Plant propagation is the process of multiplying the numbers of a species, perpetuating a species or maintaining youthfulness of a plant. There are two types of propagation: sexual and asexual.

Sexual propagation occurs when compatible pollen lands on the flower’s stigma, grows down the style and fertilizes the egg in the flower’s ovary. The seed grows from the flower’s union of the pollen and the egg and is often contained in a fruit or similar structure.

There are advantages to sexual propagation:
- It may be cheaper and quicker than other methods.
- It may be the only way to obtain new varieties.
- In certain species, it is the only viable method of propagation.
- It avoids transmission of certain diseases.

Asexual propagation involves regenerating a new plant from a vegetative part (root, stem or leaf) of one parent. The new plant is genetically identical to the parent plant. Asexual propagation also has advantages:
- In some species, it may be easier and faster than sexual propagation.
- It may be the only way to perpetuate some cultivars.
- It bypasses the juvenile characteristics of certain species.

Successful plant propagation requires practice and patience. It is a means to start new plants, increase existing plant populations and garden with native plants.

Sexual propagation

Sexual propagation involves the union of pollen from a male flower part with the egg of a female ovary to produce a seed. The seed is made up of three parts: the outer seed

Adapted from The Virginia Master Gardener Handbook. Edited by Ray McNeilan, Extension Agent Emeritus, Multnomah County, Oregon State University.

Adapted by Robert Gorman, Extension Faculty, Natural Resources and Community Development, Cooperative Extension Service, University of Alaska Fairbanks.
coat, which protects the seed; the endosperm, 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 germinates (begins active growth).

**Seeds**

Seeds can be collected late in the growing season after plants have flowered and their seeds have matured. Some plants grown in Alaska are best propagated by gardeners collecting, cleaning and storing seed for the next season. Usually, however, gardeners purchase seed from professional seed growers.

To obtain high-quality plants, start with high-quality seed from a reliable dealer. Seed products should not contain any debris or other crop or weed seeds.

Select varieties to provide the size, color and growth habit you desire. Choose varieties that are adapted to your area and will reach maturity before an early frost.

Many vegetable and flower varieties are hybrids (a cross between two species), which cost a little more than open-pollinated types. However, hybrid plants usually have more vigor, more uniformity and better production than nonhybrids. Sometimes they have specific disease resistance or other unique cultural characteristics.

**Heirloom**

One hundred years ago there were more types of vegetables and flowers. Basically, this meant that there was more biodiversity or genetic diversity in agricultural plant and animal life. Historically, garden seeds were planted, pollinated by the wind and insects, and allowed to mature and go to seed. Seeds were then collected and replanted the next year. This natural process is referred to as open pollination. Gardeners and farmers selected the best plants for collecting seeds, and varieties improved over time. Some varieties were especially treasured, given names and handed down for many years in families. These very old varieties are referred to as heirlooms. These are plant varieties that have been saved and replanted for a minimum of 50 years.

**Bioengineered**

Bioengineered seed, from genetically manipulated plants, is the newest type of seed in the industry. Scientists today can take genes out of many living things and inject them into another plant or animal. Insect-killing genes from bacteria have been introduced into plants, and the new varieties are resistant to insect attack. This whole process is relatively new and scientists are not sure what the long-term effects will be.

**Storing**

Most flower and vegetable seeds will remain viable for more than one year, but germination percentage will decrease with age. How long a seed can be stored and remain viable or germinate is determined by the type of seed and the storage conditions. Proper storage conditions are cool, dry and dark.

Store seeds in an airtight container, such as a glass jar or a doubled plastic bag. Humidity should be kept between 25 and 35 percent as a general rule. A location that remains a constant, cool temperature — around 40°F — is best. The storage area should be very dark since light causes chemical changes and deterioration of seeds.

Most seed companies take great care in handling seeds. Seed packets usually indicate the year for which the seeds were packaged, the expected germination percentage, the plant variety and the chemical seed treatment (e.g., with fungicides), if applicable.
Generally, do not expect more than 65 to 80 percent of seeds to germinate. From these germinated seeds, expect about 60 to 75 percent to produce satisfactory vigorous, sturdy seedlings.

Some gardeners save seeds from their own gardens; however, such seeds are the result of random pollination by insects or other natural agents and may not produce plants like the parents. This is especially true of hybrid varieties.

Most plants transplant well and can be started indoors in flats or trays. A few, however, are difficult to transplant and generally are directly seeded outdoors or sown into individual containers indoors. Examples include beets and carrots.

Germination

Four environmental factors affect germination: water, oxygen, light and heat. Different seeds have different requirements, especially for heat and light. Table 1 lists specific requirements of several kinds of seeds. Seed catalogs and packets often list germination or cultural tips for individual varieties.

An adequate, continuous supply of water is important to ensure germination. Although seeds have a great ability to absorb (imbibe) water, the amount of water available in the soil affects imbibition. And once the germination process has begun, a dry period will kill the embryo.

Light can stimulate or inhibit germination of some seeds. The light reaction involved is complex. Some crops require light for seed germination. Examples are ageratum, begonias, browallia, impatiens, lettuce and petunias. Others, such as calendula, annual phlox and verbena, require darkness. For other plants, light doesn’t matter at all.

When sowing seeds that require light, leave them on the soil surface, or at most cover them lightly with fine peat moss or vermiculite. These materials, if not applied too heavily, permit some light to reach the seeds and do not limit germination. You can provide supplemental light by suspending fluorescent lights 6 to 12 inches above the seeds for 16 hours a day.

In all viable seed, respiration takes place. Respiration is the conversion of stored carbohydrates into energy, a process that requires oxygen. The respiration rate in nongerminating seed is low, but some oxygen still is required. Because respiration increases during germination, the medium in which seeds are planted should be loose and well aerated. If the oxygen supply is limited, germination can be severely inhibited.

Temperature of the planting medium is another important factor in germination. Temperature not only affects germination percentage, but also the speed of germination. The importance of maintaining proper temperature cannot be overemphasized.

Some seeds germinate over a wide range of temperatures, while others require a narrow range. Many seeds have minimum, maximum and optimum temperatures for germination. For example, the minimum germination temperature for tomato seed is 50°F and the maximum is 95°F, but the optimum is about 80°F.

When germination temperature is listed on a seed packet, it usually is the optimum temperature unless otherwise specified. Generally, 65° to 75°F is best for most plants. You may need to place germination flats in special chambers or on radiators, heating cables or heating mats to maintain the optimum temperature.

If environmental conditions are satisfactory, germination begins when certain internal requirements are met. A seed must have a mature embryo, a large enough
endosperm to sustain the embryo during germination, and sufficient hormones to initiate the process.

**Artificially breaking dormancy**

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

*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:

- To scarify seeds mechanically, file them with a metal file, rub them with sandpaper or crack them with a hammer.
- To scarify seeds with acid, put them in

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### Table 1.—Seed germination requirements.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Approximate time to start seed indoors before last spring frost (weeks)</th>
<th>Approximate germination time (days)</th>
<th>Optimum germination temperature (°F)</th>
<th>Germinates in light (L) or dark (D)</th>
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<tbody>
<tr>
<td>Ageratum</td>
<td>8</td>
<td>5–10</td>
<td>70</td>
<td>L</td>
</tr>
<tr>
<td>Alyssum</td>
<td>8</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
<tr>
<td>Aster</td>
<td>6</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
<tr>
<td>Balsam</td>
<td>6</td>
<td>5–10</td>
<td>L, D</td>
<td></td>
</tr>
<tr>
<td>Begonia</td>
<td>18</td>
<td>10–15</td>
<td>70</td>
<td>L</td>
</tr>
<tr>
<td>Broccoli</td>
<td>4–6</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
<tr>
<td>Cabbage</td>
<td>4–6</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>4–6</td>
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<td>70</td>
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<td>8</td>
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<td></td>
</tr>
<tr>
<td>Centaurea</td>
<td>6</td>
<td>5–10</td>
<td>65</td>
<td>D</td>
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<td>Coleus</td>
<td>8</td>
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<td>4</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
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<td>Cucumber</td>
<td>3</td>
<td>5–10</td>
<td>85</td>
<td>L, D</td>
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<tr>
<td>Dahlia</td>
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<td>L, D</td>
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<td>Geranium</td>
<td>12</td>
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<td>L</td>
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<td>Impatiens</td>
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<td>70</td>
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<td>L</td>
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<td>65</td>
<td>D</td>
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<tr>
<td>Pepper</td>
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<td>80</td>
<td>L, D</td>
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<td>Petunia</td>
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<td>D</td>
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<td>70</td>
<td>D</td>
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<td>3</td>
<td>5–10</td>
<td>85</td>
<td>L, D</td>
</tr>
<tr>
<td>Tomato</td>
<td>7–9</td>
<td>5–10</td>
<td>80</td>
<td>L, D</td>
</tr>
<tr>
<td>Verbena</td>
<td>10</td>
<td>15–20</td>
<td>65</td>
<td>D</td>
</tr>
<tr>
<td>Watermelon</td>
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<td>5–10</td>
<td>85</td>
<td>L, D</td>
</tr>
<tr>
<td>Zinnia</td>
<td>6</td>
<td>5–10</td>
<td>70</td>
<td>L, D</td>
</tr>
</tbody>
</table>
Chapter 4—Plant Propagation

a glass container and cover them with concentrated sulfuric acid at about twice the volume of seed. Stir gently and allow the seeds to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat becomes thin, remove the seeds, wash them and plant them.

- To scarify seeds with hot water, heat water to 170° to 212°F and pour it over the seeds. As the water cools, allow the seeds to soak for 12 to 24 hours and then plant them.
- To use a warm-moist scarification method, store seeds for several months in nonsterile, warm, damp containers; the seed coat will be broken down by decay.

Seed stratification is a procedure that provides an artificial chilling period for seeds that require a cold, dormant period before germinating.

To stratify seeds, fill a container with sand or vermiculite to about 1 inch from the top. Place the seeds on the surface of the medium and cover them with an additional ½ inch of medium. Water thoroughly and allow excess water to drain through the hole in the pot. Place the pot in a plastic bag and tie the bag with a twist-tie or rubber band. Place the bag in a refrigerator. Periodically check to make sure the medium is moist, but not wet. Additional water probably will not be necessary. After 10 to 12 weeks, remove the bag from the refrigerator. Take the pot out and set it 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 3 inches tall, transplant them into pots to grow until planting time.

Another chilling procedure that usually is successful uses sphagnum peat moss. Seeds of most fruit trees can be germinated successfully by this procedure. Wet the moss thoroughly and then squeeze out the excess water. Mix the seeds with the moss and place the material in a plastic bag. Use a twist-tie or rubber band to secure the top and then refrigerate the bag. Check it periodically. If there is condensation on the inside of the bag, the process probably will be successful. Temperatures in the range of 35° to 45°F are effective. Most refrigerators operate in this range. After 10 to 12 weeks, remove the bag from the refrigerator. Plant the seeds in pots. Handle the seeds carefully; often small roots and shoots are emerging by this time, so take care not to break them.

Soil mixes for starting seeds

Many kinds of planting media can be used to start seeds, ranging from vermiculite alone or mixed with other artificial materials to various amended soil mixes. Regardless of the material, a germinating medium must be:

- Fine and uniform, yet well aerated and loose
- Free of insects, disease organisms and weed seeds
- Low in fertility and total soluble salts
- Capable of holding and moving moisture by capillary action

One mixture that meets these criteria is a combination of one-third pasteurized soil; one-third sand, vermiculite or perlite; and one-third sphagnum peat moss. Do not use garden soil by itself to start seedlings because it is not sterile, is too heavy, does not drain well, and will shrink from the sides of containers if allowed to dry out.

The importance of using a sterile medium and container cannot be overemphasized. You can easily pasteurize a small quantity of soil mixture in an oven. Place slightly
Moist soil in a heat-resistant container, cover it and bake it in a 180°F oven. Use a candy or meat thermometer to ensure that the mix reaches 180°F for at least 30 minutes. Avoid overheating, which can damage the soil. Be aware that this process can cause very unpleasant odors. It should, however, prevent damping-off and other plant diseases, as well as eliminate potential plant pests (Figure 1).

Pots and other growing containers also should be thoroughly clean. First wash them to remove debris, and then rinse them in a solution of 1 part chlorine bleach to 10 parts water. Avoid recontaminating the medium and tools.

An artificial soilless mix does not need to be sterilized. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which generally are free of diseases, weed seeds and insects. These materials are readily available, easy to handle, lightweight and able to produce uniform plant growth.

Ready-made soilless (“peat-lite”) mixes or similar products are commercially available or can be made at home by thoroughly mixing the following ingredients:

- 4 quarts shredded sphagnum peat moss
- 4 quarts fine-grade vermiculite
- 1 tablespoon superphosphate
- 2 tablespoons ground limestone

Another recipe is:

- 50 percent vermiculite or perlite
- 50 percent milled sphagnum peat moss with fertilizer

These mixes have little fertility, so you must water seedlings with a diluted fertilizer solution soon after they emerge.

**Containers for starting seeds**

Seedlings can be grown in a wide assortment of containers. You can buy plastic flats and trays or make them from scrap lumber. A convenient size is about 12 to 18 inches long, 12 inches wide and 2 inches deep. Leave ¼-inch cracks between the boards in the bottom, or drill a series of holes to ensure drainage. Clay or plastic flowerpots can be used, too. Aluminum pie pans, cottage cheese containers and the bottoms of milk cartons or bleach containers can be recycled for starting seeds, but you must provide good drainage.
Numerous types of pots and strips made of compressed peat, plant bands and plastic cells are sold in garden stores and nurseries. Each cell or minipot holds a single plant, reducing the risk of root injury during transplanting. Peat pellets, peat or fiber-based blocks, and expanded plastic-foam cubes also can be used. With these products, the growing medium itself forms the container.

**Starting seeds**

The proper time for sowing seeds indoors for transplants depends on when plants may be safely moved outdoors. Sowing dates range from 4 to 12 weeks prior to the last spring frost, depending on cold hardiness of the plant, speed of germination, rate of growth and conditions provided (Table 1). A common mistake is to sow seeds too early and then attempt to hold seedlings back under poor light or improper temperature. The result usually is tall, weak, spindly plants that do not perform well in the garden.

Fill your selected container to within \( \frac{3}{4} \) inch from the top with moistened medium. For very small seeds, at least the top \( \frac{1}{4} \) inch should be a layer of fine, screened mix or vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.

For medium to large seeds, make furrows with a narrow board or pot label about 1 to 2 inches apart and \( \frac{1}{8} \) to \( 1\frac{1}{4} \) inch deep across the surface of the growing medium (Figure 2). Sowing in rows encourages good light and air movement, so if damping-off fungus does appear, it has less chance of spreading. Seedlings in rows also are easier to label and to handle at transplanting time than those sown by broadcasting.

Sow the seeds thinly and uniformly in the rows by gently tapping the seed packet as you move it along the row. Lightly cover the seeds with dry vermiculite or sifted medium if they require darkness for germination. Do not cover seeds too deeply. A suitable planting depth usually is about twice the diameter of the seed.

Do not cover extremely fine seeds such as those of petunias, begonias and snapdragons; instead, lightly press them into the medium or water them in with a fine-mist spray. If you broadcast these seeds, strive for a uniform stand by sowing half the seeds in one direction, then sowing the other way with the remaining seed.

Large seeds frequently are sown into some sort of individual 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.

Pregermation is another method of starting seeds. This method involves sowing the seeds before planting them in pots or in the garden. It reduces the time to germination because temperature and moisture are easy to control, and it guarantees a high germination percentage because no seeds are lost to environmental factors.

To pregerminate seeds, lay them between folds of cotton cloth or paper towels placed on top of a layer of vermiculite or similar material in a pan. Water gently and place in a warm place. Keep the seeds moist. When roots begin to show, plant the seeds in containers or directly in the garden. Be careful not to break tender roots.

When planting pregerminated seeds in a container that you’ll later set in the garden, place one seed in each 2- to 3-inch-deep container. Plant the seeds only one-half the recommended depth. Gently press a little soil over the sprouted seed and add about 1⁄4 inch milled sphagnum peat moss or sand. These materials keep the surface uniformly moist and are easy for shoots to push through. Keep pots in a warm place and care for them like any other newly transplanted seedlings. Continued attention to watering is critical.

A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. Make a gel by blending cornstarch with boiling water until the consistency is thick enough to keep the seeds suspended. Be sure to cool it thoroughly before use. Place the gel and 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 soil.

The proper amount of moisture is crucial to seedling survival. After sowing seeds, moisten the planting mix thoroughly. Use a fine-mist spray or place the containers in a pan or tray with about 1 inch of warm water in the bottom. Avoid splashing or excessive flooding that might displace small seeds. When the planting mix is saturated, set the container aside to drain.

While seeds are germinating, keep the planting medium moist, but not wet. Ideally, seed flats should remain sufficiently moist without additional water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering. Many home gardeners cover flats with panes of glass instead of plastic bags. The plastic or glass should be at least 1 to 1½ inches above the soil. Keep the container out of direct sunlight to prevent the temperature inside from rising too high and harming the seeds.

Be sure to remove the plastic bag or glass cover as soon as the first seedlings appear. Then, as the growing medium surface dries, water carefully to avoid washing seedlings out of the medium.

**Care of indoor seedlings**

Proper watering is crucial to good seedling growth. Lack of uniformity, over-watering and drying out are problems related to hand watering. A low-pressure misting system can give excellent moisture uniformity. During the daytime, give 4 seconds of mist every 6 minutes, or 10 seconds every 15 minutes. Bottom heat is helpful with a mist system.

Subirrigation (watering from below) also may work well to keep the flats moist. Do not let flats or pots sit in water constantly or seeds may rot from lack of oxygen.
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After seedlings are established, move the flats to a light, airy, cool location, where nighttime temperatures are 55° to 60°F, and daytime temperatures are 65° to 70°F. These conditions prevent soft, leggy growth and minimize disease troubles. Some crops, of course, may germinate or grow best at a different temperature. Keep them in a separate location in proper conditions.

Seedlings must receive bright light after germination. If possible, place them in a south-facing window. If a large, bright window is not available, place seedlings under a fluorescent light. Use two 40-watt, cool, white fluorescent tubes or special plant-growth lamps. Position the plants 6 inches from the tubes and keep the lights on no more than 16 hours each day. As the seedlings grow, raise the lights to keep them 6 inches from the plants.

Transplanting seedlings to larger pots

If you don’t plant seeds in individual containers, you’ll need to transplant them to give them proper growing space. One of the most common mistakes is leaving seedlings in a seed flat too long. The ideal time to transplant seedlings is when they are small and there is little danger from setback — usually about the time the first true leaves appear above or between the cotyledons (the “seed” leaves).

You can buy or make growing mixes and containers for seedlings. A growing medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes contain fertilizer. Add fertilizer to those that do not.

To transplant seedlings, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart or gently ease them apart into small groups. Then pick out individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not their delicate stems.

Punch a hole in the planting medium. Make it deep enough to put the seedling at the same depth it was growing in the seed flat. Place small plants or slow growers 1 inch apart and rapid-growing, large seedlings about 2 inches apart.

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.

Continue watering as before. About every 2 weeks after the seedlings are established, use a soluble houseplant fertilizer at the dilution recommended by the manufacturer. Remember that young seedlings are easily damaged by too much fertilizer, especially if they are under any moisture stress.

Hardening indoor-grown seedlings

Hardening is the process of altering plant growth to withstand the change in environment that occurs when plants are transferred from a greenhouse or home to a garden. A severe setback in growth may occur if indoor-grown plants are planted outdoors without a transition period. Hardening is more critical for early crops, which are more likely to face adverse climatic conditions, than it is for crops planted later in the season.

Harden plants by gradually reducing temperature, relative humidity and water. As a result, plants will accumulate carbohydrates and cell walls will thicken, thus changing soft, succulent growth to firmer, harder tissue.
Start this process at least 2 weeks before planting seedlings outside. If possible, move plants to a location indoors with a temperature of 45° to 50°F, or outdoors in the shade. A cold frame is excellent for this purpose. Shade plants at first, then gradually move them into sunlight. Each day, increase the length of exposure slightly. Reduce the frequency of watering, but don’t allow plants to wilt.

Don’t put tender seedlings outdoors on windy days or when temperatures are below 45°F. Even cold-hardy plants will be hurt if exposed to freezing temperatures before they are hardened.

The hardening process is intended to slow plant growth. If carried to the extreme of actually stopping growth, however, some crops suffer significant damage. For example, cauliflower may make thumb-size heads and fail to develop further if hardened too severely.

Transplanting seedlings to the garden

If transplanting seedlings from individual plastic pots or cell packs, remove each plant and its soil/root ball from its pot before planting. Seedlings growing in individual peat pots or compressed peat pellets can be planted directly in the garden, pot and all. Be careful to cover the pot completely. If the top edge of the pot extends above the soil level, it may act as a wick and draw water away from soil in the pot. To avoid this problem, tear off the top lip of the pot and then plant the pot flush with the soil level.

If seedlings have been grown in community packs, you’ll need to break or cut apart the roots of individual plants to separate them. Water seedlings thoroughly before cutting the growing medium.

Spores (ferns)

Although ferns are more easily propagated by other methods, some gardeners like the challenge of raising ferns from spores. One tested method for propagating small quantities is described here.

First, sterilize a solid brick by baking it at 250°F for 30 minutes. Place it in a pan and cover it with water. When the brick is wet throughout, squeeze a thin layer of moist soil and peat (equal parts) onto the top of the brick. Pack a second layer (about 1 inch) on top of that. Sprinkle fern spores on top. Cover the brick with plastic (not touching the spores) and put it in a warm place in indirect light. It may take up to a month or more for spores to germinate. Keep them moist at all times.

Each spore will develop a prothallus (first generation of a fern), forming a light green mat. Mist lightly once a week to maintain high surface moisture; the male gametes must be able to swim to the archegonia (female parts).

After about 3 weeks, fertilization should have occurred. Use tweezers to pull apart the mat into ¼-inch squares. Space them ½ inch apart in a flat containing 2 inches of sand, ¼ inch of charcoal and about 2 inches of soil/peat mix. Cover with plastic and keep moist. When fern fronds appear and become crowded, transplant to small pots. Gradually reduce the humidity until they can survive in the open. You can increase exposure to light at this time.

Asexual propagation

Asexual propagation is the best way to maintain an individual plant that best represents a species. Clones are identical to their one parent and can be propagated only asexually. Bartlett pears (developed in
1770) and Delicious apples (1870) are two examples of clones that have been propagated asexually for many years.

The major methods of asexual propagation are as follows:

- **Cuttings** (rooting a severed piece of the parent plant)
- **Layering** (rooting a part of the parent and then severing it)
- **Offsets** (removing new shoots that form at a plant’s base)
- **Separation** (dividing bulbs or corms)
- **Division** (dividing rooted crowns)
- **Grafting** (joining a piece of shoot and dormant buds from one plant to a different rootstock)
- **Budding** (joining a bud from one plant to a different rootstock)

### Cuttings

Many types of plants, both woody and herbaceous, are propagated by cuttings. A cutting is a vegetative plant part severed from the parent plant that ultimately will form a whole new plant. Plant species differ when it comes to the optimum time to take cuttings (hardwood, semihardwood, and softwood) as well as the plant material (leaf, leaf-bud, stem and root). Some plant cuttings root anytime during the growing season while other plants only root from cuttings taken during a particular point in the growing season.

To hasten rooting, to increase the number of roots or to obtain uniform rooting (except on soft, fleshy stems), dip the cut tip in rooting hormone. Prevent possible contamination of the entire supply of rooting hormone by putting some in a separate container for dipping cuttings.

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, well drained and able to retain enough moisture to prevent water stress. Use coarse sand, vermiculite, soil or a mixture of peat and perlite. 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 bright, but indirect, light. Root cuttings can be kept in the dark until new shoots appear.

### Stem cuttings

Many plant species are propagated by stem cuttings. For some plants, you can take cuttings at any time of the year. Stem cuttings of many woody plants must be taken in the fall or in the dormant season.

There are three types of stem cuttings, depending on the location of the cut. They are discussed below.

**Tip**—Detach a 2- to 6-inch piece of stem that includes the terminal bud (Figure 3a). Make the cut just below a node. Remove lower leaves that would touch or be below the growing medium. Dip the cut end of the stem in rooting hormone if desired, and gently tap the end of the cutting to remove any excess hormone. Insert the cutting deeply enough into the medium to support itself. At least one node must be below the surface.
Medial—Make two cuts on the stem (Figure 3b). The first cut should be just above a node, and the second cut just above another node 2 to 6 inches down the stem. Prepare and insert the cutting as for a tip cutting. Be sure to position it right-side up. (Look for axial buds; they always are above the leaves.)

Cane—Cut cane-like stems into sections containing one or two “eyes” (nodes) (Figure 4). Dust ends with fungicide or activated charcoal. Allow to dry for several hours. Lay the cutting horizontally with about half of the cutting below the medium surface, eye facing upward (Figure 4a). Cane cuttings usually are potted when roots and new shoots appear, but new shoots from dracaena and croton often are cut off and rerooted in sand.

Use single-eye cane cuttings for plants with alternate leaves when space or stock material is limited (Figure 4b). Cut a stem about ½ inch above and ½ inch below a node. Place the cutting horizontally or vertically in the medium.

Use double-eye cuttings for plants with opposite leaves when space or stock material is limited (Figure 4c). Cut a stem about ½ inch above and ½ inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

A heel cutting efficiently uses stock material from woody stems (Figure 4d). Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Remove the shield containing the leaf and bud and insert it horizontally into the medium.

Leaf cuttings

Leaf cuttings are used almost exclusively for a few indoor plants. Leaves of most plants either produce a few roots but no plant, or just decay. The four types of leaf cuttings are described below (Figure 5).

Whole leaf with petiole (Figure 5a)—Detach a leaf and ½ to 1½ inches of petiole. (The petiole is the part that attaches a leaf to a stem.) Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. Once the new plants have their own roots, you can sever the leaf and reuse the petiole for additional cuttings.
Whole leaf without petiole (Figure 5b)—This method is used for plants with petioleless leaves. Insert a leaf vertically into the medium. A new plant will form from the axillary bud. You can remove the leaf when the new plant has its own roots.

Split vein (Figure 5c)—Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay 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 rooting medium.

Leaf section (Figure 5d)—This method frequently is used with snake plants and fibrous-rooted begonias. Cut begonia leaves into wedges, each with at least one vein. Lay wedges 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. Roots will form fairly quickly, and eventually a new plant will appear at the base of the cutting.

These and other succulent cuttings rot if kept too moist.

Root cuttings
Root cuttings usually are 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. Other plants develop root systems from the cuttings before producing new shoots.

Plants with large roots—This method often is used outdoors on woody and perennial species. Make a straight top cut first. Then make a slanted cut 2 to 6 inches below the first cut. Store about 3 weeks in moist sawdust, sphagnum 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 (Figure 6a).

Plants with small roots—This method usually is done indoors or in a hotbed. Take 1- to 2-inch sections of roots. Insert cuttings horizontally about ½ inch below the medium surface (Figure 6b).
Layering

Stems still attached to their parent plant may form roots where they touch a rooting medium (Figure 7). When severed from the parent plant, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, is highly successful because it helps the cutting avoid shortages of water and carbon dioxide that often affect cuttings from other methods of propagation. The rooting medium should provide aeration and a constant supply of moisture.

Some plants layer themselves naturally, but you can assist the process. Some ways to encourage layering include:

- Girdling the stem where it is bent
- Wounding one side of the stem
- Bending the stem very sharply

**Simple layering**

Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed (Figure 7b). Bend the tip into a vertical position and stake in place. The sharp bend often induces rooting, but wounding the lower side of the branch or twisting the stem to loosen the bark may help. Examples of plants suitable for simple layering are rhododendrons, honeysuckle and forsythia.

**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 (Figure 7c). Wound the lower side of the stem sections to be covered. Heart-leaf philodendrons and pothos respond well to this method of layering.

**Mound (stool) layering**

Cut the plant back to 1 inch above the ground in the dormant season. Mound soil over emerging shoots in spring to enhance their rooting (Figure 7d). Gooseberries and apple rootstocks are propagated this way.

**Tip layering**

Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil (Figure 7a). The tip will grow downward first, then bend sharply and grow upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the new plant and plant it in early spring or late fall.

*Figure 7.—Types of layering.*
Air layering

Air layering is used to propagate some indoor plants with thick stems, or to rejuvenate them when they become leggy. Slit the stem just below a node. Pry open the slit with a toothpick. Surround the wound with wet, unmilled sphagnum peat moss. Wrap plastic or foil around the moss and tie it in place (Figure 7e). When roots pervade the moss, cut the plant off below the newly formed root ball. Air layering commonly is used with dumb-cane and rubber trees.

Plants with stolons or runners

Plants that produce stolons or runners also reproduce by layering because new plants grow along stems of the original one (Figure 8). A stolon roots wherever it touches the growing medium and then produces new shoots. A runner 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 propagated by severing the new plants from their parent stems. You can root plantlets at the tips of runners while they still are attached to the parent, or detach them and place them in a rooting medium. Strawberries and spider plants often are propagated this way.

Offsets

Plants with a rosette stem often reproduce by forming new shoots, or offsets, at their base or in leaf axils (Figure 9). To propagate them, sever the new shoots from the parent plant after they develop their own root system. For some species, you can remove unrooted offsets and place them in a rooting medium. In some cases, you must cut the offsets from the parent, while others may simply be lifted off. Examples of plants with offsets are date palms, haworthia, bromeliads and many cacti.

Separation

Separation is a form of propagation used with plants that produce bulbs or corms.

Bulbs

New bulbs form beside the originally planted bulb. Separate bulb clumps every 3 to 5 years to obtain the largest blooms and to increase the bulb population. Dig up the clump after the leaves have withered. Gently pull apart the bulbs, and replant them immediately so their roots can begin to develop. Small bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Tulips and narcissus produce bulbs.

Corms

A large, new corm forms on top of an old corm, and tiny cormels form around the large corm (Figure 10). After the leaves wither, dig up the corms and al-

Figure 8.—Propagation using stolons.

Figure 9.—A plant with offsets.

Figure 10.—Separating corms.
low them to dry in indirect light for 2 to 3 weeks. Remove the cormels, and then gently separate the new corm from the old corm. Discard the old corm. Dust new corms with fungicide and store in a cool place until planting time. Crocus reproduces via corms.

**Division**

You can divide plants with more than one rooted crown and plant the crowns separately (Figure 11). If the stems are not joined, gently pull apart the plants. If crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some plants should be dusted with a fungicide before they are replanted. Division commonly is used on snake plants, iris, prayer plants and daylilies.

**Grafting**

Grafting and budding are methods of asexual plant propagation that join parts from two different plants so they will grow as one. These techniques are used to propagate cultivars that do 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.

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 a stem and branches. The **rootstock**, or stock, provides the new plant’s root system and sometimes the lower part of the stem.

When the scion is grafted onto the rootstock, the cambium of the two must touch. The cambium is a layer of cells located between a stem’s xylem and phloem. New xylem and phloem cells originate from cambial tissue.

Four conditions must be met for grafting to be successful:
- The scion and rootstock must be compatible.
- Each must be at the proper stage of development.
- The cambial layers of the scion and stock must meet.

The graft union must be kept moist until the wound heals.

**Cleft grafting**

Cleft grafting often is used to change the cultivar or top growth of a shoot or young tree, usually a seedling (Figure 12). It is especially successful if done in early spring.

Collect scion wood \( \frac{3}{8} \) to \( \frac{5}{8} \) inch in diameter. Cut a limb or small trunk of the stock perpendicular to its length. Make a 2-inch vertical cut through the center of the first cut. Be careful not to tear the bark. Use a wedge to keep this cut open.

![Figure 11.—Dividing daylilies (a), irises (b) and dahlias (c).](image-url)
Prepare two scion pieces 3 to 4 inches long. Cut the lower end of each scion piece into a wedge. Insert the scions at the outer edges of the cut in the stock. Tilt the tops of the scions slightly outward and the bottoms slightly inward to be sure the cambial layers of the scions and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.

At the time of grafting, cut back limbs of the old variety (the rootstock). Gradually reduce the total leaf surface of the old variety as the new ones increase, until at the end of 1 or 2 years the new variety completely takes over. Completely removing all of the limbs of the old variety at the time of grafting increases the shock to the tree and causes excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

**Bark grafting**

Unlike most grafting methods, bark grafting can be used on large limbs (Figure 13). Collect scion wood ⅜ to ½ inch in diameter when the plant is dormant. Wrap the wood in moist paper, place it in a plastic bag and store it in a refrigerator. Saw off a limb or the trunk of the rootstock at a right angle to itself.

In spring, when bark is easy to separate from wood, make a ¼-inch diagonal cut on one side of the scion and a 1- to 1½-inch diagonal cut on the other side. Leave two buds above the longer cut. Cut through the bark of the stock a little wider than the scion. Remove the top third of the bark from this cut. Insert the scion with the longer cut against the wood. Nail the graft in place with flat-headed wire nails. Cover all wounds with grafting wax.

Cut back selected limbs of the old variety as described earlier for cleft grafting.

**Whip or tongue grafting**

This method often is used for material ⅛ to ⅜ inch in diameter (Figure 14). The scion and rootstock usually are the same diameter, but the scion may be narrower. This type of graft is strong, heals quickly, and provides excellent cambial contact. Make one sloping cut, 2½ inches long, 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.
Care of grafts
It is an excellent idea to inspect grafts after 2 to 3 weeks to see whether the wax has cracked. If necessary, rewax the exposed areas. After this time, the union probably will be strong enough that no more waxing is necessary.

For successful grafting, be sure to maintain proper care for the following year or two. If using a binding material such as strong cord or nursery tape on the graft, cut it shortly after growth starts to prevent girdling and later death of the graft. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut because they deteriorate and break after a short time.

Budding
Budding, or bud grafting, is the union of a rootstock with a scion containing one bud and a small piece of bark. It is especially useful when scion material is limited. It also is faster and forms a stronger union than grafting. Budding is a common method of propagating roses.

Patch budding
Plants with thick bark should be patch budded while the plants are actively growing so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cover this wound with a bud and matching piece of bark from the scion (Figure 15). If the rootstock bark is thicker than that of the scion, pare it down to meet the thinner bark so the patch is held firmly in place when you wrap the union.

Chip budding
This budding method can be used when bark is not slipping. Slice downward into the rootstock at a 45° angle through one-fourth of the wood. Make a second cut about 1 inch above the first cut. From the scion, remove a bud with a chip of bark and wood that will fit the rootstock wound. Fit this chip to the stock and wrap the union (Figure 16).

T-budding
This is the most commonly used budding technique. When bark is slipping, make a vertical cut (same axis as the rootstock) through the rootstock’s bark, avoiding any buds. 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 one bud, bark and a thin section of wood. Push the shield under the loosened stock bark. Wrap the union, leaving the bud exposed (Figure 17).
Care of buds

Place the bud into the rootstock in August. Force the bud to develop the following spring by cutting the stock off 3 to 4 inches above it. You can tie the new shoot to the resulting stub to prevent wind damage. After the shoot makes a strong union with the stock, cut off the stub close to the budded area.

Plant tissue culture

Although technical procedures for aseptic culture of plant cells, tissues and organs vary widely, you can use a simplified procedure at home. You need only a few supplies, which you can easily obtain at a grocery store. Follow the procedures below to propagate various species of plants. Some are easy (e.g., African violets, coleus and chrysanthemums), while others are difficult (e.g., orchids, ferns and weeping figs).

Medium preparation

For 1 quart of medium, use the following ingredients:
- ⅛ cup sugar
- 1 teaspoon all-purpose, soluble fertilizer. Check the label to make sure it has all of the major and minor elements, especially ammonium nitrate. If the latter is lacking, add ½ teaspoon of a 35-0-0 soluble fertilizer.
- 1 tablet (100 mg) of inositol (myo-inositol), available at most health food stores
- ¼ of a pulverized vitamin tablet containing 1 to 2 mg thiamine
- 4 tablespoons coconut milk (a cytokinin source) drained from a fresh coconut. Freeze the remainder for later use.
- 3 to 4 grains of a commercial rooting compound with 0.1 percent active ingredient IBA.

Mix all of the ingredients in a 1-quart home-canning jar. Fill the jar with distilled or deionized water. If purified water is not available, boil water for several minutes before adding. Shake the mixture and make sure all materials have dissolved.

Any heat-resistant glass receptacle with a lid can be used as a culture jar. Baby food jars work well.

Half fill each culture bottle with cotton or paper to support the plant material. Pour the medium into each culture bottle so that the support material is just above the solution. Loosely screw on the lids.

Now sterilize the bottles in a pressure cooker under 10 pounds of pressure for 30 minutes or in an oven at 320°F for 4 hours. Remove them from the sterilizer, place them in a clean area and allow the medium to cool.

If you won’t be using the bottles for several days, wrap groups of bottles in foil before sterilizing and then sterilize the whole package. Then remove the bottles and cool them without removing the foil cover. Tweezers and razor blades can be sterilized in the same manner. You’ll also need additional sterilized water.
Plant disinfestation and culture

Once the growing medium is sterilized and cooled, prepare plant material for culture. Because plants usually harbor bacterial and fungal spores, they must be cleaned (disinfested) before placement on the sterile medium. Otherwise, bacteria and fungi may grow faster than the plants and dominate the culture.

Scrub your hands and countertops with soap and water just before disinfesting plant material. Use rubbing alcohol or a dilute bleach solution to wipe down the working surface.

Various plant parts can be cultured, but small, actively growing portions usually result in the most vigorous plantlets. For example, ferns are most readily propagated by using only $\frac{1}{2}$ inch of the tip of a rhizome. For other species, $\frac{1}{2}$ to 1 inch of the shoot tip is sufficient.

Remove leaves attached to the tip and discard. Completely submerge the plant part in a solution of 1 part commercial bleach to 9 parts water for 8 to 10 minutes. Then rinse off excess bleach by dropping the plant part into sterile water. Remember, once the plant material has been in the bleach, it has been disinfested and should be touched only with sterile tweezers.

After rinsing the plant material, remove any bleach-damaged tissue with a sterile razor blade. Then remove the cap of a culture bottle containing sterile medium and place the plant part onto the support material in the bottle. Make sure the plant part is not completely submerged in the medium, and recap the bottle quickly.

After culturing all of the plants, place them in a warm, well-lighted (no direct sunlight) environment to encourage growth. If the medium is contaminated, it will be obvious within 3 to 4 days. Remove and wash contaminated culture bottles as quickly as possible to prevent spread of bacteria or fungi to uncontaminated cultures.

When plantlets have grown to sufficient size, transplant them into soil. Handle as gently as possible because they are leaving a warm, humid environment for a cool, dry one. After transplanting, water the plants thoroughly and place them in a clear plastic bag for several days. Gradually remove the bag to acclimate the plants to their new environment; start with 1 hour per day and gradually increase time out of the bag over a 2-week period until the plants are strong enough to no longer need the bag.

For more information

UAF Cooperative Extension publications

*Airlayer to Renew Indoor Plants*, HGA-00135.
*Native Plants of Alaska: Twinflower*, HGA-00232A.
*Native Plants of Alaska: Chocolate Lily*, HGA-00232B.
*Native Plants of Alaska: Red Huckleberry*, HGA-00232C.
*Native Plants of Alaska: Oval-leafed Blueberry*, HGA-00232D.
*Native Plants of Alaska: Bunchberry*, HGA-00232F.
*Native Plants of Alaska: Devil’s Club*, HGA-00232G.
*Native Plants of Alaska: Highbush cranberry*, HGA-00232H.
*Native Plants of Alaska: Crowberry*, HGA-00232I.
Native Plants of Alaska: Red-Osier Dogwood, HGA-00232J.
Seed Starting and Transplanting, HGA-00032.

UAF School of Natural Resources and Agricultural Sciences

Holloway, Patricia. Propagating Asiatic Hybrid Lilies. Georgeson Botanical Note No. 22.

WSU Cooperative Extension publications

Grafting and Budding Plants to Propagate, Topwork, Repair, PNW0496.
Layering to Renew or Multiply Plants, PNW0165.
Propagating Deciduous and Evergreen Shrubs, Trees, and Vines with Stem Cuttings, PNW0152.
Propagating from Bulbs, Corms, Rhizomes, and Tuberous Roots and Stems, PNW0164.
Propagating Herbaceous Plants from Cuttings, PNW0151.
Propagating Plants from Seed, PNW0170.