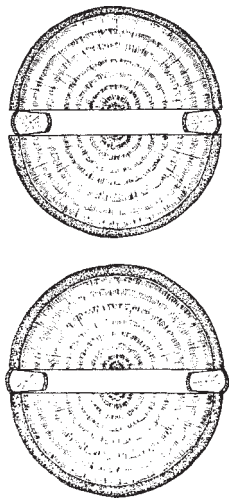
1. Most perennials left in the same place for more than 3 years are likely to be overgrown, overcrowded, have dead or unsightly centers, and in need of basic feeding and soil amendment. The center of the clump will grow poorly, if at all, and the flowers will be sparse. The clump will deplete the fertility of the soil as the plant crowds itself.
   a. To divide mature clumps of perennials, select only vigorous side shoots from the outer part of the clump. Discard the center of the clump. Divide the plant into sections of three to five shoots each. Be careful not to overdivide; too small a section will not give much color the first year after replanting.
   b. Divide perennials when the plants are dormant, just before a new season of growth, or in the fall so they can become established before the ground freezes.

D. Grafting

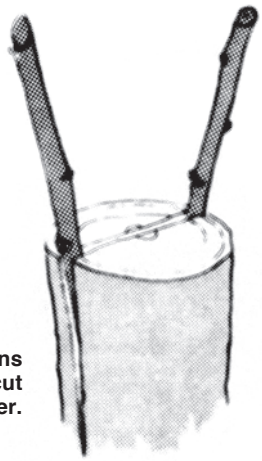
Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant. These

techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate. One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.

1. The portion of the cultivar that is to be propagated is called the scion. It consists of a piece of shoot with dormant buds that will produce the stem and branches. The rootstock, or stock, provides the new plant's root system and sometimes the lower part of the stem. The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate.
2. Four conditions must be met for grafting to be successful: (1) The scion and rootstock must be compatible, (2) each must be at the proper physiological stage, (3) the cambial layers of the scion and stock must meet, and (4) the graft union must be kept moist until the wound has healed.
   a. Cleft grafting: Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree (usually a seedling). It is especially successful if done in the early spring. Collect scion wood 3/8- to 5/8-inch in diameter. Cut the limb or small tree trunk off at the area that it is to be reworked. Make a 2-inch vertical cut through the center of the limb or trunk. Be careful not to tear the bark. Keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3 to 4 inches long. Insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.

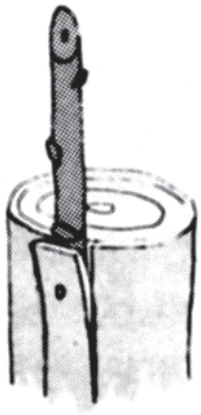


Cleft graft (correct method on top; incorrect method below)



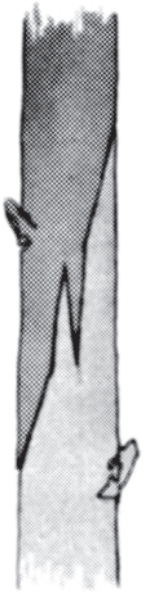
Cleft graft with both scions inserted at slight angles. All cut surfaces should be waxed over.

   b. Veneer or bark grafting. Unlike most grafting methods, bark grafting can be used on large limbs, although these are often infected before the wound can completely heal. Collect scion wood 3/8- to 1/2-inch in diameter when the plant is dormant, and store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock to be worked. In the spring, when the bark easily separates from the wood, make a 1- to 2-inch diagonal cut on one side of the scion, and a 1 1/2-inch diagonal cut on the other side. Leave two buds above the longer cut. Slice through the bark of the stock cutting a little wider than the scion. Insert the scion between the bark and wood with the longer cut against the wood. Nail the graft in place with flat-headed wire nails. Cover all wounds with grafting wax.



Bark graft

   c. Whip or tongue grafting: This method is often used for material 1/4- to 1/2-



Whip or tongue graft

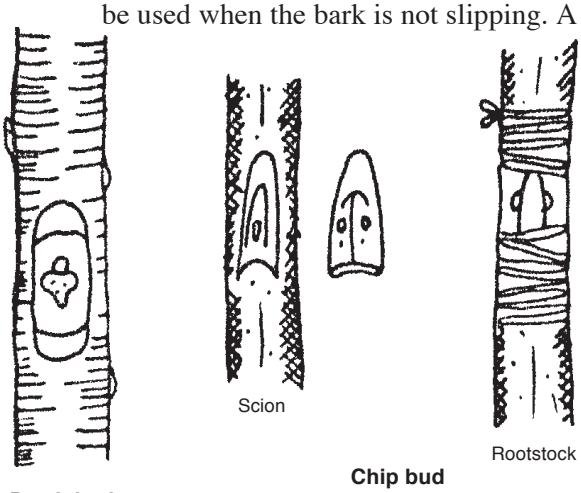
inch in diameter. The scion and rootstock are usually of the same diameter, but the scion may be narrower than the stock. This strong graft heals quickly and provides excellent cambial contact. Make one 2 1/2-inch sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface, slice downward into the stock and up into the scion so the pieces will interlock. Fit the pieces together, then tie and wax the union.

3. Care of the graft—Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts to prevent girdling. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut, as they deteriorate and break after a short time. It is also an excellent idea to inspect the grafts after 2 or 3 weeks to see if the wax has cracked, and if necessary, rewax the exposed areas. After this, the union will probably be strong enough and no more waxing will be necessary.
4. Limbs of the old variety that are not selected for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually reduced as the new grafted variety increases until at the end of 1 or 2 years, the new variety has completely taken over. Completely removing all the limbs of the old variety at the time of grafting will increase the shock to the tree and cause excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

E. Budding

Budding, or bud grafting, is the union of one bud (attached to a small piece of bark) from the scion to the rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.

1. Patch budding—Plants with thick bark should be patch budded. This is done while the plants are actively growing, so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cut a matching rectangular piece with a bud and piece of bark from the scion to cover this wound. If the rootstock's bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped, the patch will be held firmly in place.
2. Chip budding—This budding method can be used when the bark is not slipping. A



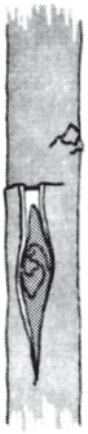
Chip bud

Patch bud

downward cut is made at a 45 degree angle about one quarter through the rootstock. About 1 inch above the first cut, a second cut is made slicing downward and inward until it connects with the first cut. The cuts removing the bud from the bud

stick are made just as those in the rootstock, except the lower cut is made about 1/4-inch below a bud. Fit the bud chip to the stock and wrap the union.

3. T-budding—This is the most commonly used budding technique. When the bark is slipping, make a vertical cut through the bark of the rootstock, avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, bark, and a thin section of wood. Push the shield under the loosened stock bark. Wrap the union, leaving the bud exposed.



T-bud

Care of buds—Place the bud in the rootstock in August. Force the bud to develop the following spring by cutting the stock off 3 to 4 inches above the bud. The new shoot may be tied to the resulting stub to prevent damage from the wind. After the shoot has made a strong union with the stock, cut the stub off close to the budded area.

F. Plant Tissue Culture

Tissue culture is a mass of undifferentiated callus tissue growing on an artificial medium, separately from the plant from which it originated. Size increases by cell division. After about 4 to 6 weeks, the mass of cells is large enough to divide into sections and reculture to produce additional tissue cultures. This procedure is usually done in a laboratory or under laboratory conditions.

A tissue culture can be started from a variety of plant parts that have cells capable of dividing. Usually tissues near the vascular area of stems and roots proliferate best, but cultures have been started from fruits, endosperm, pollen, and embryos. To read more about this exciting method of propagation refer to books in your local library.

Further Reading

Books

The Virginia Master Gardener Handbook, Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The Nevada Master Gardener Handbook, University of Nevada Cooperative Extension, phone 702/784-4848.

Wilkins, H. M. 1988. *Plantwatching: How Plants Live, Feel, and Work*. MacMillan Co., New York, NY.

Wilkins, H. M. 1988. *Plantwatching: How Plants Remember, Tell Time, Form Partnerships, and Move*. Facts on File Publications, New York, NY.

Booklets and Pamphlets

University of Idaho Extension

CIS 869 Controlling Sunscald on Trees and Vines

PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair

CIS 866 Homeowner's Guide to Fruit Tree Fertilization

CIS 881 Success with Very Small Seeds

PNW 121 Nutrient Disorders in Tree Fruits (online only)

PNW 164 Propagating from Bulbs, Corms, Tubers, Rhizomes, and Tuberous Roots and Stems

PNW 151 Propagating Herbaceous Plants from Cuttings

PNW 170 Propagating Plants from Seed

CIS 1043 Selecting Grape Cultivars and Planting Sites in Idaho

PNW 400 Training and Pruning Your Home Orchard

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