

# \* 20

## Propagation of Ornamental Trees, Shrubs, and Woody Vines

### INTRODUCTION

Ornamental trees, shrubs, and woody vines are perennial plants. A few ornamental shrubs and vines are used as annuals and planted in landscapes for one season in hardiness zones where they will not survive winter temperatures. This chapter describes propagation systems that include seed, cuttings, grafting, and micropropagation where appropriate for the listed species. Extensive references are included for more in-depth details of propagation.

As a general rule, shrubs and vines are propagated by cuttings, whereas trees are produced by seed or selected cultivars grafted onto seedling rootstocks. There are exceptions, such as tree species that can be propagated by cuttings or micropropagated.

In any commercial propagation system it is **important to conduct small trials** before propagating on a large scale. The propagation techniques and references listed are to serve as a guide. Propagators must develop their own procedures and chemical treatments that work best for their particular propagation systems.

***Abelia xgrandiflora*.** Abelia, Glossy Abelia. Commercially propagated with semi-hardwood cuttings. Can be rooted easily under mist in spring, summer, or fall. Rooting is enhanced by applying talc or quick-dips of 1,000 to 2,000 ppm IBA, or IBA-NAA combinations totaling 1,000 to 2,000 ppm have produced superior results (131). Hardwood cuttings also may be rooted in fall or late winter but less successfully than with semi-hardwood cuttings. Abelia is commercially micropropagated.

***Abies* spp.** Fir.

**Seed.** Seed propagation is not difficult, but fresh seed should be used, since most species lose their viability after 1 year in ordinary storage. Embryo dormancy is generally present; fall planting or stratification at about 4°C (40°F) for 1 to 3 months is required for good germination. Bulk presoaking *A. procera* (noble fir) seed in water should be avoided because of imbibition damage. It is best to allow seeds to slowly uptake water on moist filter paper and then stratify at 4°C (40°F) for a minimum of 3 weeks (237). Alternatively, seeds can be placed for 5 to 10 days in moist perlite for imbibition, and then cold stratified. *Abies* seedlings are very susceptible to damping-off. They should be given partial shade during the first season, since they are injured by excessive heat and sunlight.





**Cuttings.** Fir cuttings are considered difficult-to-root, but *A. fraseri* hardwood cuttings—selected from young trees, and basally wounded and treated with IBA—can be rooted in high percentages (210). First order laterals root in higher percentages than primary axes (49). Cuttings taken from lateral branches root readily, but tend to become plagiotropic. A quick-dip of 5,000 ppm IBA and maintaining a bottom heat of 18 to 24°C (65 to 75°F) is best for rooting hardwood cuttings (49). This species, along with white fir (*A. concolor*), red fir (*A. magnifica*), and the California ‘Silver Tip,’ are important Christmas tree species.

**Grafting.** The side-veneer graft is commonly used. Japanese Momi fir (*A. firma*) is one of the few firs that will tolerate the heavy clay, wet soil conditions (low soil oxygen), and heat of the southeastern United States. Consequently, researchers at North Carolina State University recommend grafting desirable fir cultivars on *A. firma* rootstock, rather than the less tolerant *A. fraseri* or *A. balsamea* (114). Fraser fir (*A. fraseri*) is cleft grafted onto rootstocks of Turkish fir (*A. bornmuelleriana*) to reduce losses by phytophthora root rot. Cleft grafting is successful in North Carolina during early spring (April) when scions are dormant and rootstocks are becoming active (206).

**Micropropagation.** *Abies* spp. have been regenerated via somatic embryogenesis (228).

**Abutilon spp.** Abutilon, Flowering Maple, Chinese Bell Flower. Seeds germinate without difficulty. Can also be rooted by leafy cuttings under mist from summer through fall.

**Acacia spp.** Acacia.

**Seed.** Generally propagated by seed. The imperious seed coats must be softened before planting by soaking in concentrated sulfuric acid for 20 minutes to 2 hours or by pouring boiling water over the seeds and allowing them to soak for 12 hours in the gradually cooling water. *A. cyanophylla* (beach acacia, golden willow), *A. farnesiana* (sweet acacia, West Indian blackthorn), and *A. koa* (koa acacia) seeds are scarified by soaking in warm water overnight. All but the youngest plants are difficult to transplant because of a pronounced taproot.

**Cuttings.** Generally considered difficult to root. Leafy cuttings of partially matured wood can be rooted under mist if treated with 8,000 ppm IBA talc. *A. redolens* and *A. subprosa* root during the fall with a 3,000 ppm IBA quick-dip. Cuttings with heels form

vigorous new wood (99). *A. baileyana* can be rooted from semi-hardwood cuttings 10 to 13 cm (4 to 5 in) in length, quick-dipped in 5,000 ppm IBA (372). *A. koa* is difficult to root from stem cuttings, and better results have occurred with micropropagation.

**Micropropagation.** Many acacia species have been micropropagated, including *A. melanoxylon* has been reported (235, 295).

**Acer spp.** Maple. Various methods of propagation are used—seeds, grafting, budding, cutting, layering, and micropropagation (62, 245). More propagation is being done via own-rooted cuttings and micropropagation.

**Seeds.** Most maples produce ripen seeds in the fall, while a few ripen seeds in the spring. Red maple (*A. rubrum*) and silver maple (*A. saccharinum*) produce mature seeds in the spring. Such spring-ripening seeds should be gathered promptly when mature and sown immediately without drying, since the seed does not store well. Typically, seed will germinate within a 7- to 10-day period. For selected species, excising embryos from fresh seed and incubating in cytokinin helps circumvent testa-imposed dormancy and the need to stratify—and results in germination within 1 week (443).

For species that produce mature seeds in the fall, stratification at 4°C (40°F) for 60 to 120 days, followed by spring planting, gives good germination. Fall planting out-of-doors may be done if the seeds are first soaked for a week, changing the water daily; seeds can also be soaked under running water. Dried seeds of the Japanese maple, *A. palmatum*, germinate satisfactorily if they are placed in warm water (about 43°C, 110°F) and allowed to soak for two days, followed by stratification for 60 to 120 days. Soaking dry seeds of *A. rubrum* (leach inhibitors) and *A. negundo* in cold running water for several days before planting may increase germination. Seeds of *Acer saccharum* var. *floridum* (formerly *A. barbatum*) and *A. negundo* are stratified. To avoid a hard seed coat, *Acer* seeds should not be allowed to dry out. Poor germination in trifoliolate maples such as paperbark maple (*A. griseum*) is due to poor seed fill.

**Cuttings (131, 436).** Leafy Japanese maple (*A. palmatum*) cuttings, as well as those of other Asiatic maples, will root if they are made from tips of vigorous pencil-sized shoots in late spring and placed under mist. IBA at 8,000 to 20,000 ppm in talc or quick-dips has given good results in rooting leafy cuttings of various *Acer* species under mist and over bottom heat in the greenhouse. In general, it is best to wait until the



terminal bud has formed, but before the last set of leaves has fully expanded. Semi-hardwood cuttings of *A. saccharum* var. *floridum* are propagated successfully with 8,000 ppm IBA talc. Softwood cuttings of *A. griseum* from stock blocks are rooted successfully with 8,000 ppm IBA talc or 5,000 ppm IBA quick-dip (212). Rooting is greatly enhanced by heavy pruning and later shading stock plants with 60 to 80 percent light-excluding saran (280). Etiolation of stock plants can improve rooting of softwood basal stem cuttings from 5-year-old plants of paper bark maple (*A. griseum*) (282). *A. macrophyllum* roots well from softwood cuttings (June and July in Washington) treated with 8,000 ppm IBA talc (206).

*A. negundo* semi-hardwood cuttings are rooted with 8,000 ppm IBA talc. Cuttings of selected *A. rubrum* and *A. xfreemanii* cultivars can be rooted from single-node cuttings treated with 3,000 to 8,000 ppm IBA talc (445). Single-node cuttings of *A. glabrum* subspecies *Douglasii* (Douglas maple) root with 8,000 ppm IBA talc; rooted cuttings should be overwintered before transplanting (410), but it is often difficult to overwinter rooted maple cuttings. To overcome this problem, new growth should be induced on the cuttings, shortly after rooting, by using supplementary lighting and supplying fertilizers. Rooting earlier in the season also allows more time to encourage new growth.

*A. rubrum* are primarily rooted by cuttings to avoid problems of graft incompatibility. Semi-hardwood cuttings are treated with 1,000 ppm IBA + 500 ppm NAA and rooted in small liner posts in 3 weeks (131); rooted liners need to be hardened-off out of doors, stored in a cooler during winter and spring planted. In Oregon, *A. rubrum* are rooted from cuttings taken from first generation tissue culture-produced plants.

In Alabama, cuttings of dwarf Japanese maple (*A. palmatum*) are taken in early spring, as soon as the new growth has hardened, and quick-dipped in 6,250 ppm IBA/2,500 ppm NAA. Liners are overwintered in a cool house, where temperatures do not drop

below  $-3^{\circ}\text{C}$  ( $25^{\circ}\text{F}$ ), and planted in the following spring. Hardwood cuttings of *A. palmatum* taken in midwinter have been rooted successfully in the greenhouse after wounding and treating with IBA (83). *A. truncatum* softwood cuttings taken from trunk sprouts of a 10-year-old tree had 79 percent rooting with a 5,000-ppm IBA ten-second quick-dip (312). Softwood cuttings taken in August (Kansas) from 3-year-old seedling stock root well with a 5,000 ppm IBA quick-dip. Growth after rooting via long-day manipulation is important for winter survival of transplanted rooted cuttings and cuttings left in the propagation bed before lifting in spring.

Sugar maple (*A. saccharum*) cuttings are best taken in late spring after cessation of shoot elongation, then rooted under mist. They are more difficult to root—IBA treatments give variable results (133).

Long, semi-hardwood cuttings of *Acer platanoides*, *A. pseudoplatanus*, and *A. campestre* ranging from 70 to 90 cm (28 to 35 in), rooted well when treated with 5,000 ppm IBA and propagated under high pressure fog systems. Rooting was enhanced and production time reduced with the larger propagules (389).

Softwood cuttings (June to August in Kansas) of *A. truncatum* root best with an IBA quick-dip of 1,000 ppm. Cuttings taken in August root readily, but are difficult to overwinter unless kept under long days to encourage some growth before winter (315).

Forcing epicormic shoots from woody stem segments [0.5 m (1.5 ft) long with a 2.5 to 25 cm (1 to 10 in) caliper] under mist and rooting the softwood cuttings can be used to propagate various *Acer* species: *A. ginnala*, *A. palmatum*, *A. rubrum*, *A. saccharum*, and *A. saccharinum* (332). Softwood cuttings are treated the same as if collected from a field-grown stock plant. Drench weekly with Banrot 40% WP fungicide.

**Grafting.** *A. palmatum* seedlings are used as the rootstock for Japanese maple cultivars. In Oklahoma, seedling rootstock of *A. palmatum* is selected from the more vigorous green-leaved cultivars, rather from

#### BOX 20.1 GETTING MORE IN DEPTH ON THE SUBJECT USING ONLY END-USE AUXIN FORMULATIONS



In the United States, it is not legal for producers/growers to use technical-grade auxins. Only end-use formulations are permitted, such as Dip'N Grow, Woods Rooting Compound, and other commercial liquid and talc auxin formulations. Information is presented in Chapters 19, 20,

and 21 for rooting with technical-grade auxins, since one can legally make recommended auxin concentrations by diluting end-use formulations. See Box 10.10, page 377 for examples of making recommended auxin concentrations with end-use formulation products for quick-dip applications.



red-leaved cultivars (167). Seedling rootstocks of *A. saccharum* are used for sugar maples, *A. rubrum* for red maple cultivars, *A. pseudoplatanus* for striped maple (*A. pennsylvanicum*), and *A. platanoides* for such Norway maple clones as ‘Crimson King,’ ‘Schwedler,’ and the pyramidal forms. There is some evidence of delayed incompatibility in using *A. saccharinum* as a rootstock for red maple cultivars.

In Oregon, Japanese maples are direct seeded in liner pots in February, and by August the seedling rootstock is of graftable size. In other systems, seedling rootstock plants are grown for 1 year in a seed bed. In the fall or early spring they are dug and transplanted into small pots and grown in propagating frames through the second summer. In late winter, the rootstock plants are brought into the greenhouse preparatory to grafting. As soon as roots show signs of growth, the rootstock is ready for grafting. Dormant scions are taken from outdoor plants. The side-veneer graft is ordinarily used with *A. palmatum* ‘Dissectum,’ *A. pennsylvanicum*, *A. pseudoplatanus*, and *A. saccharinum* (181).

In Southern California, summer-grafted *A. palmatum* cultivars are side-grafted and wrapped with budding rubbers or poly tape for 3 weeks with 90 percent grafting success. It is important to completely remove the leaves of the scion, prior to grafting in the summer. In Canada, an apical splice graft is preferred to the traditional side-veneer graft for bench grafting cultivars of *A. palmatum* with containerized seedling rootstock (225).

See the published list of *Acer* rootstocks that can be used for interspecific grafting of rare and common *Acer* species (417). In general, scions of “milky” sap groups will not graft on “non-milky” rootstock, and conversely, “non-milky” scions will not take on “milky” rootstock (i.e., use *A. platanoides* rootstock for scions of *A. cappadocicum*, *A. catalpifolium*, *A. lobelii*, and other cultivars). These scions will not take on *A. pseudoplatanus* rootstock, which is “non-milky.”

Maples are also T-budded and chip budded on one-year seedlings in the nursery row from mid- to late summer. In T-budding on active rootstock, the wood (xylem) is removed from the bud shield, which then

consists only of the actual bud and attached bark. The seedling is cut back to the bud the following spring just as growth is starting. *A. platanoides* ‘Crimson King’ is more successfully chip budded than T-budded.

**Micropropagation.** Maple species are commercially micropropagated. The combination of cytokinins TDZ and BA enhanced micropropagation of sycamore maple (*A. pseudoplatanus*) (424).

**Actinidia spp.** Gooseberry. See *Actinidia deliciosa* (kiwifruit). Fast-growing vigorous vines with fragrant flower and edible fruit. *A. hemslayana* is a vigorous, narrow-leaved climbing vine that grows to 10 m (35 ft) and has attractive red soft bristles on the new growth. Gooseberry (*A. arguta*) can be propagated by seed, which is cold stratified for 3 months. It is best to use cuttings selected from female plants for flower and fruit characteristics. Can be propagated from single-node cuttings with talc applications of 8,000 ppm IBA (275). *Actinidia* is commercially micropropagated (448).

**Aesculus spp.** Buckeye, Horse chestnut (131).

**Seed.** This tree may be propagated by seeds, but prompt sowing or stratification after gathering in the fall is necessary. If the seeds lose their waxy appearance and become wrinkled, their viability will be reduced. For best germination, seeds of *A. arguta* (Texas buckeye), *A. xcarnea* (red horse chestnut), *A. hippocastanum* (common horse chestnut), *A. indica*, *A. flava*, *A. sylvatica*, and *A. turbinata* should be stratified for 4 months at about 4°C (40°F) immediately after collecting. *A. californica* and *A. parvifolia* seed need no pretreatment. Though no dormancy has been reported for *A. pavia*, a one-month cold stratification is recommended (131). In southern California, seeds of *A. carnea* and *A. hippocastanum* are leached in a bag with running water for 10 days; seeds germinate within this leaching period. Seeds of buckeye are poisonous if eaten.

**Cuttings.** Cuttings of *A. parviflora* are taken from new growth on stock plants from June to July (Chicago). Leafy single node cuttings with two leaves and 2.5+ cm (1+ in) of stem tissue are treated with 1,250

#### BOX 20.2 GETTING MORE IN DEPTH ON THE SUBJECT

##### CAUTION IN HANDLING CONCENTRATED ACIDS FOR SCARIFICATION



Extreme care should be used when handling concentrated acids for scarification. Protective clothing, including safety glasses or face shields, should be worn. Use of the acid ideally should be under a laboratory hood, or at least in a

well-ventilated area. The acid should be properly disposed of after use. It is important that seeds be thoroughly washed after acid treatment before storage or handling.





to 2,000 ppm IBA + 625 to 1,000 ppm NAA—the higher IBA/NAA level is used if the cutting wood is more lignified. The cuttings are inserted with buds set below the top surface of the propagation medium. Cuttings will not root under very moist medium conditions (247). Terminal stem cuttings of 15 cm (6 in) taken in May rooted better than those taken in July (North Carolina); a 2,500 ppm IBA quick-dip in ethanol gave the best results (45). *A. parviflora* can also be propagated by root cuttings.

**Grafting.** T-budding, cleft grafting, or bench grafting, using the whip graft, can be used for selected cultivars grafted on *A. hippocastanum* as the rootstock. Although normally propagated by seed, grafting is done to: (a) perpetuate superior sterile forms (*A. hippocastanum* ‘Baumannii’), (b) more quickly produce a large-caliper tree, (c) avoid suckering problems, and (d) produce a plant with better flowers and foliage.

**Agarita.** See *Berberis trifoliata* (*Mahonia trifoliata*).

***Ailanthus altissima*.** Ailanthus, Tree of Heaven. Easily propagated by seed. Embryo dormancy is present in freshly harvested seed. Stratification at about 4°C (40°F) for 2 months aids germination. Seed propagation produces both male and female trees, but planting male trees should be avoided, since the staminate flowers produce an obnoxious odor. The more desirable female trees can be propagated by root cuttings planted in the spring. *A. malabarica* (110) and *A. altissima* (452) have been micropropagated.

***Alberta magna*.** An attractive, flowering evergreen species, native to South Africa. It is used as a small landscape tree and has potential as a flowering pot plant. Seed propagation is poor and the seedlings have a long juvenile period. Cuttings taken from mature trees root poorly. Mature-phase scionwood has been successfully wedge-grafted onto micropropagated juvenile plants, which also speeds up flowering (34).

***Albizia julibrissin*.** Albizzia, Silk tree, Mimosa. This species is propagated by seed. The impermeable seed coat is scarified by a 30-minute soak in sulfuric acid. Seed selection is important for obtaining plants with good flower color. Stem cuttings do not root, but root cuttings about 7.5 cm (3 in) long and 12 mm (0.5 in) or more in diameter taken and planted in early spring are successful (163). Juvenile shoots arising from root pieces can be removed and rooted with 1,000 to 3,000 IBA quick-dip or talc (123). Seedling material has been successfully micropropagated (361).

**Alder.** See *Alnus*.

***Allamanda cathartica*.** Yellow Allamanda, Golden Trumpet. Easily propagated using semi-hardwood cuttings in summer and fall (Texas) with 1,000 to 2,000 ppm IBA quick-dip.

**Almond (Dwarf, Flowering).** See *Prunus*.

***Alnus* spp.** Alder.

**Seed.** *A. incana* (gray alder), *A. serrulata* (tag alder), *A. rhombifolia* (sierra alder), *A. rugosa* (speckled alder), *A. cordata* (Italian alder), and *A. glutinosa* (European alder). Seeds of this small deciduous tree should be thoroughly cleaned and can be planted immediately after fall harvest, but 3 to 5 months of stratification improves germination. Seed will also germinate if given a 24-hour soak in 0.2 percent potassium nitrate. Six weeks of cold stratification are optimal for seaside alder (*A. maritima*) (371). Light appears to be beneficial in germinating *Alnus* seed.

**Cuttings.** Softwood cuttings of *A. glutinosa* root with 3,000 ppm IBA talc. *A. incana* stem cuttings are rooted with 8,000 ppm IBA talc, and can also be grafted on potted seedling understock. Cultivars of *A. glutinosa* can also be side-veneer grafted (222). *A. maritima* can be rooted from softwood cuttings treated with 8,000 ppm IBA (370).

**Micropropagation.** Alder can be micropropagated.

***Amelanchier* spp.** Serviceberry (124, 131). These trees and shrubs are generally seed-propagated, however cutting propagation and micropropagation are also used.

**Seed.** Seeds show embryo dormancy, which can be overcome by stratification at 2°C (36°F) for 3 to 6 months. Seeds should not be allowed to dry out. Seeds of *A. alnifolia* (Saskatoon) and *A. laevis* (Allegheny serviceberry) require 15 to 30 minutes of sulfuric acid scarification prior to 3 months of cold stratification.

**Cuttings.** Many species are readily propagated by leafy softwood cuttings taken before the terminal bud has formed and when the new growth is several inches long, then rooted under mist. Talc and quick-dips of IBA from 1,000 to 10,000 ppm enhance rooting. At 40°N latitude, softwood to semi-hardwood cuttings of *A. laevis* taken in mid-May to mid-June root best with a K-IBA of 2,500 ppm or greater.

**Micropropagation.** The cultivars ‘Prince Charles’ and ‘Princess Diana,’ which are selections of *A. laevis* and *A. xgrandiflora*, respectively, are commercially micropropagated.



***Amorpha* spp.** Indigo bush (123). A large deciduous shrub in the legume family. They have an impermeable seed coat which requires acid scarification. *A. canescens* (leadplant amphora) seed is acid-scarified for 15 minutes followed by 2 to 8 weeks of stratification. Seed of *A. fruticosa* (indigo bush amorpha) can be fall planted or given 10 minutes of acid scarification; easily roots from untreated softwood cuttings. *A. canescens* is rooted with cuttings treated with 8,000 ppm IBA talc.

**Anacho Orchid Tree.** See *Bauhinia*.

**Angelica Tree.** See *Aralia*.

**Anise.** See *Illicium*.

**Apricot (Japanese flowering).** See *Prunus*.

***Aralia* spp.** Walking stick, Angelica tree. Suckering shrubs and trees. Seeds should be sown in early fall. Scarify with sulfuric acid for 30 to 40 minutes, and cold stratify for 3 months to overcome the double dormancy requirement. *A. spinosa* has a 3-month cold stratification requirement. Asexual propagation is with 10 to 13 cm (4 to 5 in) root cuttings, which are taken in fall and stored in cool storage until spring planting (123).

***Araucaria* spp.** These large evergreen trees are seed propagated.

**Seed.** Seeds of *A. bidwillii* (bunya-bunya), *A. columnaris* (Cook or New Caledonia pine), *A. araucana* (monkey puzzle tree), and *A. cunninghamii* (colonial pine) must be cleaned and then sown within a month after collection. There are no dormancy problems and germination time is 2 to 4 weeks. Plant seed of *A. heterophylla* (Norfolk Island pine) directly in pots, placing the seed vertical and burying to half the seed height. Keeping seeds moist is critical for the first 10 to 14 days after planting and can be accomplished by misting once each hour (Texas).

**Cuttings.** Can also be propagated by semi-hardwood cuttings. Cuttings of side branches will root but produce horizontally growing plants. Plants produced from terminal cuttings grow upright.

**Micropropagation.** *A. cunninghamii* and other species can be micropropagated (70).

**Arborvitae.** See *Thuja*.

***Arbutus* spp.** Pacific Madrone (*A. menziesii*), Texas madrone (*A. xalapensis*), Eastern strawberry tree (*A. andrachne*). *A. menziesii* is a Pacific coast evergreen tree that is usually propagated by seeds, which are stratified for 2 to 3 months at 2 to 4°C (35 to 40°F) (277).

Seedlings are started in flats and then transferred to pots. They are difficult to transplant and should be set in their permanent location when not over 18 in tall. Propagation can be done by cuttings, layering, and grafting. *A. andrachne*, which is native to the East Mediterranean, can be seed propagated. While there are differences in seed provenance, a cold-moist stratification of 10 weeks or 24-hour soak with gibberellic acid enhances seed germination (404). *Arbutus* 'Marina' is a California hybrid that is more adaptable to varied landscapes than *A. menziesii*. However, it is difficult to produce by seed or cuttings. Air-layering is successful using stem diameters of 7 to 12 mm. A 1 to 2 cm (0.5 to 1 in) complete girdle was made, then painted with DipGel (gel thickener of Dip'N Grow rooting hormone) from 5,000 to 7,500 ppm, covered with moss and wrapped with a poly bag and aluminum foil (441).

*A. xalapensis* is native to Texas and southern New Mexico and propagated from fresh seed collected in the fall. The seed must be harvested at optimum ripeness and sown immediately to ensure high germination percentages. Rooting can be done with nonflowering stock material (405).

*A. menziesii* is commercially micropropagated, and *A. xalapensis* can be micropropagated on WPM (276).

***Arctostaphylos* spp.** Manzanita (*A. spp.*), bearberry (*A. uva-ursi*).

**Seed.** Seeds are water permeable, but benefit from sulfuric acid treatment for 3 to 6 hours (151). Seed of both species can also be scarified by inserting in boiling water, then immediately turning off the heat and soaking the seed in the gradually cooling water for 24 hours. This is followed by chilling stratification between 60 to 90 days for Manzanita or a combination of warm [60 days at 25°C (77°F)] then chilling [60 to 90 days at 5°C (41°F)] stratification for bearberry.

**Cuttings.** Cutting propagation is much more practical. Terminal cuttings are taken from November to February (California), submerged in 5 to 10 percent Clorox, given a 1,000 ppm IBA plus 500 ppm NAA quick-dip or 8,000 ppm IBA talc, and rooted under intermittent mist with bottom heat [21°C (70°F)]. The U.S. eastern form of this species is more difficult to root; cuttings taken from very short side branches from the middle of the plant root better than cuttings from long, end runners. Cuttings root best when taken in early March and treated with 8,000 ppm IBA (107). Colorado Manzanita (*Arctostaphylos xcoloradensis*) is considered difficult to propagate, but can be rooted



with dormant cuttings. Cuttings are taken from previous year's growth from February to early April (Colorado). Cuttings are trimmed to 8 cm (3 in), quick-dipped in 1:10 Woods Rooting Hormone, lightly sprayed with water, paced in a Ziploc bag overnight in refrigeration to allow the cutting end to slightly dry down and not rot. The next morning cuttings are immersed in a 1:50 Zeritol (hydrogen peroxide) for disease control, removed, and excess solution drained off. Cuttings are stuck in small bottomless containers (bands) with a 3 perlite: 1 pear (v/v), bottom heated to 21°C (70°F) and rooted under mist (383). During propagation, a diluted concentrate is watered in containing the beneficial fungus, *Trichoderma harzianum*, for damping-off control, and a cocktail of ectomycorrhiza for enhanced stress resistance of the rooted cutting (383). Cuttings treated with 3,000 ppm Woods Hormone solution (1.03% IBA + 0/66% NAA) plus inoculum of arbuscular and arbutoid mycorrhizal fungi had enhanced rooting.

**Micropropagation.** *Arctostaphylos* is micropropagated.

**Ardisia spp.** Coralberry, spiceberry (*A. crenata*), and Japanese (*A. japonica*). These medium-sized evergreen shrubs and ground covers (*A. japonica*) can be seed-propagated without stratification. *A. crenata* can be propagated by softwood cuttings. *A. japonica* is easily rooted with a 1,000 ppm IBA quick-dip; this stoloniferous plant can also be divided (123).

**Aronia arbutifolia.** Red Chokeberry (*Aronia arbutifolia*) and black (*A. melanocarpa*). Propagated by seed, which should be collected in autumn and then stratified for about 3 months at 5°C (41°F) before planting. Can also be started by leafy cuttings treated with a 4,000 ppm IBA quick-dip under mist or by suckers.

**Ash.** See *Fraxinus*.

**Asimina triloba.** Common pawpaw and dwarf pawpaw (*A. parviflora*) (177, 264). This fruit crop, small tree, and deciduous shrub are propagated primarily by seed. Seeds are recalcitrant and germination is reduced when seed moisture is less than 25 percent (157). Seed must be stored moist at chilling temperatures, but remains viable for only 2 years. Some seed lots require cold stratification (5°C, 41°F) for about 3 months to overcome dormancy. Seedling emergence occurs between 30 and 45 days after sowing (177). A southern ecotype of *A. triloba* easily germinates without stratification (131). Successful cutting propagation has not been reported. Chip budding is the most common

method for propagating pawpaw cultivars with superior fruit characteristics onto seedling rootstock. Other clonal propagation techniques include grafting with the whip-and-tongue, cleft, or inlay bark graft (177, 264). Seedlings of *A. triloba* can be micropropagated (156), but microcuttings from mature sources have not been successfully rooted, nor acclimatized (176, 177).

**Aspen.** See *Populus*.

**Aspen (Quaking).** See *Populus*.

**Australian Pine.** See *Casuarina*.

**Avocado.** See Chapter 19.

**Azalea.** See *Rhododendron*.

**Baccharis spp.** False willow, narrowleaf baccharis (*B. angustifolia*), and eastern baccharis (*B. halimifolia*). These small evergreen shrubs have excellent salt tolerance. Baccharis is seed-propagated with no seed pretreatment required. Germination occurs within 1 to 2 weeks. In Arizona, cuttings of male plants of *B. sarothodes* (Desert broom) are trimmed to 18 cm (7 in), dipped in 8,000 ppm IBA talc, stuck in a peat:perlite medium, and rooted under mist (357). *B. halimifolia* roots easily from softwood cuttings treated with 2,500 ppm K-IBA.

**Bald Cypress.** See *Taxodium*.

**Bamboo.** See *Bambusa*.

**Bambusa spp.** Bamboo (*Arundinaria*, *Dendrocalamus*, *Gigantochloa*, *Phyllostachys*, *Pseudoasa*, *Sasa*, *Schizostachym*, *Sinarundinaria*, *Thamnocalamus*, *Thyrsostachys*, spp.) (344, 380). Bamboo has about 1,000 species in some 50 genera. Two classes of bamboo are commercially propagated in containers (Louisiana) to eliminate much of the hand labor and extensive field stock space needed in the old traditional method of hand digging and separating established clumps.

**Division.** *Clump-forming bamboo* (pachymorphs—with constricted rhizomes) are propagated by dividing the young, peripheral rhizomes in late spring or early summer; the culms (above-ground stem with branches and leaves) are cut back and the rhizome is containerized in a 5 bark to 1 sand medium with slow-release fertilizer and watered as needed. The following spring, rhizomes from the containerized stock plant are further divided and transplanted with attached culms and roots to new containers for further propagation or finishing-off as a marketable plant.

In Oregon, bamboo from 5-gallon containers are sawed vertically into quarters and then replanted into





5-gallon containers with 100 percent survival and faster reestablishment.

The *running-type bamboos* (leptomorphs—with vigorous rhizomes extending beyond parent plants) are more cold-tolerant but less desirable in the garden. They are propagated by the division technique described above for rhizomes less than 1 cm (1/2 in) thick, or by using 30-cm (1-ft) rhizomes 2 cm (3/4 in) thick, which are containerized and grown for 2 years as stock plants. Rhizomes 15 cm (6 in) long are then containerized and grown until they are a finished crop. It is important to prevent drying during transplanting. Best results are obtained from rhizomes taken and planted in late winter or early spring before the buds begin to elongate.

**Micropropagation.** Some 15 genera and 54 species of bamboo have been micropropagated, which offers potential for those bamboo species which are currently difficult to propagate or transplant (15, 334). Somatic embryogenesis and successful transplanting of plantlets has been reported (352).

***Banksia* spp. (35).** *Banksia* are native Australian shrubs and small trees in the Proteaceae family. Two species with promise as a plantation-grown flower crop with export potential are *B. coccinea* (scarlet banksia) and *B. menziesii* (raspberry frost banksia).

**Seed.** These species are propagated by seed, although they are difficult to remove from the seed-containing structures. One method is to soak seed several days in water and then dry quickly. There are no pregermination treatments; however, 15°C is the optimum germination (20 days) temperature for *B. coccinea*.

**Cuttings.** *B. coccinea* can also be propagated from semi-hardwood cuttings using a quick-dip of 8,000 to 12,000 ppm IBA in 50 percent ethanol (35). Cuttings should be wounded and inserted in a porous mix under intermittent mist with 25°C (77°F) bottom heat. It is best to root cuttings directly in liner pots and avoid root disturbance. Graft incompatibility limits successful grafting of *Banksia* spp. to rootstock that are resistant to *phytophthora* and tolerant of high soil phosphorus and poorly drained sites.

**Barberry.** See *Berberis*.

**Basswood.** See *Tilia*.

***Bauhinia* spp.** Orchid Tree. *Bauhinia lunarioides* (formerly *B. congesta*) Anacho Orchid Tree (219). This multi-stemmed deciduous shrub has emerald leaves,

which are cleft to the petiole, and produces abundant white flowers from March through summer (Texas). Seeds of this species germinate without pregermination treatment. However, other *Bauhinia* spp. seeds have physical dormancy and must often need scarification. *Bauhinia variegata* and *B. xblakeana* (evergreen tree with thick leaves and striking purplish red flowers) are also important *Bauhinia* plants. *B. xblakeana* is a sterile hybrid propagated by air layering. *B. purpurea* has been micropropagated (254).

**Bayberry.** See *Myrica*.

**Bay Laurel.** See *Laurus nobilis*.

***Beaucarnea recurvata*.** Ponytail palm. See *palms*.

**Beech.** See *Fagus*.

***Berberis* spp.** Barberry.

**Seed.** Propagated without difficulty by fall-sowing or by spring-sowing seeds that have been stratified for 2 to 6 weeks at 4°C (40°F). Some species require up to 2 to 3 months of stratification, or seed can be sown in fall. It is important to remove all pulp from seeds. Seedlings are susceptible to damping-off and some to black stem rust (Oregon).

**Cuttings.** *Berberis* are generally propagated by cuttings. Semi-hardwood cuttings taken from spring to fall can be rooted under mist (431). Some propagators have success with hardwood cuttings (leaves still attached) taken from October to November. IBA from 2,000 to 8,000 ppm aids rooting in some species. *B. thunbergii* 'Atropurpurea nana' is propagated with 5 to 6 in (14 cm) semi-hardwood cuttings in May and June (Texas), which are collected when the new growth is firm at the cutting base (25). The stem of the cutting should have a greenish-yellow color; avoid using brown wood. Cuttings are quick-dipped into 1,870 ppm IBA with 50 percent alcohol and direct stuck into 5 cm (2 1/4 in) liner pots. Timing, application of mist, and the hardening-off process are critical. In Georgia, cuttings of *B. thunbergii* cultivars and other *Berberis* species are taken from May 15 through July; the 8 to 10 cm (3 to 4 in) cuttings are wounded 6 to 12 mm (1/4 to 1 1/2 in) from the base and quick-dipped with 1,500 to 3,500 ppm IBA. In Alabama, golden barberry (*B. koreana* × *B. thunbergii*) can be rooted from softwood medial stem cuttings 7 to 10 cm (3 to 4 in) long, treated with a 1,250 ppm IBA quick-dip and propagated under 70 to 80 percent shade (302).

Greenhouse grafting of some selected types is also practiced, and layering is done occasionally. Division of crowns is useful for small quantities of plants.





**Micropropagation.** *B. thunbergii* 'Atropurpurea' is micropropagated (411).

**Berberis trifoliata.** (*Mahonia trifoliata*). Agarita (219). A dense evergreen rounded shrub with holly-like leaves that is an early spring bloomer in Texas with yellow fragrant flowers in March. This drought-resistant plant also has edible red berries and grows best in full sun. Seeds require a 2- to 3-month cold stratification. *B. trifoliata* can be micropropagated (297).

**Betula spp.** Birch.

**Seed.** Seeds germinate without pretreatment. Birch seed needs stratification to germinate in the dark, but will generally germinate without stratification if germinated in the light. Stratification and germination in the light accelerates germination rate compared to light alone. The key is to plant seeds shallow and not too deep (131).

**Cuttings.** Birch is considered difficult to propagate by cuttings, but leafy, semi-hardwood cuttings root under mist if taken in midsummer. Softwood cuttings of *B. alleghaniensis*, *B. lenta*, *B. nigra*, *B. papyrifera*, and *B. pendula* are rooted with 8,000 ppm IBA talc. Softwood cuttings (July in Ohio) of *B. nigra* root best with a 1,000 ppm IBA dip. Softwood one-node cuttings of 18-year-old *B. papyrifera* collected in mid-July (Vermont) treated with 4,000 to 6,000 ppm IBA in 50 percent ethanol had 40 to 60 percent rooting; problems occurred with survival of post-rooted cuttings (319).

**Grafting.** Some of the selected, weeping forms are grafted on *Betula pubescens* or *B. pendula* seedlings (117). T-budding and chip budding have been used in field-grown rootstocks of *B. pendula* (109). In the selection of birches that will tolerate the wet soils and high temperatures of the southeast United States, whitespire Japanese birch (*B. platyphylla*)—which has heat and drought resistance, but is intolerant of poorly drained soils—has proven ideal when grafted to rootstock of river birch (*B. nigra*) or European birch rootstock (*B. pendula*) (339, 340). Other white birches, such as *B. pendula* 'Youngii' have been successfully grafted to *B. nigra* rootstock, which is tolerant of poorly drained soils, high humidity, and high temperature (22).

**Micropropagation.** Birch is commercially micropropagated (62, 224, 284). *B. platyphylla* 'Fargo' (Asian white birch) can be micropropagated with WPM and BA (95).

**Birch.** See *Betula*.

**Bittersweet.** See *Celastrus*.

**Black gum.** See *Nyssa*.

**Black Haw.** See *Bumelia*.

**Black Tupelo.** See *Nyssa*.

**Boston Ivy.** See *Parthenocissus*.

**Bottlebrush.** See *Callistemon*.

**Bougainvillea spp.** Bougainvillea. This showy, tropical, woody, evergreen vine grows outdoors only in mild climates and is propagated by leafy cuttings taken at any time of the year. Rooting is aided by supplemental bottom heat. Difficult-to-root cultivars should be treated with IBA. In Australia, semi-hardwood (wood changing from green to brown) 4- to 6-node cuttings are cut to 10 to 13 cm (4 to 5 in) length (207). IBA at 4,000 to 16,000 ppm is applied, depending on the cultivar and the time of year. Bottom heat is used to maintain a propagation bed surface temperature of 25 to 27°C (77 to 81°F). Intermittent mist is used, but bougainvilleas do not tolerate an overly wet environment. Can be micropropagated by shoot-tip culture (93).

**Boxwood.** See *Buxus*.

**Boxwood (Oregon).** See *Paxistima*.

**Breath of Heaven.** See *Diosma (Ericoides)*.

**Broom.** See *Cytisus*.

**Buckeye.** See *Aesculus*.

**Buckeye (Mexican).** See *Ungnadia*.

**Buckthorn.** See *Rhamnus*.

**Buddleia spp.** Butterfly Bush. Seeds require no pretreatment. Seeds started in the greenhouse in early spring will provide flowering plants by fall, although reproduction is not genetically true by seed. Generally propagated by softwood or semi-hardwood cuttings taken in the summer, treated with 8,000 ppm IBA, and rooted under mist. *Buddleia* is micropropagated (322).

**Buffaloberry.** See *Shepherdia*.

**Bumelia lanuginosa.** Bumelia, Black Haw, or False Buckthorn. This deciduous small tree is propagated by seed. Seed is fall-collected and stratified at 4°C (40°F) for 2 months. Seed is sown in the spring in outdoor beds.

**Bunya-Bunya.** See *Araucaria*.

**Butia capitata.** Pindo palm. See palms.

**Butterfly Bush.** See *Buddleia*.

**Buxus spp.** Boxwood (*Buxus sempervirens* and *B. microphylla*). Seeds are rarely used because of the very slow growth of the seedlings. Cuttings are commonly used—either softwood taken in spring or summer,



semi-hardwood taken in late summer and fall, or hardwood cuttings taken in the winter (Texas). Quick-dips of 2,500 to 5,000 ppm IBA enhance rooting (424). An Oregon nursery uses a light application of liquid fertilizer (about 50 ppm N) after callus formation to help speed root development. Young liner plants should always be grown in containers or transplanted with balls of soil around their roots.

**Cactus (Prickly Pear).** See *Opuntia* spp. in Chapter 19, page 748.

***Callistemon* spp.** Bottlebrush. Although seeds germinate without difficulty, seedlings should be avoided because many of them prove worthless as ornamentals. The preferred method of propagation is by semi-hardwood cuttings taken from selected cultivars, which root under mist quite easily.

***Calluna vulgaris.*** Heather. See *Erica* (Heath).

***Calocedrus decurrens.*** Incense Cedar. Propagated by seed. Germination is promoted by a stratification period of about 8 weeks at 0 to 4°C (32 to 40°F). Can be rooted from cuttings treated with quick-dips of 2,500 ppm NAA, or 2,500 ppm NAA plus 2,500 ppm IBA. *C. decurrens* can be grafted on *Thuja*.

***Calycanthus* spp. (123).** Sweetshrub, Allspice. Stoloniferous shrubs. *C. floridus* is common to the eastern and southern United States. *C. floridus* 'Athens' ('Katherine') is very fragrant with yellow flowers, while *C. occidentalis* has reddish flowers. Seed should be collected when receptacles change from green to brown, and immediately planted. Seed collected later should be cold stratified for 3 months. Good rooting success is reported with summer semi-hardwood cuttings using 2,000 to 3,000 ppm IBA, or a 10,000 ppm K-IBA quick-dip.

***Camellia* spp.** Camellias can be propagated by seed, cuttings, grafting, layering, and micropropagation (274, 359), but they do not come true from seed. Seedlings are used in breeding new cultivars, as rootstocks for grafting, or in growing hedges where foliage is the only consideration. To perpetuate cultivars, cuttings, grafts, and micropropagation are used.

**Seed.** In the fall when the capsules begin to turn reddish brown and split, seeds should be gathered before the seed coats harden and the seeds become scattered. The seeds should not be allowed to dry out and should be planted before the seed coats harden. If the seeds must be stored for long periods, they will keep satisfactorily mixed with ground charcoal and

stored in an airtight container placed in a cool location. After the hard seed coats develop, scarification is accomplished by pouring boiling water over the seeds and allowing them to remain in the cooling water for 24 hours. It takes 4 to 7 years to bring camellias into flowering from seeds.

**Cuttings.** Most *C. japonica*, *C. oliefera*, *C. sasanqua*, *C. reticulata*, and *C. sinensis* cultivars and hybrids are produced commercially from cuttings. Cuttings are best taken from midsummer to mid-fall from the flush of growth after the wood has matured somewhat and changed from green to light brown in color. Tip cuttings are used, 8 to 15 cm (3 to 6 in) long, with two or three terminal leaves. Rooting is much improved if the cuttings are treated with IBA quick-dips of 3,000 to 5,000 ppm, 6,000 to 8,000 ppm IBA plus 2,500 ppm NAA, or 3,000 to 8,000 ppm IBA talc (27, 38, 131). *C. reticulata* hybrids root best with 8,000 to 20,000 ppm IBA talc (354). In Alabama, semi-hardwood cuttings 8 to 10 cm (3 to 4 in) in length are collected in September and October from stock blocks of *C. japonica*, *C. sasanqua*, *C. xhiemalis*, and quick-dipped in 10,000 ppm IBA (365). Wounding the base of the cuttings before they are treated is also likely to improve rooting. Cuttings root best either in a polyethylene closed frame or under mist.

Camellias also may be started as leaf-bud cuttings which are handled as stem cuttings. In this case, high auxin concentrations should be avoided because this may inhibit development of the single bud.

**Grafting.** Camellias are frequently grafted since some cultivars (e.g., 'Pink Pagoda') are poor rooters and grow poorly on their own roots. Grafting is also used for multiplying new cultivars faster and changing out cultivars of older established plants. Vigorous seedlings or rooted cuttings of either *C. japonica* or *C. sasanqua* can be used as rootstocks for grafting. Any of the side-graft methods are suitable. *C. japonica*, *C. sinensis*, and *C. reticulata* can be container-grafted by using a whip graft.

**Micropropagation.** Camellias are commercially micropropagated.

**Camphor Tree.** See *Cinnamomum*.

***Campsis* spp.** Trumpet Creeper. This vine is usually propagated by cuttings, but seeds can also be used. With the latter method, stratification for 2 months at 4 to 10°C (40 to 50°F) hastens but does not increase germination. Both softwood and hardwood cuttings root readily and can be quick-dipped with 1,000 ppm IBA. *C. radicans* can be started by root cuttings. One



Oregon nursery takes root pieces [5 cm length  $\times$  0.6 cm width (2  $\times$  1/4 in)], which are direct-stuck vertically with 0.3 cm (1/8 in) of the root showing. Maintain the correct polarity of the root cutting.

**Cape Jasmine.** See *Gardenia*.

***Caragana* spp.** Peashrub.

***C. arborescens* (Siberian Peashrub).** The most common peashrub for northern gardens. Seed germination is erratic, so best to soak in water for 24-h; 4-weeks stratification or fall planting results in good germination (131). *C. arborescens* is propagated from softwood cuttings, similar to *C. pygmaea* (pygmy peashrub). Untreated cuttings taken in May–July will root. A 3,000 ppm IBA-talc can slightly enhance rooting (131). Weekping and other specialty cultivars are top grafted on seedling rootstock.

***C. pygmaea* [Pygmy (Dwarf) peashrub].** Shrub with bright yellow, pealike pendulous flowers. Propagated by softwood tip cuttings, which are treated with 1,000 ppm IBA + 500 ppm NAA quick-dip. Rooted cuttings are transplanted the following spring.

**Carob.** See *Ceratonia* in Chapter 19.

***Carpinus* spp.** Hornbeam.

**Seed.** For seed propagation, collect seeds while the wings are still soft and pliable. Check to make sure that seeds have embryos, which may be absent after stressful growing conditions. Do not allow seeds to dry out. Sow outdoors in autumn or stratify (3 to 4 months), overwinter, and sow in spring. If seeds of *C. caroliniana* are allowed to dry, the seed coat hardens and inhibits germination. Consequently, double dormancy occurs and seeds must be scarified and then warm stratified for 2 months, followed by 2 months of cold stratification (61).

**Cuttings.** Summer stem cuttings of *C. betulus* ‘Fastiagata’ root with a quick-dip of 20,000 ppm IBA, *C. caroliniana* ‘Pyramidalis’ with 16,000 ppm IBA, and *C. japonica* with 3,000 ppm IBA talc (131). Wounding cuttings has been recommended. Softwood cuttings may root better than semi-hardwood cuttings. Stock plant etiolation, shading, and stem banding improved rooting of *C. betulus* softwood cuttings (281).

**Grafting.** Cultivars may be side-veneer grafted or budded on seedlings of the same species. *C. betulus* is used as the principle understock, since the majority of hornbeam cultivars are from European hornbeam (*C. betulus*), while grafting onto American hornbeam (*C. caroliniana*) results in significant overgrowth of the

understock by the scion. However, *C. japonica* or *C. cordata* should not be grafted onto (*C. betulus*) (444).

***Carya* spp.** Hickory, Water Hickory (*Carya aquatica*), bitternut hickory (*C. cordiformis*), pignut hickory (*C. glabra*), shellbark (*C. laciniosa*), nutmeg hickory (*C. myristicae-formis*), shagbark hickory (*C. ovata*), and mockernut hickory (*C. tomentosa*). Some of these tree species have edible fruits. Seeds (nuts) are fall-collected and will erratically germinate without pretreatment. Most species have a 3- to 4-month cold stratification requirement for uniform germination. Few reports exist on successful rooting or grafting of hickory, and cutting propagation is difficult. However, Medina (294) reported high rooting success with pecans using mounding and stooling techniques. Pecan (*C. illinoensis*) is successfully grafted by patch budding, the inlay bark graft, and four-flap (banana graft). Some of these asexual propagation techniques could be applied to other *Carya* species (see Chapter 19).

***Castanea* spp.** Chestnut. American chestnut (*Castanea dentata*), Chinese chestnut (*C. mollissima*), and sweet chestnut (*C. sativa*).

**Seed.** These deciduous medium-sized trees are predominantly seed propagated. Seeds are harvested in early fall and stratified for 2 to 3 months. It is important that seeds not dry out.

**Cuttings.** Mature cuttings are very difficult to root. Rooting success has occurred with juvenile cuttings of *C. mollissima* (8,000 ppm IBA talc or a 7,000 ppm IBA quick-dip in 95 percent alcohol) (131). Limited success has occurred with hardwood cuttings quick-dipped with up to 12,000 ppm IBA and with air layering. Leafy softwood summer cuttings have rooted with 1,250 ppm IBA five-second quick-dip in a high-humidity ventilated fog system; pretreatment with a blanching tape also improved rooting (327). Grafting success has occurred with cleft graftage, inlay bark graftage, and chip budding.

**Micropropagation.** Juvenile (349) and mature (418) explants of *Castanea* have been successfully micropropagated (375, 449, 450).

***Casuarina* spp.** Ironwood (*C. cunninghamiana*), Australian pine (*C. equisetifolia*), and longleaf casuarina (*C. glauca*). These large evergreen trees from Australia are easily propagated from seeds. Seeds require no pretreatment, and after harvesting and cleaning, seeds are stored and spring-sown in outdoor beds. Seed germination of *C. cunninghamiana* varies from 30 to 70 percent. Poor germination results from shriveled, empty, and





insect damaged seeds. There was a 91 percent germination when seed coats were removed (377). It is recommended to inoculate seedling roots with the nitrogen-fixing bacteria, *Frankia*. *C. cunninghamiana* can be micropropagated (377).

**Catalpa spp.** Catalpa.

**Seed.** Catalpa seeds germinate readily without any pretreatment. They are stored dry, overwintered at room temperature, and planted in late spring. Catalpa species can also be propagated in summer by softwood cuttings rooted under mist. Hardwood cuttings of *C. bignonioides* and *C. speciosa* root with 8,000 ppm IBA talc (131). The terminal bud of the cuttings should be removed.

**Grafting.** *C. bignonioides* ‘Nana’ is often budded or grafted high on stems of *C. speciosa*, giving the “umbrella tree” effect. A strong shoot is forced from a 1-year-old seedling rootstock, which is then budded with several buds in the fall at a height of 1.8 m (6 ft).

**Ceanothus spp.** Ceanothus can be propagated by seed, cuttings, layering, and sometimes grafting.

**Seed.** Seeds must be gathered shortly before the capsules open or they will be lost. Those of *C. arboreus*, *C. cuneatus*, *C. jepsoni*, *C. megacarpus*, *C. oliganthus*, *C. rigidis*, and *C. thyrsiflorus* have only seed coat dormancy. Germination is aided by placing seeds in hot water [82 to 87°C (180 to 190°F)] and allowing them to cool for 12 to 24 hours. To obtain germination in other *Ceanothus* species, which have both seed-coat and embryo dormancy, the seed should be immersed in hot water (as previously described) and then stratified at 2 to 4°C (35 to 40°F) for 2 to 3 months.

**Cuttings.** Ceanothus hybrid cultivars ‘Concha,’ ‘Frosty Blue,’ ‘Joyce Coulter,’ and ‘Victoria’ are all cutting-grown. Semi-hardwood cuttings can be rooted under mist at any time from spring to fall. Rooting is enhanced with 1,000 to 3,000 ppm (and up to 5,000 ppm) IBA/NAA quick-dips (387). Terminal softwood cuttings taken from vigorously growing plants in containers root when treated with 1,000 ppm IBA.

**Cedar.** See *Cedrus*.

**Cedar (Incense).** See *Calocedrus*.

***Cedrus* spp.** Cedar.

**Seed.** Seeds germinate if not permitted to dry out. No dormancy conditions occur, but soaking the seeds in water several hours before planting may be helpful. Also, a 1-month cold stratification period will improve the germination rate.

**Cuttings.** *C. ailantica* and *C. libani* are difficult to root. *C. deodara* can be rooted by wounding cuttings and using bottom heat; cuttings are collected in late fall to early winter and quick-dipped with 5,000 ppm IBA.

**Grafting.** Side-veneer grafting of selected forms on 1- or 2-year-old potted seedling stocks may be done in the spring (or winter in southern California). Scions should be taken from vigorous terminal growth of current season’s wood rather than from lateral shoots. In winter grafting, both lateral and terminal scions from the previous season’s growth can be used, producing identical results. *C. atlantica* selections and other species are grafted on *C. deodara* seedling rootstock. Rooted cuttings of *C. deodara*, which are a year or older, also make acceptable rootstock material.

***Celastrus* spp.** Bittersweet. These dioecious twining vines have male flowers on one plant and female on another, and the two types must be near each other to produce the plant’s attractive berries.

**Seed.** To propagate, seeds must be removed from the berries and then fall-planted or stratified for about 3 months at 4°C (40°F) before planting.

**Cuttings.** Clones of known sex can be propagated by softwood cuttings taken in midsummer, or by hardwood cuttings taken in winter. Semi-hardwood summer cuttings root well when treated with 8,000 ppm IBA talc (131). IBA-treated softwood cuttings can also be used.

***Celtis* spp.** Hackberry. Seeds are ordinarily used, sown either in the fall or stratified for 2 or 3 months at about 4°C (40°F), and planted in the spring (288). Clones of two species, *C. occidentalis* and *C. laevigata* (sugarberry), can be started by cuttings, but the rooting percentage is low. Grafting and chip budding also have been used with *C. occidentalis* and *C. laevigata* as rootstock for other species.

***Cephalotaxus harringtonia*.** Japanese plum yew. This ornamental species also has anticarcinogenic attributes. Can be propagated by seed, which requires a 3-month cold stratification period. Rooting by cuttings is difficult. An IBA talc or quick-dip of 5,000 to 10,000 ppm is reported to enhance rooting (131). Rooting of cuttings varies with cultivars. The species can be micropropagated. Micropropagated shoots can be rooted *ex vitro* under mist with or without auxin (229). See *Taxus* spp.

***Ceratonia siliqua*.** Carob. See *Ceratonia* in Chapter 19, page 732.





### ***Cercis* spp.** Redbud.

**Seed.** Seed propagation is successful, but seed treatments are necessary because of dormancy resulting from an impervious seed coat plus a dormant embryo. Probably the most satisfactory treatment is a 30- to 60-minute soaking period in concentrated sulfuric acid, or an 82°C (180°F) hot-water soak; scarification treatments must be followed by stratification for 3 months at 2 to 4°C (35 to 40°F). A 1-hour sulfuric acid scarification followed by 35 days of cold stratification is optimum for Mexican redbud (*C. canadensis* var. *mexicana*) (407). Gibberellic acid and ethephon can overcome dormancy in nonchilled dormant seed (174). Outdoor fall-sowing of untreated seeds also may give good germination. Seed provenance is important, since ecotypic variation affects survival, dormancy, and plant growth potential (e.g., Florida versus Canadian seed sources).

**Cuttings.** Propagating *Cercis* by cuttings is difficult. Leafy softwood cuttings of some *Cercis* species root under mist if taken in spring or early summer. *C. canadensis* var. *mexicana* roots readily when 10 to 15 cm (4 to 6 in) long, leafy terminal cuttings are taken 4 weeks after bud-break and treated with a 10,000 ppm K-IBA 5-second dip (406). Softwood and semi-hardwood cuttings of *C. Canadensis* 'Flame' rooted best with, respectively, 5,000 and 10,000 ppm K-IBA (447).

**Grafting.** T-budding in midsummer on *C. canadensis* seedlings is used commercially for *Cercis* cultivars such as *C. canadensis* var. *texensis* 'Oklahoma' (429, 430). Chip budding redbuds is commercially done. Stick budding is used in California. Apical wedge grafts are used with *C. canadensis* 'Forest Pansy' using a hot-pipe callusing system (303).

**Micropropagation.** *Cercis* is commercially micropropagated. Both *C. canadensis* and *C. canadensis* var. *mexicana* have been micropropagated and somatic embryos have been produced from micropropagated zygotic embryo explants (172, 175, 451).

***Chaenomeles* spp.** Quince (Flowering). Flowering quince is easily started by seeds, which should be fall-planted or stratified for 2 or 3 months at 4°C (40°F) before sowing. Clean the seeds from the fruit. Softwood cuttings treated with 1,000 to 5,000 ppm IBA root readily. Quince is commercially micropropagated.

***Chamaecyparis* spp.** *Chamaecyparis*, False cypress. *C. thyoides* (Atlantic white cedar).

**Seed.** In the fall, cones are collected and dried, and the seeds knocked free. The seeds are stratified at about 4°C (40°F) for 2 to 3 months. Some species such as *C. nootkatensis*, *C. thyoides*, and *C. praecox* germinate better with warm followed by cold stratification. Optimal seedling growth of *C. thyoides* occurs under long-day with day/night temperatures of 30/22°C (86/72°F) (240).

**Cuttings.** Cuttings of most species are not difficult to root, particularly if juvenile forms are used. Cuttings may be taken in fall and rooted in a cold frame, or in winter and rooted under mist or a polytent using bottom heat. Quick-dips of 3,000 to 8,000 ppm IBA are used. *C. thyoides* roots well with hardwood or softwood cuttings 24 cm (9 in) long. At high auxin levels, more primary roots are produced, while at lower to moderate auxin levels, more secondary roots are produced, which is more desirable (211).

**Micropropagation.** *C. nootkatensis* (Alaska yellow cedar) is micropropagated (271).

***Chamelaucium* spp.** Waxflower. Small- to medium-sized shrubs with waxy flowers. In Australia, terminal stem cuttings 8 to 10 cm (3 to 4 in) long with growing points intact are dipped in a 2 percent sodium hypochlorite solution for disease prevention. Leaves are stripped from the basal 2 cm of the stem and cuttings quick-dipped in 2,000 ppm IBA in ethanol solution (183). Grafting is done on *Phytophthora*-resistant rootstock using a splice graft wrapped with Parafilm or Buddy tape (318).

**Cherry (Flowering).** See *Prunus*.

**Chestnut.** See *Castanea*.

***Chilopsis linearis*.** Desert willow. This small tree is a member of the *Bignoniaceae* family, and has funnel-form flowers in open terminal panicles that range in color from white to lavender to burgundy. Can be propagated by seed or cuttings (408). Seeds will germinate immediately after harvest, or they can be stored under refrigeration. Germination takes 1 to 3 weeks. Hardwood cuttings root easily. Softwood and semi-hardwood cuttings treated with less than 5,000 ppm IBA can be rooted either under mist or in a high-humidity chamber. Air-layering is optimal during most active growth period (July and August in Arizona) (42).

***Chionanthus* spp.** Fringe Tree (*Chionanthus virginicus* and *C. retusus*).

**Seed.** Seed propagation can be used but is very slow. Manually nicking the seed coat helps. There is a double dormancy requirement, with a 3-month warm



stratification period (watch for the radicle to emerge) followed by a 3-month cold stratification period, after which seeds can be sown (131).

**Cuttings.** Cutting propagation of the Chinese fringe tree (*C. retusus*) is very difficult, but by taking softwood cuttings in late spring, treating cuttings with 8,000 to 10,000 ppm IBA talc and propagating under mist, excellent rooting percentages can be obtained. Rooting improves when stock plants are kept juvenile or when serial propagation is used.

Cuttings of *C. virginicus* are very difficult to root, but some success has been reported in Alabama by taking cuttings in early spring from hardened-off new growth and quick-dipping with 1,250 ppm IBA. Wounding appears to be helpful, and soft-tip cuttings have been reported to root in limited percentages (20). Serially propagating those cuttings that root can increase rooting success.

**Micropropagation.** *C. virginicus* can be micro-propagated via embryo culture (89).

**Chokeberry (Red).** See *Aronia*.

**Cinquefoil.** See *Potentilla*.

***Cinnamomum camphora*.** Camphor Tree. Seed propagation is the most common propagation method, unless cultivars have been selected. Can also be propagated by semi-hardwood cuttings taken in spring and rooted under mist.

***Citrus* spp.** See Chapter 19, page 732. There are a number of citrus cultivars for landscapes and home gardens, all of which are asexually grown by cuttings or grafted or budded onto seedling rootstock. *Citrus sinensis* ‘Valencia’ and ‘Washington’ are grown by cuttings (California).

**Grafting.** In Texas, citrus varieties are grafted on *Poncirus trifoliata* ‘Rubidoux’ rootstock. Some grafted cultivars include ‘Improved Myer’s Limon’ (*C. limon*), which is grown by cuttings in California, ‘Satsuma’ (*C. reticulata*), ‘Tomango’ and ‘Louisiana Sweet’ (*C. sinensis*), ‘Blossomsweet,’ ‘Rio Red’ and ‘Star Ruby’ (cutting-grown) (*C. xparadisi*), and ‘Kumquat’ (*Fortunella miewa*).

T-budding in Texas is done in the spring and fall. Dormant budwood is collected in February and refrigerated. Budding begins as soon as the bark begins slipping and ends in mid-April when the weather gets hot. In the fall, budwood is taken from stems that are round—compared to the normal triangular shape of citrus stems. The fall budding is from October until mid-November when the bark stops slipping. Budding rubbers and clear poly tape are used for tying.

***Clematis* spp.** Clematis can be propagated by seed, cuttings, grafting (358), division of roots, or layering (153).

**Seed.** Seeds of some clematis species have embryo dormancy, so stratification for 1 to 3 months at 4°C (40°F) is needed. Some species require a warm-cold stratification.

**Cuttings.** Clematis is probably best propagated by cuttings taken from young plants; these root under mist in about 5 weeks. Young wood with short internodes taken in the spring gives satisfactory results, but partially matured wood taken in late spring to late summer is more commonly used. Leaf-bud cuttings taken in midsummer will also root readily under mist. Semi-hardwood and hardwood cuttings can be treated with 3,000 to 8,000 ppm IBA talc, and softwood cuttings with a 3,000 to 5,000 ppm IBA quick-dip. Internodal cuttings (leaf-bud cuttings with one leaf intact) and the stem node inserted above the rooting medium root best with 1,000 ppm IBA quick-dip or 4,000 ppm talc (336). Basal cuttings can also be taken from unwanted flower stems, treated with 3,000 ppm IBA powder, set in a mix of 1 river sand: 1 perlite (v/v) and rooted under mist at 25°C (77°F) (369).

**Micropropagation.** Clematis is commercially micropropagated.

***Clethra* spp.** Sweet pepperbush. Clethra are low-growing shrubs or small trees with attractive foliage, bark, and fragrant flowers; they can be propagated by seed sown in flats under mist. *C. alnifolia* is rooted from softwood cuttings (June to September in Delaware, USA) and treated with 1,000 ppm K-IBA (69, 128). Other species are rooted with 1,000 to 5,000 ppm IBA.

***Coccoloba* spp. (317).** Sea grape. Some of these species are useful landscape plants with high salt tolerance. *C. uvifera* (sea grape) and *C. diversifolia* (pigeon plum) are primarily seed-propagated. Seeds are collected from August to November (Florida), and the seed coats peeled off. No other pregermination is needed, but it is important that seeds not dry out before planting. Some nursery producers propagate *C. uvifera* by cuttings and air layering.

***Conospermum mitchellii* (Proteacea).** Victorian Smokebush. Can be rooted from softwood cuttings treated with 3,000 ppm IBA (321).

**Coralberry.** See *Ardisia*.

***Cornus* spp.** Dogwood.

**Seed.** Seeds have various dormancy conditions; those of the popular flowering dogwood (*C. florida*) require either fall planting or a stratification period of



about 4 months at 4°C (40°F). Best germination is obtained if the seeds are gathered as soon as the fruit starts to color and sown or stratified immediately. If allowed to dry out it is best to remove seeds from the fruit and soak in water. Seed germination of *C. canadensis* is enhanced with a 4-month cold stratification. Low precipitation during seed formation reduces seed germination of red-osier dogwood (*C. stolonifera*), which must also be stratified (1). Other species require a warm-moist stratification to soften the seed coat, such as 2 months in moist sand at diurnally fluctuating temperatures (21 to 30°C, 70 to 85°F), followed by cold-moist stratification of 4 to 6 months at 0 to 4°C (32 to 40°F). With some species, the warm stratification period may be replaced by mechanical scarification or soaking in sulfuric acid.

**Cuttings.** Some dogwoods can be started easily by cuttings. *C. kousa* cuttings collected in mid-June through July (Massachusetts) root well when wounded on one side and treated with either 8,000 ppm IBA talc or quick-dips of 2,500 ppm IBA and NAA (165). Summer softwood cuttings of *C. alba* root readily when treated with a 1,000 to 3,000 IBA quick-dip or talc. Cuttings of *C. florida* are best taken in late spring or early summer from new growth after flowering, then rooted under mist. In Alabama, two-node cuttings of *C. florida* 'Stokes Pink' and 'Weaver's White' are taken from slightly stiff new growth early in the spring and quick-dipped with 10,000 ppm IBA. *C. florida* 'Spring Grove' roots well from softwood cuttings (June, July in Ohio) treated with 8,000 ppm IBA in talc. In Florida, semi-hardwood cuttings taken in May and late August are quick-dipped in 10,000 ppm K-IBA for 3 or 10 seconds, respectively (106). *C. florida* 'Rubra' can be rooted successfully if cuttings are taken in early summer after the second growth flush, treated with 3,000 ppm IBA, and propagated under mist (364).

To ensure survival through the following winter in cold climates, the potted cuttings should be kept in heated cold frames or polyhouses to hold the temperature between 0 and 7°C (32 and 45°F). Rooted cuttings that had shoot growth in the fall, but were not fertilized, had the best overwinter survival (182).

**Grafting.** Chip- and T-budding are major ways that *C. florida*, *C. kousa* and their hybrids are propagated in the southeast United States. Selected types, such as the red flowering dogwood, *C. florida* 'Rubra' and the weeping forms (difficult to start by cuttings), are often propagated by T-budding in late summer or by whip grafting in the greenhouse in winter on *C. florida* seedling rootstock. *C. kousa* and *C. florida* can be reciprocally grafted (165).

**Micropropagation.** Dogwood is micropropagated for breeding programs aiming to incorporate resistance to dogwood anthracnose and powdery mildew in flowering dogwood. Other dogwood species have been micropropagated (144, 147).

***Corylopsis* spp.** Winterhazel. Difficult to propagate by seeds, which have a warm and cold stratification requirement. Softwood to semi-hardwood cuttings can be treated with a 1,000 ppm IBA quick-dip and rooted under mist. IBA talc at 3,000 ppm has also been used. Buttercup winterhazel (*C. pauciflora*) is commercially micropropagated.

***Corylus* spp.** Filbert, Hazelnut. European filbert (*C. avellana*) is grown for fruit production and ornamental characteristics (*C. avellana* 'Contorta' and *C. fargesii*).

**Seed.** Seeds should be stored under refrigerated conditions immediately after cleaning (131). Seeds have a 2- to 6-month cold stratification requirement. *C. fargesii* has a 3-month cold stratification requirement (4).

**Cuttings.** In Oregon, cuttings in an active stage of growth are taken in mid-June to mid-July and treated with 5,000 to 10,000 ppm IBA quick-dip or talc. Cuttings are very sensitive to overwatering and should be kept in an active growth stage after rooting. Etiolation of stock plants and use of softwood cuttings enhanced rooting of *C. maxima* (281). Stooling and collection of hardwood cuttings in mid-February (England), and treating cuttings with 10,000 ppm IBA at 21°C (70°F), can enhance rooting. *C. avellana* is commercially propagated by mound layering in Oregon. Stooled shoots are ringed at the base, a 1,000 to 2,500 ppm IBA paste applied, and stools covered with soil or sawdust. IBA at 750 ppm sprayed on the lower 15 cm of each sucker (stool) and in combination with girdling enhance root quality (152). *C. fargesii* has not been successfully rooted.

**Grafting.** Commercial fruit and ornamental cultivars are grafted using a whip graft on *C. avellana* seedling rootstock. Chip building is successful and budded plants are more vigorous than grafted plants (131). *C. fargesii* can be grafted with a modified veneer graft (side wedge graft) (4, 412).

**Micropropagation.** *Corylus* is micropropagated (7).

***Cotinus coggygria*.** Smoke Tree or Smoke Bush. Smoke trees should not be propagated by seeds, since many of the seedlings are male plants, lacking the showy flowering panicles. Only vegetative methods





should be used, with cuttings taken from plants known to produce large quantities of the desirable fruiting clusters. Also, the purple foliage color will only come true from vegetative reproduction.

**Cuttings.** Tip cuttings taken from spring growth (May in Oregon) should be very soft and flexible, 5 to 8 cm (2 to 3 in) long. Treated with a 1,000 to 3,000 ppm IBA quick-dip, cuttings should root in about 5 weeks. After the mist is discontinued, the rooted cuttings are left in place, undisturbed, and transplanted the following spring. *C. coggygria* 'Royal Purple' can be rooted from softwood cuttings [13 to 19 cm (5 to 7.5 in) long] taken in late May (Oklahoma) and treated with 10,000 ppm IBA + 5,000 ppm NAA (140).

**Cotoneaster spp.** Cotoneaster.

**Seed.** Seeds of most Cotoneaster species should be soaked for about 90 minutes in concentrated sulfuric acid, rinsed, and then stratified for 3 to 4 months at about 4°C (40°F).

**Cuttings.** Leafy cuttings of many species taken in spring or summer will root under mist without much difficulty. Evergreen/semi-evergreen types root better than deciduous, and are treated with a 1,000 to 3,000 ppm IBA quick-dip. Semi-hardwood cuttings of *C. buxifolius* root best with a 4,000 to 6,000 ppm IBA quick-dip in 100 percent perlite medium.

**Grafting.** Cotoneaster can be budded high onto pear trees to produce a "tree" cotoneaster. A blight-resistant pear rootstock, such as 'Old Home,' should be used. *C. bullatus* and *C. actifollus* rootstocks are more commonly used.

**Cottonwood.** See *Populus*.

**Crab Apple (Flowering).** See *Malus*.

**Crape Myrtle.** See *Lagerstroemia*.

**Crataegus spp.** Hawthorn.

**Seed.** Hawthorns tend to reproduce true by seed. Seeds have a pronounced dormancy and generally more from acid scarification and stratification. Scarify seed with sulfuric acid, and then cold stratify for 5 months at about 4°C (40°F). Some species germinate better with a warm treatment prior to cold stratification. Since hawthorn develops a long taproot, transplanting is successful only with very young plants. Air pruning of seedling roots may be beneficial.

**Grafting.** Selected clones may be T-budded or root-grafted on seedlings of *C. crus-galli*, or *C. coccinea* for the American (entire-leaf) types and on seedlings of

*C. laevigata* or *C. monogyna* for the European (cut-leaf) types.

***Cryptomeria japonica.*** Japanese Cryptomeria, Sugi. Can be propagated either by seeds or by cuttings.

**Seed.** Seeds should not dry out. Seeds should be cold stratified for 3 months or given a 3-month warm stratification followed by a 3-month cold stratification.

**Cuttings.** Chinese and Japanese foresters have been commercially propagating Sugi by cuttings for more than 500 years, and detailed methods for taking and rooting cuttings were published in the 1600s (348). Cuttings, 5 to 15 cm (2 to 6 in) long, should be taken from greenwood at a stage of maturity at which they break with a snap when bent. Root with bottom heat; keep the cuttings shaded and cool. After roots start to form, in about 2 weeks, give more light; transplant to pots when roots are about 13 mm (1/3 in) long. Stem cuttings of *C. japonica* 'Yoshino' can be rooted year-round. Hardwood cuttings taken in January (North Carolina) can be rooted when tips of first-order laterals or proximal halves of first-order laterals are treated with 3,000 to 9,000 IBA quick-dip applications (238, 239).

***xCupressocyparis leylandii.*** Leyland Cypress. This bigeneric hybrid of *Cupressus macrocarpa* and *Chamaecyparis nootkatensis* is propagated by cuttings and rooted under mist with bottom heat (440). Cuttings can be taken any time from late winter to autumn and should be treated with IBA at 3,000 ppm, or 8,000 ppm in December–January (Georgia) (331). In California, 6,000 ppm IBA was optimal (54). Hardwood cuttings of 'Castlewellan Gold' are propagated in winter (Greece) and treated with 9,000 ppm IBA (413). Leyland cypress is micropropagated (400).

***Cupressus spp.*** Cypress. Seeds have embryo dormancy, so stratification for about 4 weeks at 2 to 4°C (35 to 40°F) is used. Cuttings can be rooted if taken during winter months. Treatments with 2,000 to 8,000 ppm IBA enhance rooting. In California, quick-dips of 6,000 to 8,000 ppm IBA or 6,000 IBA + 6,000 NAA aid rooting (54). *C. arizonica* (Arizona cypress) can be rooted by hardwood cuttings treated with 4,000 ppm IBA (399). Side-veneer grafting of selected forms on seedling *Cupressus* rootstocks in the spring is often practiced.

**Currant (Red Flowering).** See *Ribes*.

**Cycads.** See *Cycas*.

***Cycas spp.*** Cycads. Species of *Cycas*, *Zamia*, and *Encephalartos*.





**Seed.** Many are seed-propagated. The seed of most cycads germinate without difficulty but sometimes slowly over a span of several months. In general, soaking the seed in water for a few days and subsequently in 1,000 ppm gibberellic acid for 24 to 48 hours enhances germination (118). Species of *Cycas*, *Zamia*, and *Encephalartos* have seed germination problems that include an impermeable seed coat (the sclerotesta), an immature embryo, and physiological dormancy. Scarification with sulfuric acid, followed by a gibberellic acid treatment, resolves most of these dormancy problems. Scarifying the seeds by cracking them is not recommended. Seeds of *Zamia floridana* germinate well when scarified with sulfuric acid for 1 hour, soaked in gibberellic acid for 48 hours, and then placed under intermittent mist for 6 weeks; *Z. furfuracea* seeds germinate best with a 15-minute acid treatment, 24-hour gibberellic acid soak, and placement under mist for 6 weeks (118).

Seeds of *Cycas* float in water whether viable or nonviable. The embryo is immature at the time of seed collection. For improved germination, Sago palm (*C. revoluta*) seed should be stored at room temperature and scarified for one hour with concentrated sulfuric acid.

Cycad seedlings should be root-pruned by severing the roots at the root-shoot juncture, dipping the cut end of the leafy portion in IBA, after which they are potted in liner pots and placed under mist for 2 weeks to encourage branched root systems and more rapid growth and development of the seedlings.

**Vegetative propagation.** Slow growth rates limit the potential for vegetative propagation. The American *Zamia* can be regenerated from its underground tuberous root and stem tissue. Cycads do not have lateral buds to produce side shoots. However, when taxa such as *Cycas* are injured, side shoots known as “pups” regenerate from callus. The pups are removed and their severed base is quick-dipped in 2,000 to 10,000 ppm IBA; rooting can take up to 1 year (118).

**Micropropagation.** The South African cycad, *Stangeria eriopus*, has been micropropagated (311). However, there is no commercial micropropagation of cycads.

**Cypress.** See *Cupressus*.

**Cytisus spp.** Broom.

**Seed.** Seeds of many of the species germinate satisfactorily if gathered as soon as mature and treated with sulfuric acid for 30 minutes to soften the hard seed coats before planting. Since the various *Cytisus* species crossbreed readily, stock plants for seed sources should be isolated.

**Cuttings.** Hardwood cuttings taken in late February or early March root well with 2,500 ppm IBA. Semi-hardwood cuttings can be rooted easily under mist in midsummer if treated with 3,000 to 8,000 ppm IBA and given bottom heat.

**Daphne spp.** Daphne can be propagated by seed, stem and leaf-bud cuttings, layering, and grafting (81, 90).

**Seed.** Seeds should be sown at once after harvest or, if dried, scarified and given a moist-chilling period before sowing. Berries are very poisonous if eaten.

**Cuttings.** Daphne is probably best propagated by leafy cuttings in perlite and peat moss (4:1) mix under mist; a well-drained 100 percent medium perlite is also recommended for cuttings (134). In England, cuttings are taken in mid- to late May, toward the end of flowering. Cuttings are also taken in summer from partially matured current season's growth. Rooting can be enhanced with a 1,000 ppm IBA + 500 ppm NAA, or a 2,500 ppm IBA quick-dip (134). The daphnes do not transplant easily and should be moved only when young.

**Micropropagation.** *D. odora* is micropropagated (346).

**Davidia involucrata.** Dove tree. Seeds require a 5 to 6 months' warm stratification followed by 3 months of cold stratification (166). Polyethylene bags containing a ratio of 1 part sand to 1 part peat is a suggested system for the pretreatment of *Davidia* seeds. Rooting is variable. Leaf-bud cuttings treated with 3,000 ppm IBA talc rooted 85 percent. Wounded cuttings with four leaves that were treated with 8,000 ppm IBA talc and propagated under mist had 50 percent rooting (131). Disturbance and overwintering of rooted cuttings can be a problem.

**Dawn Redwood.** See *Metasequoia*.

**Delonix regia.** Royal Poinciana. This spectacular tropical flowering tree is propagated by seed. Germination is rapid when seeds are treated to soften seed coats, as by pouring boiling water over seeds or by soaking in concentrated sulfuric acid for 1 hour.

**Deutzia spp.** Deutzia is easily propagated either by hardwood cuttings lined-out in the nursery row in spring, or by softwood cuttings taken in the spring or summer and treated with IBA talc or quick-dip at 1,000 to 3,000 ppm.

**Diosma ericoides.** Diosma, Breath of Heaven. Propagated by leafy cuttings taken in summer and rooted under mist.



***Diospyros* spp.** Japanese persimmon (*D. kaki*), common persimmon (*D. virginiana*), and Texas persimmon (*D. texana*). Japanese persimmon is an important fruit crop and propagation is covered in Chapter 19. Texas and common persimmon are propagated from seed. No pretreatment is required for Texas persimmon, but germination percentages can be low (219). Common persimmon requires 3 months of cold stratification at 4°C (40°F) for 5 months for good germination. *D. kaki* is also propagated by shield (T-budding) or chip budding and side-veneer or side-tongue grafted on *D. virginiana* rootstock. Other cultivars of *D. kaki* are chip-budded on *D. kaki* rootstock (379). *D. kaki* is micropropagated (104).

***Disanthus cercidifolius* (123).** A multistemmed shrub of potential in the Hammamelidaceae family with red fall color and purple flowers. Seeds require a warm stratification for 5 months followed by 3 months of cold stratification. Cuttings collected in July (Georgia) root best when treated with a 10,000 ppm IBA alcohol quick-dip and propagated under mist in a peat-perlite media. Successfully overwintered in a polyhouse if potted up immediately after rooting, fertilized, and allowed to harden-off naturally in the fall. *Disanthus* is commercially micropropagated.

**Dogwood.** See *Cornus*.

**Douglas-fir.** See *Pseudotsuga*.

**Dove Tree.** See *Davidia*.

***Elaeagnus* spp.** Elaeagnus, Russian olive, Silverberry, Silverthorn. Seeds planted in the spring germinate readily following a stratification period of 3 months at 4°C (40°F). Removal of the pit (endocarp) for silverberry seeds (*E. commutata*) resulted in about 90 percent germination of unstratified seeds, since a germination inhibitor is apparently present in the pit; if not fall-planted, seeds should be cold stratified for 3 months. Seeds of the Russian olive, *E. angustifolia*, should be treated with sulfuric acid for 30 to 60 minutes before fall planting or stratification; this deciduous species is commercially seed-propagated, and only limited rooting success (28 percent) has been obtained with 3,000 ppm IBA talc (131). Leafy cuttings of the evergreen species root readily. Hardwood and semi-hardwood cuttings of *E. pungens* root well when treated with 8,000 to 20,000 ppm IBA talc (38).

**Elderberry.** See *Sambucus*.

**Elm.** See *Ulmus*.

**English Ivy.** See *Hedera*.

***Enkianthus* spp.** Enkianthus are attractive shrubs with pronounced fall color. Seed propagation requires no pretreatment, and germination occurs within 2 to 3 weeks after sowing (131, 307). Cuttings root quite easily. Leafy cuttings taken in mid-June (Massachusetts) are treated with talc or quick-dips of IBA at 5,000 to 8,000 ppm, and rooted under mist. Rooted cuttings should be allowed to harden-off and overwinter before they are disturbed. An extended photoperiod is helpful in ensuring overwintering success. Enkianthus is micropropagated.

***Epigaea repens.*** Mayflower, trailing arbutus. This creeping, evergreen shrub has fragrant white to pink flowers and is propagated by seed collected in late spring (Massachusetts). Immature seed is white, and dark when mature. The cleaned seed is stored at 4°C (40°F) until sowing; there is no stratification requirement (350).

***Erica* spp.** Heath. The propagation of the closely related genera, Heather (*Calluna vulgaris*), is quite similar (132).

**Seed.** Seeds may be germinated in flats in the greenhouse in winter or in a shaded outdoor cold frame in spring.

**Cuttings.** Leafy, partially matured cuttings taken at almost any time of year, but especially in early summer, root readily under mist in a glasshouse or polyethylene-covered cold frame. While most species root readily, IBA (1,000 ppm quick-dip or 4,000 ppm talc) speeds up rooting.

**Micropropagation.** *Erica* and *Calluna* are micropropagated.

***Eriobotrya japonica.*** Loquat. These large evergreen shrubs or small trees can be propagated by seed, without pretreatment. Considered difficult-to-root. Side grafting and budding is another form of propagation. *E. japonica* has been successfully micropropagated. See Chapter 19.

***Eriostemon* spp.** Eriostemon. An Australian evergreen shrub with long-lasting white or pink flowers and fragrant foliage. Can be propagated by seed and stem cuttings. Stem cuttings can be slow to root or root poorly, and ease of rooting is clonally variable. *E. myoporoides* and *E.* 'Stardust' can be micropropagated (14).

***Escallonia* spp.** Escallonia is easily started by leafy cuttings taken after a flush of growth. Cuttings root well under mist and respond markedly to treatment with 1,000 ppm IBA. It is best to direct-root in liner pots, since transplanting is difficult.



### ***Eucalyptus* spp.** Eucalyptus.

**Seeds.** Eucalyptus is largely propagated by seeds planted in the spring. Mature capsules are obtained just before they are ready to open. No dormancy conditions occur in most species, so seeds are able to germinate immediately following ripening. Seeds of some species, however—for example, *E. dives*, *E. niphophila*, and *E. pauciflora*—require stratification for about 2 months at 4°C (40°F) for best germination. Eucalyptus seedlings are very susceptible to damping-off. Seeds are usually planted in flats of pasteurized soil placed in a shady location or flats covered with a white plastic (46). From flats, they are transplanted into small pots, from which they are later lined-out in a nursery row. The roots of young trees will not tolerate drying, so the young plants should be handled as container-grown stock. Seeds may be sown directly into containers in which the seedlings are grown until planting in their permanent location (188).

**Cuttings.** Eucalyptus is difficult to start from cuttings, but good rooting can be obtained from some species. For example, leafy cuttings of *E. camaldulensis* root when taken in early spring from shoots arising from the base of young trees, wounded, treated with a 4,000 ppm IBA + 4,000 ppm NAA, and propagated under mist with bottom heat at 21°C (70°F) (155). *E. grandis* stock plants are hedged and new developing shoots are used as cuttings. Four-node cuttings are prepared and treated with IBA. Leaf retention is very important, so avoid using older shoots with leaves that will abscise before rooting occurs (82). Clones of *E. cladocalyx*, *E. tereticornis*, *E. grandis*, *E. camaldulensis*, and *E. trabutii* will root when three- to four-node cuttings are treated with a quick-dip of 4,000 to 8,000 K-IBA (356). Rooting is best when cuttings are taken from rapidly growing stock plants (April to October in California). Apical minicuttings are taken from intensively managed mother plants to optimize shoot production and rooting of cuttings (385). Mother plants are maintained in cell trays or small pots and flood irrigated. Apical minicuttings are taken every 7 to 10 days, treated with auxin and rooted under mist. Plants produced from mini-cuttings, compared to semi-hardwood cuttings, have better form, a more robust and developed root system, reduced production time as juvenile apical shoot grows more rapidly, and the area required for hedging mother plants for traditional semi-hardwood production is reduced (385).

**Grafting.** *E. ficifolia* has been grafted successfully by a side-wedge method, using young vigorous Eucalyptus seedling rootstocks growing in containers and placed under very high humidity following grafting.

Use of scions taken from shoots that had been girdled at least a month previously increased success. Top cleft grafting is used in Australia. Semihardwood scions are grafted onto seedling rootstocks and the grafted ramets are initially placed under intermittent mist (385).

**Micropropagation.** Eucalyptus are routinely micropropagated, even with mature explant tissue (36, 116, 236, 265, 296).

### ***Euonymus* spp.** Euonymus.

**Seed.** Generally cold stratification at 0 to 10°C (32 to 50°F) for 3 to 4 months is required for satisfactory seed germination (171). Some species (*E. atropurpureus* and *E. europaeus*) require several months of warm stratification prior to cold stratification for germination. Remove seeds from fruit (colorful aril) and prevent drying.

**Cuttings.** Euonymus is easily started by cuttings. Deciduous species are started from hardwood cuttings in late winter/early spring, while evergreen types are propagated with leafy semi-hardwood cuttings. *E. alatus* roots best from stem cuttings collected before growth is fully hardened in the spring. IBA can be applied as a 1,000 to 3,000 ppm quick-dip or from 3,000 to 8,000 ppm talc (131). The production cycle of *E. fortunei* 'Sarcoxie' is significantly shortened when summer-rooted cuttings are exposed to a minimum of 500 chilling hours and then winter-forced in a heated greenhouse (96).

**Micropropagation.** *E. alatus* has been commercially micropropagated, and somatic embryogenesis has been successful with other Euonymus species (228).

***Euphorbia* spp.** Poinsettia (*E. pulcherrima*). This species is generally propagated by leafy cuttings under mist. A quick-dip of 500 to 1,000 ppm IBA + NAA enhances rooting. Stock plants of self-branching cultivars should be used as a source of cuttings. It is best to root cuttings in small container liners or root cubes, so that the roots of rooted cuttings are not disturbed during transplanting to larger containers. Cuttings can be rooted in the greenhouse from spring to fall. Specialists or their licensed propagators will sell rooted liners to greenhouse producers for either stock plants or for shifting up to a larger pot for finishing. Scarlet plum (*E. fulgens*), which is a medium-sized shrub from Mexico used for cut-flower production in greenhouses, is generally propagated by cuttings. Micropropagation of this species is faster and requires less greenhouse space than conventional cuttage (453).

### ***Fagus* spp.** Beech.





**Seed.** Seeds germinate readily in the spring from fall planting or after being stratified for 3 months at about 4°C (40°F). Seeds should not be allowed to dry out. *F. sylvatica* seeds are sometimes hollow and nonviable.

**Cuttings.** Cuttings taken from seedling plants will root at different percentages due to clonal influences. Overwintering survival of rooted cuttings (Denmark) is a problem (263). Etiolation of stock plants and covering shoot bases with black adhesive tape enhances rooting.

**Grafting.** Selected clones are grafted by the cleft, whip, or side-veneer method on seedling rootstock of European beech (*F. sylvatica*). In Oregon, *F. sylvatica* cultivars are field-grafted on seedling rootstock using a “stick bud” method; the scionwood generally contains two buds and is inserted into a T-cut in the rootstock (149). Cleft grafting is used with American beech (*F. americana*), but the species is difficult to graft with only a 25 to 30 percent success rate (338). Grafting success increased when the scion diameter was slightly greater than rootstock diameter.

**False Cypress.** See *Chamaecyparis*.

**xFatsbedera (*Fatsia* × *Hedera*).** See *Hedera helix*.

**Feijoa sellowiana.** See *Feijoa* in Chapter 19.

***Ficus* spp.** Fig, rubber plant. A wide range of ornamental trees, vines, and ornamental potted plants. For the edible, common fig, see *Ficus carica* in Chapter 19. Many species form aerial roots, and are easily rooted by cuttings and layering.

**Cuttings.** Single-node propagation of *Ficus* spp. produces many more plants per stock plant than the common method of air layering (329). *F. benjamina* (weeping fig) is easily started by leafy semi-hardwood cuttings taken in spring or early summer and rooted under mist. *F. elastica* (rubber plant) is propagated by cuttings taken from 5 to 27 cm (6 to 12 in) shoots; single buds or “eyes” can be removed and rooted. These cuttings are made in spring, inserted in sand or a similar medium, and held in a warm greenhouse. *F. pumila* (creeping fig) is propagated with 10 to 13 cm (4 to 5 in) long cuttings. The juvenile form, which is a climbing vine with aerial rootlets, roots easily all year round; 1,000 to 1,500 ppm IBA quick-dips enhance rooting (113). The mature form lacks aerial roots, but can be rooted successfully with 2,000 to 3,000 ppm IBA. *F. lyrata* (fiddleleaf fig) can be propagated by cuttings, or by air layering (234).

**Air layering.** Shoots of trees growing outdoors in the tropics are air layered and the rooted air layers are shipped to wholesale nurseries for finishing off the crop. In subtropical regions of the United States, *Ficus* stock blocks are maintained for air layering (see Fig. 14–5). Indoor plants that become too “leggy” also can be air layered.

**Micropropagation.** *Ficus* are commercially micropropagated (328).

**Fig.** See *Ficus*.

**Fig (Common).** See *Ficus carica* in Chapter 19.

**Filbert.** See *Corylus*.

**Fir.** See *Abies*.

**Firethorn.** See *Pyracantha*.

***Forsythia* spp.** Forsythia is easily propagated by hardwood cuttings set in the nursery row in early spring or by leafy softwood cuttings taken during late spring and rooted under intermittent mist.

***Fothergillia gardenii*.** Dwarf Fothergillia. Generally difficult to propagate by seed—based on lack of availability, and a 6-month warm stratification, followed by a 3-month cold stratification requirement. Easy to root by cuttings, which are treated with 4,000 ppm IBA (131). Cultivars of *Fothergillia* are commercially micropropagated.

***Franklinia alatamaha*.** Franklinia can be propagated by seed that is sown immediately (if fresh). Otherwise, seed needs a 1-month stratification period if stored. Roots easily by cuttings treated with 1,000 ppm IBA. Root early in the season to allow growth of rooted liners prior to overwintering. Franklinia is commercially micropropagated.

***Fraxinus* spp.** Ash.

**Seed.** Seeds of most species germinate if stratified for 1 to 3 months followed by cold stratification for up to 6 months. In some cases, seeds of some species like *F. anomala* and southern accessions of *F. pennsylvanica* and *F. Americana* require only a 3-month cold stratification treatment.

**Cuttings.** Ashes are difficult to propagate from stem cuttings. *F. greggii* (littleleaf ash) roots readily when 10 to 15 cm (4 to 6 in) long—leafy terminal cuttings are taken 16 weeks after bud-break and treated with a 17,000 ppm K-IBA quick-dip (406). Rooting is enhanced with early, softwood cutting material. *F. pennsylvanica* ‘Summit’ has been rooted in low percentages





when taken from softwood cuttings in April and May in Pennsylvania (20). *F. anomala* cuttings taken from containerized seedling stock plants had high rooting when treated with auxins from 5,000 to 20,000 ppm.

**Grafting.** *F. excelsior*, *F. ornus*, and *F. pennsylvanica* seedlings are used as rootstocks for grafting or budding ash cultivars.

**Micropropagation.** Ashes are commercially micropropagated (12, 30).

**Fringe Tree.** See *Chionanthus*.

**Fuchsia spp.** Fuchsia is easily rooted by leafy cuttings maintained under humid conditions (422). Roots develop in 2 to 3 weeks.

**Gardenia jasminoides.** Gardenia, Cape jasmine. Leafy terminal cuttings are treated with 3,000 ppm IBA and rooted under mist from spring to fall. Gardenias are difficult to transplant and should be moved only when small. Gardenia is commercially micropropagated (146).

**Garrya elliptica (345).** Garrya 'James Roof' is an ornamental tree producing catkins 300 mm long. Seeds generally require cold stratification at 4°C (40°F) for 1 to 3 months. In some cases, a 1-day gibberellic acid (100 ppm) treatment following stratification has improved germination. It is generally considered difficult to propagate asexually. Tip nodal cuttings 10 cm long on side shoots taken with a heel with well-developed terminal buds are collected from late summer to December (England). Wounding is optional and cuttings are treated with 8,000 ppm IBA talc and propagated under mist or plastic film. Direct rooting in small liner pots is desirable to avoid root disturbance problems. Rooted cuttings should complete their first spring flush of growth before transplanting. *Garrya* is micropropagated.

**Genista spp.** Genista. Landscape plants that range from creeping ground covers to massing shrubs. These species are not difficult to propagate.

**Seed.** Seed propagation is similar to that of other legumes with hard seed coats. Scarify with a 30-minute treatment of concentrated sulfuric acid or a boiling-water treatment. Seeds are placed in boiling water which is immediately allowed to cool to room temperature (162). Some species have no scarification requirement. Seeds of *G. tinctoria* and some other species also require a 3-month cold stratification of 5°C (41°F). When in doubt, immerse seeds in water overnight, and then separate those that have imbibed water and swelled from

those that did not. Cold stratify swollen seeds for 3 months or until radicle growth first becomes visible. Soak those seeds that did not swell in concentrated sulfuric acid for 30 minutes, then wash them thoroughly, and cold stratify in the same way (162).

**Cuttings.** Softwood cuttings taken in early summer (Indiana) root easily without auxin, while semi-hardwood cuttings taken in late summer and hardwood cuttings taken in fall root best with 8,000 ppm IBA in talc (162). Bottom heat should not be allowed to drop below 18°C (65°F). Seedlings or rooted cuttings should be grown in containers, since field-dug plants do not transplant well.

**Micropropagation.** *G. monosperma* has been micropropagated (353).

**Ginkgo biloba.** Ginkgo. Seed propagation should not be used except for rootstock production. The "fruits" are collected in mid-fall and the pulp removed. A warm and cold stratification of 1 to 2 months, each, is required. Seedlings produce either male or female trees, but the sex cannot be determined until the trees flower—after about 20 years. The plumlike "fruits" on the female trees have a very disagreeable odor, so only male trees are used for ornamental planting. Cutting-produced male liners do not grow as quickly as grafted plants. Softwood cuttings taken in early summer are treated with 8,000 ppm IBA talc or quick-dip and rooted under mist. Commercial propagation is also by T-budding or chip budding, using buds from male trees inserted into ginkgo seedlings. Male cultivars can also be cleft or whip grafted on container seedling rootstock during winter.

**Gleditsia triacanthos.** Common Honeylocust. Readily propagated either by seeds planted in the spring or by budding. In seed propagation, soaking the seed in sulfuric acid for 1 to 2 hours, gives good germination. Very difficult to propagate by cuttings—can be rooted by root cuttings. The thornless honey locust, *G. triacanthos*, var. *inermis*, and the thornless and fruitless 'Moraine' locust are usually propagated by T-budding on seedlings of the thorny type.

**Gold Tree.** See *Tabebuia argentea*.

**Golden Chain.** See *Laburnum*.

**Golden Trumpet.** See *Allamanda*.

**Goldenrain Tree.** See *Koelreuteria*.

**Gordonia spp. (131).** Loblolly bay, Black laurel. These medium-sized trees can be propagated by seed, which germinates readily without pregermination



requirements. Semi-hardwood cuttings are easily rooted with a 2,500 to 3,000 ppm IBA quick-dip or 3,000 ppm IBA talc. These species transplant easily after rooting.

**Grevillea spp.** These Australian native shrubs or trees are propagated by seed, cuttings, or graftage. Cuttings of the low-growing species root readily, but larger-growing species, such as *G. robusta*, silk oak, are best propagated by seed. *G. johnsonii* is difficult to root, but fall cuttings (Australia) treated with 4,000 ppm IBA-ethanol 5-second quick-dip have 70 percent rooting (150). With *G. asplenifolia*, single-node cuttings with reduced leaf areas work best, whereas retaining all leaves on larger two- to three-node cuttings is optimal for *G. juniperina*. A number of *Grevillea* species can also be grafted using a whip graft (56). *G. robusta* is the primary rootstock, since it has resistance to *Phytophthora cinnamomi*. Specialized weeping forms of *Grevillea* are produced by using approach grafting of two independent, containerized *Grevillea* plants (108). *G. scapigera* (68) and *G. robusta* (337) can be micropropagated.

**Gymnocladus dioicus.** Kentucky Coffeetree. An attractive landscape tree that is dioecious. Male trees are more desirable than female trees, which have long seed pods that abscise and detract from the ornamental value of the plant. Can be propagated by seed, but undesirable female plants are produced. Seeds require 2 to 4 hour acid scarification, but no stratification needed to germinate. Cutting propagation is very difficult. Can be propagated by root cuttings. Seedlings (173) and mature male trees have been successfully micropropagated (386).

**Hackberry.** See *Celtis*.

**Halesia spp.** Silverbell. A small, valuable landscape tree, native to the southeastern United States. It has a striped bark, bell-shaped flowers, and interesting fruit (two- to four-winged drupe). Seed propagation of *Halesia* requires complex stratification regimes and success is often limited. *H. carolina* is warm stratified for 2 to 4 months, followed by 2 to 3 months of cold stratification. Spring and summer cuttings root well when treated with 1,000 to 10,000 ppm IBA quick-dips (123). Silverbell is commercially micropropagated (60).

**Hamamelis spp.** Witch Hazel. Propagated by seed, budding, or grafting.

**Seed.** *Hamamelis* requires a 3-month warm stratification followed by a 3-month cold stratification. The treated seed can be germinated in the spring.

**Cuttings.** Cutting propagation is difficult but possible. Leafy cuttings of *H. mollis*, *H. virginiana*, *H. japonica*, and *H. vernalis* are treated with 8,000 ppm IBA talc or a 10,000 IBA quick-dip and rooted under mist. Cuttings of *H. xintermedia* 'Arnold Promise' should be taken as early as possible in spring—cuttings taken in late spring and summer will root, but not survive the winter. Collect three- to four-node cuttings with basal portion firm, quick-dip with 10,000 ppm K-IBA, or use an 8,000 ppm talc. For softer tissue use 2,500 to 5,000 ppm IBA (130). To improve overwintering survival, it is best to induce a growth flush after rooting and prior to winter. The rooted cuttings need to be left undisturbed in an unheated house (avoid freezing) and not transplanted until leaves have started to expand in the spring (148, 257).

**Grafting.** Cultivars of *H. mollis*, *H. xintermedia*, and *H. japonica* are propagated by budding or grafting (side-veneer graft) on *H. virginiana* seedlings; however, rootstocks tend to sucker and compete with scions (293, 335). In Oregon, chip budding works well. Bud as low as possible on the rootstock.

**Micropropagation.** Witch hazel is commercially micropropagated (62).

**Hawthorn.** See *Crataegus*.

**Heath.** See *Erica*.

**Heather.** *Calluna*. See *Erica* (Heath).

**Hebe spp.** Hebe, Veronica. Propagated by seed, by leafy cuttings in summer under mist, or by layering. Hebe is commercially micropropagated.

**Hedera helix.** English Ivy. English ivy is readily propagated by rooting cuttings of the juvenile (nonfruiting, lobed-leaf) form. For *H. canariensis* (Algerian ivy), cuttings are taken after first growth flush and treated with a 1,000 ppm IBA quick-dip (131). *H. helix* is also sometimes grafted onto Fatshedera (*Fatsia japonica* x *Hedera helix*) as a rootstock.

**Hemlock.** See *Tsuga*.

**Heptacodium miconioides.** Seven Son Flower. A small deciduous flowering tree in the *Caprifoliaceae* family, which is native to China. It has potential as a new nursery crop because of its exfoliating bark, vigorous growth, and fragrant, white, late-summer flowers. In the fall it has beautiful rose to crimson fruit display that is as ornamental as the flowers. Best rooting occurred with basal and middle softwood cuttings and basal semi-hardwood cuttings (266). A quick-dip of 5,000 ppm K-IBA enhanced rooting. Shoots from



lateral cuttings appear to exhibit plagiotrophic growth, but vertical shoots will rapidly grow from the base of the plant. Plagiotrophic growth can be reversed by growing rooted cuttings for a season or two and then cutting back to one bud.

***Heteromeles arbutifolia.*** Toyon, Christmas Berry. Usually propagated by seed, which is stratified for 3 months or sown in the fall to obtain outdoor winter chilling of the seed. It can be rooted from softwood tip cuttings that are taken in mid-spring, treated with 8,000 ppm IBA talc, and placed under mist (185). It can also be propagated by layering.

***Hibiscus* spp.** Hibiscus.

**Seed.** There are no pregermination requirements. Seed propagation is not commonly used for propagation.

**Cuttings.** Softwood and hardwood cuttings of *H. rosa-sinensis* (Chinese hibiscus) are not difficult to root; however, there are cultivar differences (242). Softwood and semi-hardwood cuttings are rooted under mist in liner pots with peat:perlite, peat blocks, or rock wool to prevent root damage during transplanting. In Australia, soft-tip cuttings 11 cm (4 in) long are taken from December to April and treated with 5,000 ppm IBA, and rooted under mist. Cultivars that root rapidly receive maximum benefit from propagation medium temperatures of 26 to 30°C (79 to 86°F) (77).

*H. syriacus* (Hibiscus, Shrub-althea, Rose of Sharon) are propagated, either by hardwood cuttings in the nursery row in spring or by softwood cuttings in midsummer under mist. Lateral shoots make good cutting material. Softwood cuttings respond well to treatment with a 1,000 ppm IBA quick-dip. Deciduous, hardwood cuttings have rooted well when treated with 8,000 ppm IBA talc. Softwood cuttings root faster than hardwood.

**Grafting.** Vigorous cultivars of *H. rosa-sinensis* which are resistant to soil pests and can be started easily by cuttings—such as ‘Single Scarlet,’ ‘Dainty,’ ‘Euterpe,’ or ‘Apple Blossom’—are also used as rootstocks. Some clones develop into much better plants when grafted on these rootstocks than on their own root system from cutting propagation. Whip grafting in the spring or cleft grafting or side grafting in late spring or early summer is successful. Scions of current season’s growth, about pencil size, are grafted on rooted cuttings of about the same size (373).

In New Zealand, simultaneous bench grafting and rooting is done with a grafting tool that makes matching “V” cuts in the scion and unrooted rootstock. After wrapping the graft union with floral tape,

the grafted rootstock is quick-dipped with 2,000 ppm IBA and rooted under mist (32).

**Micropropagation.** Hibiscus is commercially micropropagated.

**Hickory.** See *Carya*.

**Holly.** See *Ilex*.

**Honey Locust (Common).** See *Gleditsia*.

**Honeysuckle.** See *Lonicera*.

**Hornbeam.** See *Carpinus*.

**Horse Chestnut.** See *Aesculus*.

***Hovenia dulcis.*** Japanese Raisin Tree. Used for ornamental, medicinal, and fruit production. Seeds should be collected in the fall (Delaware). Fruits are dried, cracked, and added to water to separate the seeds. Discard seeds that float. The remaining seeds are scarified with sulfuric acid for 45 minutes, stratified by storage at 5°C (41°F) for 90 days, and planted in seedling flats (169).

**Huckleberry (Evergreen).** See *Vaccinium*.

***Hydrangea* spp.** Most species are propagated by cuttings and not seeds. Seed propagation is used for plant breeding purposes. While seeds germinate without pretreatment, cold stratification enhances germination (131). Hydrangea are generally easy to root. Softwood and semi-hardwood cuttings are treated with 1,000 ppm IBA, and hardwood cuttings and more difficult-to-root species with 3,000 to 5,000 ppm IBA as a talc or quick-dip (131). In Oregon, soft-tip cuttings of *H. pedicularis* are taken late May to early June, treated with 1,000 ppm IBA, and rooted under mist. In Michigan, softwood cuttings [10 to 15 cm (4 to 6 in)] at 1 cutting per tray cell are propagated from April to September, and hardwood cuttings [15 to 20 cm (6 to 8 in)] at 2 to 3 per tray cell from November to March are used (105). Prophylactic fungicides applied at 2 days after sticking, and then rotated on 21-day cycle, include Terrachlor-75WP, Cleary 3336, BannerMax, Terrazole, and Chipco (105). Cuttings are quick-dipped in 500 ppm IBA:330 ppm NAA. In Alabama, *H. quercifolia* roots well from spring to early summer. Half of the leaf surface on one-node cuttings are trimmed off and the cuttings are dipped in 2,500 ppm IBA. Rooted liners do not overwinter well in a warm greenhouse, so they must be kept cool during the winter. Florists’ hydrangea have been rooted with 5,000 to 10,000 ppm IBA talc under mist (16).

Forcing epicormic shoots from woody stem segments [0.5 m (1.5 ft) long with a 2.5 to 25 cm (1 to





10 in) caliper] under mist and rooting the softwood cuttings can be used to propagate *H. quercifolia* oak leaf hydrangea (332). This species is unique in that individual stem segment continue to produce softwood shoots for several successive months. Softwood cuttings are treated the same as if collected from a field-grown stock plant. Drench weekly with Banrot 40% WP fungicide.

Hydrangea is commercially micropropagated (17).

***Hypericum* spp.** St. John's wort. Easily started by softwood cuttings taken in late summer from the tips of current growth and rooted under high humidity or mist. *Hypericum* is commercially micropropagated.

***Ilex* spp.** Holly. Can be propagated by seeds, cuttings, grafting, budding, layering, division, and micropropagation (161, 381). *Cutting propagation is the preferred method for producing superior clones.* Most hollies are dioecious. The female plants produce the very desirable decorative berries if male plants are nearby for pollination. For most hollies, any male will pollinate the female flower as long as the two are in bloom at the same time and planted fairly close together. In seed propagation, sex cannot be determined until the seedlings start blooming at 4 to 12 years.

**Seeds.** The only reason to grow seedlings is for rootstock graftage, or for breeding and selection work. Germination of holly seed is very erratic; species such as *I. crenata*, *I. cassine*, *I. glabra*, *I. vomitoria*, *I. amelanchier*, and *I. myrtifolia* germinate promptly and should be planted as soon as they are gathered. Seeds of other species, *I. aquifolium* (English holly), *I. cornuta* (Chinese holly), *I. verticillata*, *I. decidua*, and most *I. opaca* (American holly), should be collected and cleaned as soon as the fruit is ripe in the fall and then stored at about 4°C (40°F) until spring in a mixture of moist sand and peat moss; they do not germinate until a year or more after planting even though stratified, due to rudimentary embryos at the time of harvest. For deciduous hollies (*I. verticillata*, *I. decidua*), stratify seeds for 3 to 4 months, and if no germination occurs, place seeds under warm stratification at 20 to 30°C (68 to 86°F) for after-ripening and embryo development for 2 to 3 months—followed by a 2- to 3-month cold stratification period (125).

**Cuttings.** This is the method most used commercially, permitting large-scale production of superior clones. Semi-hardwood tip cuttings from well-matured current season's growth produce the best plants. Cuttings taken from flat, horizontal branches of *I. crenata* tend to produce prostrate plants (plagiotropic) and those from upright growth produce upright (orthotropic) plants.

Timing is important—best rooting is usually obtained from mid to late summer, but cuttings may be successfully taken into the following spring. Wounding the base of the cuttings helps induce root formation. The wounding induced by stripping off the lower leaves may be sufficient.

The use of auxins, particularly IBA at relatively high concentrations (8,000 to 10,000 ppm), is essential in obtaining rooting of some cultivars, such as *I. opaca* 'Savannah' (10,000 ppm IBA liquid), whereas 2,500 ppm IBA is sufficient for medium-difficult species such as *I. cornuta* (38). Semi-hardwood cuttings of *I. crenata* root best with 8,000 ppm talc, whereas hardwood cuttings should be treated with a 10,000 ppm IBA dip. Deciduous hollies such as *I. serrata*, *I. decidua*, and *I. verticillata* are best rooted in early July (Indiana) with 10 to 13 cm (4 to 5 in) cuttings having four to five nodes; the bottom leaf is stripped off and the cutting quick-dipped in 5,000 ppm IBA. Hollies can be sensitive to solvents used as IBA carriers. They usually exhibit chlorosis, followed by defoliation, e.g., *I. vomitoria* is sensitive to alcohol quick-dips. It is best to switch to water-based K-IBA products.

*I. vomitoria* 'Nana' are direct-stuck into 6-cm (2 1/4-in) liner pots using 3,000 ppm K-IBA spring-summer (Alabama) and 5,000 ppm K-IBA fall-winter (139). Semi-hardwood cuttings taken in early fall (Alabama) are strip-wounded at the base by tearing off the lowest branch and given a three-second dip with 2,000 ppm IBA (189, 190). Using NAA on *I. vomitoria* will burn the stem and cause defoliation. Bottom heat at 21 to 24°C (70 to 75°F) is beneficial. A table of liquid auxin solutions for *Ilex* taxa has been published (40).

**Micropropagation.** *Ilex* are commercially micropropagated.

***Illicium* spp.** Anise. Medium-sized, fragrant, evergreen shrubs that are fragrant. Seed propagation requires no pretreatment; however, most species are propagated by semi-hardwood cuttings, with good to poor rooting, depending on the species. Summer cuttings treated with a 3,000 ppm IBA quick-dip are rooted in peat-perlite media with mist (123).

**Incense Cedar.** *See Calocedrus.*

**Indigo Bush.** *See Amorpha.*

**Ironwood.** *See Casuarina.*

***Jacaranda mimosifolia.*** Jacaranda. Propagation is by softwood cuttings, grafting, or by seed. Easily propagated by seed taken from capsules after blooming (432). Seeds should be sown fresh for best germination





results; fresh seed soaked in water for 24 hours prior to sowing. A white flowering form is grafted in California.

**Jamesia americana.** Cliffbush. A native shrub of United States Rocky Mountain states with peeling bark with white and pink flowers. Seeds require a 4-month cold stratification period (23). Seedlings should not be overwatered and prophylactic application of Daconil or similar fungicide is recommended. Can be propagated by softwood cuttings. Semi-hardwood cuttings should be wounded and direct stuck into liner pots. No auxins are applied, but bottom heat is recommended. Go light on the mist. Cuttings root in about 3 weeks with a 50 to 60 percent success rate (23).

**Japanese Raisin Tree.** See *Hovenia*.

**Japanese Ternstroemia (Cleypa).** See *Ternstroemia*.

**Jasmine (Asiatic).** See *Trachelospermum*.

**Jasmine ('Maid of Orleans,' 'Sambac Jasmine,' and 'Grand Duke').** See *Jasminum*.

**Jasmine (Star, Confederate).** See *Trachelospermum*.

**Jasminum spp.** Jasmine. Propagated without difficulty by leafy semi-hardwood cuttings taken in late summer and rooted under mist. *J. sambac* 'Maid of Orleans,' 'Sambac Jasmine,' and 'Grand Duke' are propagated by single- or double-node cuttings that root within 4 to 5 weeks. Cuttings of *J. nudiflorum* root best when treated with a 3,000 ppm IBA quick-dip (115). Layers and suckers also can be used.

**Juglans spp.** Walnut. See Chapter 19.

**Juniperus spp.** Juniper. Junipers are divided into ground cover types, bushes, and upright pyramidal types. They are generally propagated by cuttings, but in some cases difficult-to-root species such as the upright types are grafted onto seedlings or select cutting-grown clonal rootstock.

**Seeds.** Seedlings of the red cedar, *Juniperus virginiana* or *J. chinensis*, are ordinarily used as rootstocks for grafting ornamental clones. Seeds should be gathered in the fall as soon as the berry-like cones become ripe. For best germination, seeds should be removed from the fruits, then treated with sulfuric acid for 30 minutes before being stratified for about 4 months at 4°C (40°F). Rather than the acid treatment, 2 to 3 months of warm [21 to 30°C (70 to 85°F)] stratification, or summer planting, could be used. As an alternative for cold stratification, the seed may be sown in the fall. Germination is delayed at temperatures above 15°C (60°F). Viability of the seed varies considerably

from year to year and among different lots, but it never germinates much more than 50 percent. Treated seed is usually planted in the spring, either in outdoor beds or in flats in the greenhouse. Two or three years are required to produce plants large enough to graft. For various species germination has been improved by treating with different stimulants, such as citric acid, hydrogen peroxide, and gibberellic acid.

**Cuttings.** The spreading, prostrate types of junipers are more easily rooted than upright kinds. Auxins enhance rooting, with easy-to-root types (*J. horizontalis*) treated at lower concentrations and more difficult-to-root species (*J. virginiana*) treated at higher auxin levels. Cuttings are made 5 to 15 cm (2 to 6 in) long from new lateral-growth tips stripped off older branches. Sometimes a small piece of old wood—a heel—is left attached to the base of the cutting. In other cases, good results are obtained when the cuttings are just clipped without the heel from the older wood. Terminal growth of current season's wood also roots well.

Cuttings to be rooted in the greenhouse can be taken at any time during the winter (209) or rooted outdoors on heated beds (southern California). In more temperate areas, exposing the stock plants to several hard freezes seems to stimulate better rooting. Optimum time for taking cuttings is when stock plants have ceased growth (late fall-winter propagation period is more successful than during summer). For propagating in an outdoor cold frame, cuttings are taken in late summer or early fall. There may be advantages to using bottom heat.

Lightly wounding the base of the cuttings is sometimes helpful, as is the use of IBA. Recommendations have included 2,500 IBA quick-dip (Alabama) for medium-difficult juniper species to 3,000 to 8,000 ppm IBA liquid or talc. For upright junipers, one large California nursery uses combinations of 3,000 to 6,000 ppm K-IBA (102).

Maintaining a minimum bottom heat of 16 to 18°C (60 to 65°F) is critical during the first 6 weeks of propagation in order for the basal wound of cuttings to callus. In southern California, heat is withheld for 6 weeks to allow callusing, then bottom heat is raised to 21 to 24°C (70 to 75°F) to encourage rooting (102). In the southern United States (Gulf Coast), many growers use no bottom heat during the rooting process and take advantage of the ambient temperatures. Hardwood cuttings can be rooted in outdoor field beds. Optimal rooting of dwarf Japanese juniper (*J. procumbens* 'Nana') occurred with an IBA quick-dip or talc at 8,000 ppm; rooted cuttings were potted up after



15 weeks and unrooted, but callused cuttings were re-treated with IBA and restuck in a peat:perlite medium to allow for further rooting (55).

In North Carolina, optimum rooting of eastern red cedar (*J. virginiana*) occurred with hardwood cuttings collected in January, then wounded, treated with 5,000 ppm IBA, and rooted under mist in a propagation house (204). Unlike many coniferous species, eastern red cedar has no problem with plagiotropism (undesirable prostrate growth); cuttings from lateral branches retain an upright growth habit after rooting.

**Grafting (18, 326).** Vigorous seedling rootstocks with straight trunks, about pencil size, are dug in the fall from the seedling bed and potted in small pots set in peat moss in a cool, dry greenhouse. Seedlings potted earlier—in the spring—may also be used for grafting in the wintertime. About 2 to 3 weeks before grafting, the rootstock is brought into the greenhouse to induce root activity before grafting takes place. Seedlings can give variable graft results, and later, variable growth of the grafted plant. In Oregon, *J. virginiana* ‘Skyrocket,’ which is clonally propagated from cuttings and has a very columnar form resembling a rocket, is widely used as a rootstock or standard for patio tree grafts.

The scions should be selected from current season’s growth taken from vigorous, healthy plants and preferably of the same diameter as the rootstock to be grafted. Scion material can be stored under high humidity at  $-1$  to  $4^{\circ}\text{C}$  ( $30$  to  $40^{\circ}\text{F}$ ) for several weeks until used.

Side-veneer or other side-graft methods are ordinarily used. The unions are best tied with budding rubber strips. The grafted plants are set in a greenhouse bench filled with peat moss deep enough to cover the union. The temperature around the graft union should be kept as constant as possible at  $24^{\circ}\text{C}$  ( $75^{\circ}\text{F}$ ) with a relative humidity of 85 percent or more around the tops of the plants. A lightly shaded greenhouse should be used to avoid injuring the grafts. Adequate healing will take place in 2 to 8 weeks, after which the temperature and humidity can be lowered. The rootstock plant is then cut off above the graft union to allow the scion to develop.

***Kalmia* spp.** Mountain Laurel. Can be propagated readily by seed germinated at about  $20^{\circ}\text{C}$  ( $68^{\circ}\text{F}$ ). Germination of *K. latifolia* (mountain laurel) seed is enhanced by cold stratification for 8 weeks, or by a 12-hour soak in 200 ppm gibberellic acid (230, 231). Seeds of *K. latifolia* should not be covered during

sowing, since they require light for germination (continuous light is optimal) and the seeds are extremely small [1.4 million seeds/28 g (1 oz)] (278). Rooting of *Kalmia* is highly variable among species and cultivars. Some respond to higher IBA concentration (8,000 ppm), but others do not (164). *Kalmia* can also be propagated by cleft or side grafting, or by layering.

*K. latifolia* cultivars are commercially micropropagated, which alleviates rooting problems and is probably the most efficient propagation method (62, 272).

**Kentucky Coffeetree.** See *Gymnocladus*.

***Koelreuteria* spp.** Goldenrain Tree. This tree is usually propagated by seed. Seeds germinate best if the seed coats are scarified for about 60 minutes in sulfuric acid or by mechanical scarification, followed by stratification for about 90 days at 2 to  $4^{\circ}\text{C}$  ( $35$  to  $45^{\circ}\text{F}$ ) to overcome embryo dormancy. In southern California, stratification is avoided by pouring  $83^{\circ}\text{C}$  ( $180^{\circ}\text{F}$ ) water on seeds and soaking overnight. Can be propagated from root cuttings, and shoots that develop from the root cuttings can also be taken as softwood cuttings in the spring and treated with 1,000 to 3,000 ppm IBA and rooted under mist.

***Laburnum* spp.** Laburnum, Golden Chain. Propagated by seed which are scarified for 2 hours in sulfuric acid. Seeds are poisonous if eaten. Some cultivars are propagated by grafting or budding on laburnum seedling rootstock.

***Lagerstroemia indica*.** Crape Myrtle. Seeds will germinate readily without pregermination treatment. However, *this species is commercially propagated by cuttings* because it is easily rooted from softwood or hardwood cuttings. Most softwood cuttings are much easier to root prior to flower initiation. An IBA quick-dip of 1,000 to 1,250 ppm will aid root formation. Most cultivars are easy to transplant; however, some dwarf cultivars must be transplanted with a ball of soil. Hardwood cuttings of field-grown plants are gathered after the first hard frost, sawed into 8-inch (20-cm) cuttings, graded, bunched, stored over winter, and then planted in open fields in spring (March in Alabama) without auxin treatment. Eighty percent rooting is achieved (72, 73) using this method. Crape myrtle can be micropropagated (454).

**Larch.** See *Larix*.

***Larix* spp.** Larch. Most of these deciduous conifers are propagated easily by fall-planted seeds (202). Cones should be collected before they dry and open on the



tree. Several species have empty or improperly developed seeds. Seeds of some species have some embryo dormancy, so for spring planting, stratification for 1 month at about 4°C (40°F) is advisable. Cutting propagation is best done by rooting leafy, semi-hardwood cuttings in late summer under mist. IBA at a 8,000 ppm quick-dip or 2,000 ppm talc promotes rooting, but only at a low percentage. Cutting material should be taken from young trees only.

Selected cultivars are side-veener grafted and weeping forms are top-grafted (whip and tongue) on established seedling rootstock during the winter.

Adult larch trees have been successfully micropropagated by shoot-tip culture and plantlets that are acclimatized (251).

**Laurel (Cherry, English).** See *Prunus*.

***Laurus nobilis*.** Bay Laurel. It is normally propagated by seed. Seed germination is best with mechanical scarification, followed by a 30-day cold stratification. Rooting of stem cuttings should be carried out in the summer (Israel), which is the period of most active growth. Semi-hardwood cuttings from hedged trees root better than softwood cuttings (342).

***Leptospermum* spp.** Tea Tree. Some species of this Australian native must be propagated by seed. Cultivars of other species, such as *L. scaparium*, can be readily propagated by cuttings.

***Leucophyllum* spp.** *L. frutescens*, *L. candidum* (Texas Sage, Purple Sage). Easily propagated from seed, but cuttings are preferred. Softwood, succulent cuttings from 8 to 10 cm (3 to 4 in) are treated with 8,000 ppm IBA talc, and propagated under mist in a well-drained propagation medium (e.g., 100 percent perlite). Cuttings will root in 3 to 4 weeks under high light and a propagation medium temperature of 20 to 22°C (70 to 72°F).

Rooting is enhanced when leaf tissue of stockplants is greater than 2 percent nitrogen. For *L. candidum* 'Silver Cloud,' stock plants are cut back to force new growth (244). In June, softwood cuttings are treated with 7,500 ppm IBA, stuck in perlite media, maintained at 25 to 30°C (77 to 86°F) and rooted under mist. Go light on the mist. Forced softwood cuttings collected later in summer (Arizona) are treated with 2,500 ppm IBA (244). Diseases after rooting cause major problems with survivability. It is difficult to transplant, so the best practice is to direct-stick (root) in small liner pots.

***Leucospermum* spp.** Leucospermum, Protea. *L. conocarpodendron* x *L. cuneiforme* 'Hawaii Gold,' which is a cut-flower protea. Leucospermum is micropropagated

(256). See *Grevillea* for other proteaceous plants that can be micropropagated.

***Leucothoe* spp.** Switch Ivy, Drooping Leucothoe (*L. fontaneisana*), Coast Leucothoe (*L. axillaris*). Evergreen shrubs with white, pitcher-shaped flowers. Because of the small seed size and light requirement to germinate, seeds should not be covered with media during propagation. Seeds can be germinated at 25°C with continuous light (50). Shrubs can be asexually propagated by stem cuttings from June to December (southern United States). Treating with 1,000 to 3,000 ppm IBA will hasten rooting but is optional (131). Terminal cuttings 10 to 13 cm (4 to 5 in) long are taken, and leaves stripped from the basal end 2.5 cm (1 in). Cuttings root in 10 to 12 weeks and can be transplanted after rooting. Leucothoe is commercially micropropagated.

**Leyland Cypress.** See *xCupressocyparis*.

***Ligustrum* spp.** Privet. Seed propagation is easily done. The cleaned seed should be stratified for 2 to 3 months at 0 to 10°C (32 to 50°F) before planting. Hardwood cuttings of most species planted in the spring root easily, as do softwood cuttings in summer under mist. Japanese privet (*L. japonicum*) is somewhat difficult to start from cuttings, but good results were obtained with actively growing terminal shoots rather than more mature wood. Treat with a 2,500 ppm IBA quick-dip (38).

**Lilac.** See *Syringa*.

**Linden.** See *Tilia*.

***Lindera* spp.** Spicebush. *L. obtusiloba* (Japanese spicebush) is propagated by cuttings quick-dipped with 4,000 ppm NAA or 8,000 ppm IBA (131). *L. benzoin* [(American) spicebush] is native to the U.S. eastern seaboard, west to Kansas. Propagation by cuttings is difficult, but propagation by seed is successful with a cold stratification treatment of 3 months (330). *Lindera* is micropropagated.

***Liquidambar styraciflua*.** Liquidambar, American Sweet Gum. Propagation is usually by seeds, which are collected in the fall. Seeds are stratified for 1 to 3 months at about 4°C (40°F) to overcome seed dormancy. Sweet gum can also be propagated by stem cuttings treated with 4,000 to 8,000 ppm IBA—overwintering may be a problem. Girdling of 10-year-old *L. formosana* prior to taking cuttings, and IBA treatment enhanced rooting (195). Selected clones are grafted or T-budded from spring through fall onto *L. styraciflua* seedlings. Sweet gum is commercially micropropagated (58, 59, 270, 401).





***Liriodendron tulipifera*.** Tulip Tree, Yellow Poplar. Seed propagation is somewhat difficult. Seeds of this species are often devoid of embryos, so cutting tests of each seed lot should be made. Seeds should be stratified for about 2 months before planting and should not be allowed to dry out. Fall planting, with outdoor stratification through the winter, also has given good germination.

Although considered difficult to root, leafy stem cuttings taken in summer that are not fully hardened have been rooted in fairly good percentages. Can be propagated by root cuttings. Propagation by both budding and grafting is successful. Cultivars can also be chip budded.

**Loblolly Bay.** See *Gordonia*.

**Locust (Black).** See *Robinia*.

***Lonicera* spp.** Honeysuckle. Seeds show considerable variation in their dormancy conditions, some species having both seed-coat and embryo dormancy, while others have only embryo dormancy, or no dormancy inhibition. This variability also occurs among different lots of seeds of the same species. In *L. tatarica*, some lots have no seed dormancy. In general, however, for prompt germination, stratification for 2 to 3 months at about 4°C (40°F) is recommended. Seeds of *L. hirsute* and *L. oblongifolia* should have 2 months of warm stratification [21 to 30°C (70 to 85°F)], followed by 2 to 3 months of cold stratification at about 4°C (40°F).

Most honeysuckle species are propagated easily by hardwood cuttings, softwood cuttings (spring), or semi-hardwood (summer) cuttings treated with a 1,000 ppm IBA talc and propagated under mist. Layering of vine types, such as 'Hall's' honeysuckle, is very easy, since roots form wherever the canes become buried under moist soil.

**Loquat.** See *Eriobotrya*.

***Loropetalum chinense*.** Chinese Witch Hazel. An evergreen shrub that averages 3 m (10 ft). 'Rubrum' has ruby-red, purplish-red to greenish-purple leaves and salmon-pink flowers. Propagated by hardwood cuttings treated with a 3,000 ppm K-IBA quick-dip (127). It is commercially micropropagated.

***Maclura pomifera*.** Osage-orange. A tree for difficult sites. Can be seed-propagated with a 30-day stratification treatment (313). A 2-day water soak overcomes dormancy and permits germination without stratification (131). Male and thornless cultivars 'Altamont,' 'Park,' and 'Wichita' can be asexually produced by softwood cuttings or hardwood cuttings (January, Kansas) treated with 5,000 to 10,000 ppm IBA. This species

can also be budded. Osage-orange can also be micropropagated (248).

**Madrone (Pacific).** See *Arbutus*.

***Magnolia* spp.** Magnolia. Seeds, cuttings, grafting, layering, and micropropagation are utilized in propagating magnolias.

**Seeds.** Magnolia seeds are gathered in the fall as soon as possible after the fruit is ripe, when the red seeds are visible all over the fruit (64). The red pulp on *M. grandiflora* seed acts as an inhibitor to germination, so cleaning is very important. After cleaning, the seeds should be either sown immediately in the fall or—prior to spring planting—stratified for 2 to 3 months at about 4°C (40°F). Allowing the seeds to dry out during storage seems to be harmful. *M. grandiflora* seeds, and some other species, lose their viability if stored through the winter at room temperature. If prolonged storage is necessary, the seeds should be held in sealed containers at 0 to 4°C (32 to 40°F). Magnolia seedlings grow rapidly, and generally are large enough to graft by the end of the first season. Transplanting should be kept at a minimum, since it retards the plants.

**Cuttings.** There is no one best way to root a magnolia cultivar. Some species, such as *M. soulangiana* and *M. stellata*, are commercially propagated by leafy softwood cuttings. Cuttings may be taken from late spring to late summer after terminal growth has stopped and the wood has become partly matured.

With *M. stellata*, 6 to 10 cm (2 to 4 in) softwood leaf-bud cuttings are wounded on the opposite side of the bud and the leaf blade is reduced 50 to 60 percent. The cutting is treated with a 8,000 ppm IBA talc or quick-dip (260). *M. stellata* can also be rooted using four- to five-node semi-hardwood cuttings. The cuttings are taken in July to early August (Canada), the basal leaf is stripped, and the cutting is quick-dipped in an ethanol-based IBA (5,000 ppm) (218).

Leafy cuttings of *M. grandiflora* (with two to four leaves per cutting) are taken from late spring to late summer. Terminal buds should be hardened and not initiating new growth. Wounding can cause rotting, but enhances rooting in some cultivars. Auxins are needed to root *M. grandiflora*. Generally, a range of 3,000 to 8,000 ppm IBA, or combinations of K-IBA and K-NAA, give best results; cultivars are treated with as little as 1,000 ppm to a high of 15,000 ppm auxin combinations (200). *M. grandiflora* root best with mist under warm conditions, i.e., a bottom heat of 24°C (75°F), minimum 16°C (60°F) in winter (200).



With *M. grandiflora* there is considerable cultivar variation in rooting. Brown-black cultivars are harder to root, with the hairy felt on the leaves that makes moisture control more difficult. Other reports indicate that semi-hardwood cuttings root well when quick-dipped in 5,000 to 10,000 ppm NAA in 50 percent alcohol (123). Cuttings should be rooted early enough in the season so that some resumption of growth will occur before fall, which will allow them to survive through the winter. In Scotland, the leaf blade of leaf-bud or nodal-tip cuttings is partially trimmed to reduce transpiration, save propagation space, and allow sufficient air circulation; cuttings are treated with 3,000 ppm IBA in talc or a 1,000 ppm quick-dip, and propagated under mist with a basal rooting temperature of 18°C (64°F) (121).

In South Carolina, *M. grandiflora* 'Little Gem' are stuck in August and rooted by February of the next year. Cuttings are maintained at an initial 35°C (95°F) air temperature [minimum 16°C (60°F) bottom heat in late fall/winter], single wounded, and quick-dipped in 5,000 ppm IBA + 2,500 ppm NAA (200). In Mississippi, 13 cm (5 in) cuttings of *M. grandiflora* 'Little Gem,' 'Red Robbins,' 'D. D. Blanchard,' 'Claudia Wanamaker,' 'Green Giant,' and 'Bracken's Brown Beauty' are taken in mid summer. Cuttings are wounded on 2 sides, about 5 to 7 cm (2 to 3 in) along the cutting base with a potato peeler. The cuttings are then given a quick-dip of 2,500 ppm K-IBA or equivalent IBA concentration of Dip'N Grow (31), then propagated at near 100 percent relative humidity at 38°C (100°F).

*M. acuminata* have uncommon yellow flowers but are difficult to propagate. Terminal cuttings had greater rooting when collected 5 to 7 weeks after budbreak and treated with 16,000 to 30,000 ppm IBA talc (376).

*M. virginiana* 'Santa Rosa' (Santa Rosa sweetbay) can be propagated from semi-hardwood cuttings (tips of first-order laterals) trimmed to 10 to 15 cm (4 to 6 in) with leaves removed from the lower half of the cuttings and the remaining leaves cut in half perpendicular to the midrib (186). A 5,000 ppm quick-dip of IBA enhanced rooting of cuttings.

**Layering.** *M. grandiflora* is also commercially air-layered in Florida. The layer is girdled with a disposable scalpel, 10,000 ppm IBA talc applied, and then covered with a split, moist Oasis root cube, and wrapped with aluminum foil (see Fig. 14–6) (74). With *Magnolia xsoulangiana* (saucer or oriental magnolia)—while commonly propagated by cuttings that are wounded, treated with 8,000 ppm IBA, and rooted under mist—can

also be layered (Alabama) via wounding with a tongue cut half-way through the stem, and covered with sphagnum treated with 8,000 ppm IBA (92).

**Grafting.** *Magnolia kobus* is probably the best rootstock for the Oriental magnolias, whereas *M. acuminata* can be used as a rootstock for either Oriental or American species. *M. sprengeri* 'Diva' makes excellent, comparably vigorous rootstocks for the large Asian species and their hybrids. *Magnolia grandiflora* seedlings are used for *M. grandiflora* cultivars.

Winter or bench graftage using side-veneer grafts are satisfactory, with the union and scion taped or waxed after grafting. Some propagators pot the seedlings in the fall, then bring them into the greenhouse and do the grafting in midwinter. The newly grafted plants may be set on open benches in the greenhouse or placed in closed propagating frames, where they stay for 7 to 10 days while the union is healing.

Cleft grafting *M. grandiflora* with containerized seedling rootstock has been reported in Alabama and Mississippi (39). Chip budding is possible throughout the growing season and has been used with more difficult-to-root cultivars budded onto container-grown rootstock (121, 205, 260) and with field-grown rootstock (214). Seedling rootstock tends to sucker and must be maintained (286). Clonal rootstock (from rooted cuttings) are also being utilized to better accommodate caliper differences that frequently occur between scions and seedling rootstocks (214). Clonal rootstocks are being selected for dwarfing characteristics so that Magnolias can be sold in bloom and better accommodate smaller-sized, urban gardens.

**Micropropagation.** Magnolias are commercially micropropagated.

**Mahogany.** See *Swietenia*.

**Mahonia spp.** Mahonia. Seed propagation is generally easy for most species, but cuttings can be difficult (101). *M. bealei*, *M. lomarifolia*, and *M. japonica* are easy to grow from seed and do not require special treatments. *M. aquifolia* and *M. repens* seed must be separated from the fruit pulp, leached of inhibitors (for 1 week with a slow continuous flow of water), and later stratified for either 3 months (Georgia) or a total of 5 months (California). Cuttings of *M. aquifolium* 'Compacta' are collected in fall or winter, quick-dipped with 3,000 ppm IBA, and rooted under mist with 25°C (77°F) bottom heat; 8,000 ppm IBA talc has also been used with cuttings of *M. bealei*, *M. nervosa*, *M. pinnata*, *M. repens*, and *M. wagneri* (131).



**Malus spp.** Crab Apple (Flowering). Crab apples can be produced from seed, rooted as cuttings, grafted or budded, and some cultivars are commercially produced from micropropagation.

**Seed.** Four species of crab apples—*M. toringoides*, *M. hupehensis*, *M. sikkimensis*, and *M. florentina*—will reproduce true from seed. Seed is also used for rootstock production for grafting. Seed should be cold stratified for 60 days, but some species require longer durations up to 120 days.

**Cuttings.** Selected forms of all other crab apple species, such as *M. sargentii*, *M. floribunda*, and *M.* ‘Dolgo,’ should be *clonally propagated by asexual methods*, which results in a stronger, more uniform crop. *M.* ‘Hopa,’ ‘Almey,’ and *M. xeleyi* are commercially propagated with July semi-hardwood cuttings (Florida), which are wounded at the base, quick-dipped in 5,000 ppm K-IBA, and rooted under mist within 4 to 6 weeks (106). Hardwood cuttings of crab apples are difficult to root. Establishing selected crab apple cultivars and species on their own root system with softwood cuttings is cheaper and avoids rootstock suckering, crooks in the trunk, and graft incompatibility associated with traditional grafting and budding systems (66). Softwood cuttings taken in late spring root when treated with 3,000 to 8,000 ppm IBA in talc (428) or 2,500 to 10,000 ppm IBA liquid under mist (123).

**Grafting.** Nursery trees are commonly propagated either by root grafting, using the whip graft, or by T-budding and chip budding (see Fig. 13–10) rootstock in the nursery row. Budding is done either in spring or summer (428). Summer budding (late summer in Oregon) is considered by most nursery people to be the faster and most desirable method of propagating crab apples. Various seedling rootstocks have been used, such as *M. xdomestica* (common apple), *M. baccata*, *M. ioensis*, and *M. coronaria*. Hardiness and suckering can be a problem with some seedling rootstock.

To eliminate suckering, clonal apple rootstock—‘EMLA 111’ and semi-dwarfing ‘M7a’—are used. They also give better anchorage than own-rooted crabs and give a moderate improvement in root-hardiness (Oregon). While T-budding generally works well on domestic apple rootstock, chip budding is preferable with ‘EMLA 111’ (428). Crab apples are commercially micropropagated (382).

**Mandevilla spp.** Mandevilla ‘Alice DuPont.’ Take one-node cuttings and trim off half of the leaf surface and dip cuttings in 2,500 ppm IBA. In Alabama, cuttings are rooted in July, rooted liners planted in October, and

plants finished off and sold in 3.7-liter (1-gal) containers in April.

**Manzanita.** See *Arctostaphylos*.

**Maple.** See *Acer*.

**Melaleuca spp.** The seeds of these native Australian species are almost dustlike but germinate easily and can be handled like eucalyptus seed.

**Mesquite.** See *Prosopis*.

**Metasequoia glyptostroboides.** Metasequoia, Dawn Redwood. Seeds germinate without difficulty, and both softwood and hardwood cuttings will root (98). The leafless hardwood cuttings may be lined-out in the nursery row in early spring. Leafy cuttings root easily under mist if taken in summer and treated with 3,000 to 8,000 IBA talc or quick-dip.

Cultivars can be grafted and weeping forms are top grafted on seedling rootstocks.

**Mimosa.** See *Albizzia*.

**Mock Orange.** See *Philadelphus*.

**Monkey Puzzle Tree.** See *Araucaria*.

**Morus spp.** Mulberry. *M. alba* (fruitless or white mulberry) and *M. nigra* (black mulberry). Some mulberry trees produce only male flowers and hence do not bear fruits. Seeds need to be separated from fruits; some seeds have dormant embryos. Seeds collected in early summer, cleaned, and sown have high percent germination. Stored seeds, cold stratified for 1 to 3 months, can be sown in the spring. Roots easily from semi-hardwood (summer cuttings) and hardwood cuttings treated with 8,000 ppm talc or 10,000 to 15,000 ppm IBA quick-dip. *M. nigra* is more difficult to propagate, is clonally regenerated using hardwood cuttings treated with 4,000 to 5,000 ppm IBA and bottom heat or softwood cuttings treated with 4,000 to 8,000 ppm IBA (421). *M. nigra* can be T-budded and chip budded (421). *M. alba* ‘Pendula’ is grafted on a standard of *M. alba* ‘Tatarica’ to produce a small weeping tree (131). The fruitless *Morus alba* ‘Chaparral’ is also grafted. Mulberry is commercially micropropagated, and *M. nigra* microcuttings have high rooting and a 90 percent survival (227).

**Mountain Ash.** See *Sorbus*.

**Mountain Laurel.** See *Kalmia*.

**Mulberry (Fruitless).** See *Morus*.

**Mussaenda.** See *Mussaenda* spp.





***Mussaenda* spp.** Mussaenda. Ornamental shrubs indigenous to the Pacific Islands, Asia, and Africa; they are important ornamental species in the Philippines. Low pollen fertility and poor fruit production limit seed propagation. They are difficult to propagate by cuttings, but rooting of *M. erythrophylla* 'Ashanti Blood' stem cuttings was enhanced with 3,000 ppm IBA (390).

***Myrica* spp.** Bayberry, Wax myrtle. Propagated by seed or by cuttings. With northern wax myrtle (*M. pennsylvanica*) and southern wax myrtle (*M. cerifera*), the wax must be removed from the seed for germination to occur. The wax coating may be removed by rubbing the seed over a screen. One propagator uses a hot water soak with several drops of mild detergent to help remove the wax. A 3-month cold stratification is recommended. Kinetin and gibberellic acid treatments are reported to enhance germination of northern wax myrtle (*M. pennsylvanica*).

*M. cerifera* is fairly easy to root under mist using a 2,000 ppm IBA quick-dip (Texas). *M. pennsylvanica* can be easily rooted from softwood cuttings (Pennsylvania) taken early before the terminal bud has formed—a 5,000 ppm IBA quick-dip is beneficial.

**Myrtle.** See *Myrtus*.

***Myrtus* spp.** Myrtle. Crop production of *M. communis* takes longer by seed than by cuttings. Seedling plants produce a special swollen root (lignotuber) that permits myrtle to survive drought conditions, disease, and insect damage. Plants produced by cuttings do not produce the lignotuber, and are not as drought-resistant as seed-propagated plants. The species is most commonly propagated from 8 to 15 cm (3 to 6 in) shoot-tip cuttings taken in August (Pennsylvania). A quick-dip of 5,000 ppm IBA enhances rooting. Seasonal variation occurs in the rooting of cuttings. Rooting is much higher in cuttings taken during December–February (Israel) than May–August (250). Micropropagation has been obtained with explants from mature field-grown plants (308).

***Nandina domestica*.** Nandina, Heavenly Bamboo.

**Seed.** Can be propagated by seed. The embryos in the mature fruits are rudimentary but will develop in cold storage. Seeds can be collected in late fall, held in slightly moist storage at 4°C (40°F), and then planted in late summer. Germination occurs in about 60 days. Germination tends to take place in autumn regardless of planting date. No cool moist stratification period is necessary.

**Cuttings.** Dwarf nandina ('Compacta nana,' 'Purpurea Nana,' 'Gulf Stream,' 'Harbour Dwarf,' and 'Moon Bay') are easy to root (26). Shoot tips (without

brown wood) are trimmed to 4 cm (1.5 in) lengths, stripped of bottom leaves, quick-dipped in 1,250 ppm IBA and 500 ppm NAA, and stuck directly into 6 cm (2.2 in) liner pots. Cuttings can be rooted any time of the year (Texas), except during the spring growth flush. Winter rooting requires bottom heat. 'Harbour Dwarf' and 'Compacta' can be propagated by separation of suckers at the base; this technique often results in suckering in the liner pot with new shoots, more rapidly producing a salable plant. Suckering and more rapid plant development in the liner pot can also be promoted by rooting a cutting with one node under soil; when the liner is transplanted, it is buried deep enough to cover the next node up the stem, which results in suckering from one or both of the nodes.

**Micropropagation.** Nandinas are commercially micropropagated (62).

***Nerium oleander*.** Oleander. Seedlings reproduce fairly true-to-type, although a small percentage of plants with different flower colors will appear. The seeds should be collected in late fall after a frost has caused the seed pods to open. Rubbing the seeds through a coarse mesh wire screen removes most of the fuzzy coating. The seeds are then planted immediately in the greenhouse in flats without further treatment. Germination occurs in about 2 weeks. Leafy cuttings root easily under mist if taken from rather mature wood during the summer and treated with a 3,000 ppm IBA quick-dip. Plant parts are very poisonous. Can be micropropagated (310).

**Norfolk Island Pine.** See *Araucaria*.

***Nyssa sylvatica*.** Black Gum, Black Tupelo, Pepperidge Tree. One of the best trees for dependable fall color, even in mild climates. Propagated by seed. A high seed germination occurs with a 3-month cold stratification. Softwood cuttings root when treated with 8,000 ppm IBA talc and 21°C (70°F) bottom heat. *N. aquatica* and *N. ogeche* can be propagated from subterminal, softwood cuttings treated with a liquid application of 2,400 ppm NAA and 130 ppm IBA. *Nyssa* can be grafted. There have been a number of new cultivars developed that are budded onto seedling rootstock.

**Oak.** See *Quercus*.

***Olea europaea*.** Olive. A fruitless cultivar, 'Swan Hill,' is available for use as a patio or street tree; it is usually grafted on *O. oblonga*. Cuttings are difficult to root. They should be placed under mist and treated with IBA at 2,000 to 3,000 ppm, or they can be grafted on easily rooted cultivars used as a rootstock (197).



*O. europaea* ‘Wilsonii’ and ‘Majestic Beauty’ are also fruitless and root more easily.

**Oleander.** See *Nerium*.

**Olive.** See *Olea*.

**Opuntia spp.** Cactus (Prickly pear). See *Opuntia* spp. in Chapter 19.

**Orchid (anacho) Tree.** See *Bauhinia*.

**Osage-Orange.** See *Maclura*.

**Osmanthus spp.** Sweet olive, Fragrant tea olive (*O. fragrans*). Seeds are slow and difficult to propagate. Semi-hardwood cuttings or those with firm wood are used. IBA at 3,000 to 8,000 ppm or quick-dip enhances rooting. Softwood cuttings of *Osmanthus xfortunei* treated with 2,500 ppm IBA root well (47). In Alabama, *O. fragrans* cuttings root best when taken from semi-hardwood, new-growth stock in early August and quick-dipped in 15,000 ppm IBA—the bigger the caliper of the cutting, the better it roots. Semi-hardwood and hardwood cuttings of *O. heterophyllus* ‘Ilicifolius’ and hardwood cuttings of ‘Rotundifolius’ root in high percentages without auxin (48).

**Oxydendrum arboreum.** Sourwood. Sourwood is propagated commercially by seeds. Fall-harvested seeds need no pretreatment, and flats containing seeds are generally placed under continuous light. Stratification of 2 to 3 months speeds germination and decreases the light required for germination (28). Propagation by cuttings is extremely difficult. However, soft-tip cuttings treated with a 2,000 to 3,000 ppm IBA quick-dip can be rooted (Pennsylvania). Sourwood is commercially micropropagated (19).

**Pachysandra terminalis.** Japanese spurge. This evergreen ground cover for shady areas spreads naturally by rhizomes. Can be propagated easily by division or by leafy cuttings under mist without auxin. *Pachysandra* is commercially micropropagated.

**Paeonia suffruticosa.** Tree Peony. Seed propagation is complicated by epicotyl dormancy. Seeds are sown in pots and exposed to a warm-moist stratification of 18 to 21°C (65 to 75°F) for root/hypocotyl growth, then cold stratified to break epicotyl dormancy. Further epicotyl growth occurs under warm conditions. Selected cultivars are propagated by grafting in late summer on herbaceous peony (*P. lactiflora*) roots as the rootstock. The grafts are covered and callused in a sand-peat medium in a greenhouse until fall, when they are potted. In Oregon, peonies are cleft grafted in early August with a fresh, single-edge razor blade for each graft. The

newly grafted units are packed in plastic-lined crates containing slightly moist peat, and maintained at 27°C (80°F) for 2 to 4 weeks until the graft union has formed. The species has been micropropagated (57).

**Palms.** There are numerous species and genera of ornamental palms. See *Phoenix dactylifera* (Date Palm) in Chapter 19.

**Seed (67, 86).** They are propagated with fully mature seed, as indicated by color changes from green to red, yellow, black, etc., depending on species. It is best to use only fresh seed, which should be planted as soon as possible after harvesting and not allowed to dry out. Generally, palm seeds remain viable for only a short period. Seed should be collected from trees and not taken from the ground. It is recommended that the fleshy seed coat be removed, in part because the coat often contains an inhibitor. Soak the cleaned seed for 3 days prior to planting, changing the water daily (341). Any seeds that float should be discarded. Presoaking seed for 1 to 2 days in water containing a fungicide and insecticide can also speed germination time and the percentage of germination. Palm seeds are susceptible to surface molds and should be protected by dusting with a fungicide.

For storing palm seed, fresh, cleaned seed should be conditioned for 2 days to 85 to 90 percent RH, then dusted with a seed protectant fungicide (e.g., thiram), tightly sealed in heavy polyethylene bags, and stored at 23°C (73°F) (135).

Seed germination of some species can be accelerated by scarification, followed by soaking in gibberellic acid at 1,000 ppm for 72 hours—and seed flats placed over bottom heat at 27°C (81°F) (305). *Rhaphidophyllum hystrix* seed can be scarified under sterile conditions by removing the seed coat and cap that cover the cavity containing the embryo (79). High germination was obtained from scarified seeds of *R. hystrix*, which were stored for 12 months at 5°C (41°F) and 100 percent relative humidity; high viability of the stored seeds was obtained when the seeds’ moisture content was 14 to 36 percent (78). Successful germination also occurs with unscarified seeds of *R. hystrix*—but the trick is to fully hydrate the seeds and expose them to alternating temperatures. Seeds are soaked for 7 days with aerated and/or running tap water at 30°C (86°F), then seeds are germinated in moist peat moss with alternating 40°C (104°F) for 6 hours and 25°C (77°F) for 18 hours daily; the fully hydrated embryos can readily penetrate the thick-walled seed coats, but need the high temperature stimulus to promote embryo growth (78, 79).



Seeds of most species germinate in 1 to 3 months, especially if bottom heat, 28°C (80°F), is maintained, but some may take as long as 1 to 2 years. Some palm species have limited optimum temperatures for seed germination, and temperatures above and below the optimum level contribute to irregular and low percentage germination. Four native Florida palms had optimum germination temperatures of 35°C (95°F) (75). As a general rule, germination temperatures should be maintained between 29 and 35°C (85 and 95°F). With *Butia capitata*, seeds require 90 to 150 days after-ripening at 5 to 25°C (41 to 77°F) before sowing (76). After ripening, it is followed by a 40°C (104°F) germination temperature, increased seed germination and reduced germination time. Removing the endocarps of *B. capitata* was reported to be more effective in enhancing germination rate than after-ripening storage of endocarps (63). Since each endocarp contains 1 to 3 seeds, removing the endocarp also increased the overall number of seedlings [i.e., from 100 endocarps more than 100 seedlings would emerge (63)]. Endocarp removal was not successful when seeds were germinated in poly bags filled with damp sphagnum peat but worked fine in seed flats containing 1 sphagnum peat:1 perlite (v:v).

**Division.** Multiclumping palms, such as some date palm species, can be asexually propagated by removing and rooting offshoots or basal suckers.

**Micropropagation.** The date palm (*Phoenix dactylifera*) (409), ponytail palm (*Beaucarnea recurvata*) (360), and Canary Island date palm (*Phoenix canariensis*) (221) can be micropropagated.

**Parrotia persica.** Persian Parrotia. Lack of available seed is a problem, as is a long warm/cold stratification requirement. Easily propagated from semi-hardwood cuttings treated with 1,000 to 4,000 ppm IBA. It is commercially micropropagated.

**Parthenocissus spp.** Virginia Creeper (*P. quinquefolia*), Boston Ivy (*P. tricuspidata*). These two ornamental vines can be propagated by seeds planted in the fall or stratified for 2 months at about 4°C (40°F) before planting in the spring. Leafy softwood cuttings taken in late summer root easily under mist when treated with a 3,000 ppm IBA talc, as do hardwood cuttings planted outdoors in early spring. Grafting of named cultivars on *P. quinquefolia* seedlings or rooted cuttings is done by some nurseries using the whip or cleft graft.

**Passiflora xalatoaerulea.** Passion Vine. This tender, subtropical vine is propagated by leafy cuttings under glass or mist. *Passiflora mollissima*, *P. tricuspsis*, and *P. nov* sp. can be seed propagated. Presoaking seed for

24 hours with 400 ppm gibberellic acid and removing the apical point enhanced germination (120). A combination of mechanical and physiological dormancy occur in these three species.

**Paxistima myrsinites.** Oregon Boxwood. An evergreen shrub native to the Pacific Northwest. Readily propagated from semi-hardwood cuttings from mid-summer until bud-break in spring (Vancouver, B.C.). Cuttings are treated with 8,000 ppm IBA talc, placed under mist, and maintained with a minimum basal temperature of 21°C (70°F). Can also be rooted in fall and winter under contact polyethylene film (410).

**Pawpaw.** See *Asimina*.

**Pear (Callery cvs. Bradford, Capital, Whitehouse, etc.).** See *Pyrus*.

**Pear (Evergreen).** See *Pyrus*.

**Penstemon fruticosus.** Purple Haze Penstemon. A low, compact, evergreen to semi-evergreen ground cover (subshrub) with tubular, mauve-purple flowers. Propagated with softwood and semi-hardwood cuttings (June through September in Vancouver); 3,000 ppm IBA talc is optional. Requires a well-drained container soil. Penstemon is commercially micropropagated.

**Peony (Tree).** See *Paeonia*.

**Persian Parrotia.** See *Parrotia*.

**Persimmon (Texas).** See *Diospyros*.

**Philadelphus spp.** Mock Orange. The many cultivars of mock orange are best propagated by cuttings, which root easily. Hardwood cuttings (late winter) treated with 2,500 to 8,000 ppm IBA or softwood cuttings treated with a 1,000 ppm IBA quick-dip can be rooted under mist. Removing rooted suckers arising from the base of old plants is an easy means of obtaining a few new plants.

**Phoenix dactylifera.** Date palm. See Chapter 19.

**Photinia arbutifolia.** See *Heteromeles*.

**Photinia spp.** Photinia. Large evergreen shrubs with small pome fruits. *P. xfraseri* (Fraser or red-tip photinia) can be propagated by seed exposed to a 2-month cold stratification. Semi-hardwood cuttings are best rooted with a 10,000 ppm IBA quick-dip (38) or 8,000 ppm talc. Wounding cuttings, trimming leaves of cuttings, and 3,000 to 8,000 ppm IBA talc or quick-dips are optional for *P. xfraseri* 'Red Robin,' which is a hybrid of *P. glabra* and *P. serrulata* (97, 122). Photinia is commercially micropropagated.





### ***Picea* spp.** Spruce.

**Seed.** Ordinarily propagated without difficulty by seed, most species of spruce have embryo dormancy, requiring a 1- to 3-month cold stratification at 4°C (40°F) for good germination. Spruce can also be fall-planted and naturally stratified. Seeds of *P. abies*, *P. engelmannii*, *P. glauca* var. *albertiana*, and *P. omorika* germinate well without stratification. Colorado blue spruce (*P. pungens* ‘Glauca’) grown from seed produces trees with a slight bluish cast. Only a small percentage of the seedlings have the very desirable bright blue color. Several exceptionally fine blue seedling specimens have been selected as clones and are perpetuated by grafting. Three of the best-known grafted blue spruces are Koster blue spruce (*P. pungens* ‘Koster’), the compact ‘Moerheim’ blue spruce (*P. pungens* ‘Moerheimii’), and *P. pungens* ‘Hoopsii’—which is considered the bluest form.

**Cuttings.** Selected clones of spruce are difficult to propagate by cuttings, but there are instances in which good percentages of cuttings have rooted (180, 226), especially from selected young source trees. In general, pyramidal forms are difficult-to-root, and are usually grafted or seed propagated. Dwarf and more prostrate, spreading forms are easier to root from cuttings.

Taking cuttings from vigorous containerized trees gives good results. Cuttings taken in spring, midsummer, and mid-autumn have been rooted. For cuttings, it is best to use only shoot terminals, which should be gathered in early morning when the wood is turgid. Wounding, mist, and high light irradiance during rooting are helpful. *P. glauca* and *P. pungens* have been successfully rooted with 3,000 to 10,000 ppm IBA treatments (131). In making cuttings of upright-growing types, terminal shoots should be selected rather than lateral branches, since the latter, if rooted, tend to produce prostrate, sprawling plants rather than the desired upright form.

**Grafting.** The Koster blue spruce is propagated commercially by grafting scions on Norway spruce (*P. abies*) seedlings. In Canada, bench grafting of *P. abies* on seedling rootstock is done with a side-veneer or apical-wedge graft. Most grafting is done in winter, but there are advantages to late summer graftage. In Oregon, blue spruce (*P. Pungens* ‘Hoopsi’) is grafted on containerized, dormant *P. abies* rootstock and overwintered in unheated structures; soaking the scion bases in 200 ppm IBA for 3 minutes increased grafting success (33).

**Micropropagation.** Clones of *P. glauca* and *P. pungens* can be vegetatively micropropagated by somatic embryogenesis (87, 228). Meristem micrografting has been done with *P. abies in vitro* (298).

***Pieris* spp.** *Pieris*. *P. floribunda* and *P. japonica* reproduce readily by seed with no treatment necessary. During sowing, seeds should not be covered with media, since they require light to maximize germination and are relatively small [210,000 seeds per 28 g (1 oz)] (393). Some *Pieris* species can be started easily by cuttings with a 1,000 ppm IBA quick-dip, but *P. floribunda* cuttings are difficult to root. Rooting under mist or polyethylene-covered frames is enhanced by wounding, IBA talc, or quick-dips at 5,000 to 8,500 ppm, and bottom heat. Rockwool propagating sheets are reported to reduce transplant shock (13). *Pieris* is commercially micropropagated (393).

***Pileostegia viburnoides*.** A self-clinging evergreen climber in the Hydrangeaceae family. Produces panicles of creamy-yellow flowers. Can be rooted from cuttings using talc applications of 8,000 ppm IBA.

**Pine.** See *Pinus*.

### ***Pinus* spp.** Pine.

**Seed.** Pines are ordinarily propagated by seed. Considerable variability exists among the species in regard to seed dormancy conditions. Seeds of many species have no dormancy and will germinate immediately upon collection, whereas others have embryo dormancy. With the latter, stratification at 0 to 4°C (32 to 40°F) for 1 to 3 months will increase germination. Moist perlite as a stratification medium will enhance overall germination. *P. cembra* may have immature embryos, so a warm stratification of 21 to 27°C (70 to 80°F) for 2 to 3 months, followed by a cool stratification for 3 months at 2°C (36°F), will aid germination.

Species whose seeds have no dormancy conditions and can be planted without treatment include *Pinus aristata*, *P. banksiana*, *P. canariensis*, *P. caribaea*, *P. clausa*, *P. contorta*, *P. coulteri*, *P. edulis*, *P. halepensis*, *P. jeffreyi*, *P. latifolia*, *P. monticola*, *P. mugo*, *P. nigra*, *P. palustris*, *P. pinaster*, *P. ponderosa*, *P. pungens*, *P. radiata*, *P. resinosa*, *P. roxburghii*, *P. sylvestris*, *P. thunbergii*, *P. virginiana*, and *P. wallichiana*. However, if seeds of the above species have been stored for any length of time, it is advisable to give them a cold stratification period before planting. Pine seeds can be stored for considerable periods of time without losing viability if held in sealed containers between -15 and 0°C (5 and 32°F). Seeds should not be allowed to dry out.

**Cuttings.** Pine cuttings are difficult to root, although those of mugo pine (*Pinus mugo*) root easily if taken in early summer (246), and selected clones of *P. radiata* are commercially rooted. Success is more



likely if cutting material is taken in winter from low-growing lateral shoots on young trees. Treatment with IBA is beneficial (269).

Considerable study has been given to the rooting of cuttings of Monterey pine (*P. radiata*) because of its importance as a timber crop in New Zealand and Australia, and as a Christmas tree species. There are clonal variations in the commercial rooting of this species. Best rooting is from cuttings taken in early winter. Wounding, plus a 4,000 ppm IBA quick-dip, enhances rooting. A more symmetrical root system could be induced by clipping the ends of the original roots and allowing a root system to develop from the secondary roots.

Rooting of *P. strobus* was improved when stock plants were etiolated and shoot bases covered with black adhesive tape. Accelerated growth techniques of supplementary lighting, elevated CO<sub>2</sub>, temperature manipulation, and optimum fertility enhance rooting in *P. echinata*, *P. thunbergiana*, and *P. elliotii* (194).

**Rooting needle fascicles (179).** Pines can be propagated asexually by rooting needle fascicles (needle leaves held together by the scale leaves, containing a base and a diminutive shoot apex). Rooting is best when the fascicles are taken from trees less than 4 years old. IBA treatments are helpful. By selecting certain seedlings whose cuttings root easily and by using critical timing in taking cuttings, it is possible to select clones in which cutting propagation is commercially feasible, as has been shown to be true for the mugo pine (179). Cuttings of the Scotch pine have been rooted by a unique method of forcing out interfascicular shoots from young stock plants. These shoots, when made into cuttings, root with a high percentage of success.

**Grafting.** Clonal regeneration of pines is usually done via grafting. Side-veneer grafting is used for propagating selected clones. Well-established 2-year-old seedlings of the same or closely related species should be used as rootstocks. Scions should be of new growth, taken from firm, partly matured wood. Winter grafting in greenhouses works well in Oregon. *P. cembra* is side-veneer grafted on *P. strobus*, and selected forms of *P. densiflora* are grafted on seedling *P. densiflora* or *P. sylvestris*.

**Micropropagation.** Selected pine species can be micropropagated (62, 374, 442, 446).

**Pistache (Chinese).** See *Pistacia*.

***Pistacia chinensis*.** Chinese Pistache. Commercially propagated from seed, which results in highly variable plant form and fall leaf color. Seeds should be collected from relatively large fruits, blue-green in color, in mid-fall. Pulp must be removed. Soak fruits in water and then

rub over a screen. Seeds that float in water have aborted embryos and should be discarded. Stratification at 4 to 10°C (40 to 50°F) for 10 weeks gives good germination. Seedlings exhibit a wide range of variability.

Propagation by cuttings is very difficult. Some rooting success was obtained with softwood cuttings treated with a quick-dip of 5,000 ppm IBA + 5,000 ppm NAA (142). T-budding selected clones on seedling *P. chinensis* rootstocks in late summer is used to produce uniform, superior trees (233), but they can also be propagated by mound layering (141). Male Chinese pistache cuttings should be collected from green softwood or red semi-hardwood stems when about 380 to 573 degree days have accumulated after orange budbreak (143). Cuttings taken in May (Oklahoma) and treated with 8,750 ppm IBA had the greatest rooting. Limited success has occurred with the micropropagation of *P. atlantica* (324).

***Pittosporum* spp.** Pittosporum. Can be started by seeds or cuttings. The seeds are not difficult to germinate; dipping a cloth bag containing the seeds in boiling water for several seconds may hasten germination. Cultivars are propagated with leafy semi-hardwood cuttings. An IBA quick-dip or talc application of 1,000 to 3,000 ppm is beneficial to rooting of *P. tobira*—and 6,000 to 8,000 ppm IBA for *P. tenuifolium*.

**Plane Tree.** See *Platanus*.

***Platanus* spp.** Plane Tree, Sycamore.

**Seed.** Seeds are ordinarily used in propagation, but they should not be allowed to dry out. The best procedure is to allow the seeds to overwinter in the seed balls right on the tree. They may be collected in late winter or early spring and planted immediately. Germination usually occurs promptly. If the seeds are collected in the fall, then stratification at about 4°C (40°F) should be used.

**Cuttings.** The hybrid London plane tree, *Platanus xacerifolium*, can be propagated by hardwood cuttings taken and planted in the nursery in autumn or by leafy softwood cuttings taken in midsummer and rooted under mist. Auxin treatments do not always enhance rooting (304). *P. xacerifolia* (London Plane tree) cultivars, such as 'Bloodgood,' 'Columbia,' and 'Liberty,' can be budded on seedling rootstock; the same cultivars can also be rooted from cuttings treated with 8,000 ppm IBA (131). Softwood cuttings propagated in June (Ontario, Canada) root well when wounded 1 cm (1/2 in) above the bottom node and treated with 5,000 ppm IBA (368).



***Platycladus orientalis***. See *Thuja*.

***Plumbago* spp.** Plumbago seeds sown in late winter usually germinate easily. Leafy cuttings taken from partially matured wood can be rooted without difficulty under mist. Root cuttings also can be used, and old plants can be divided. *Plumbago* has been micropropagated (255).

***Plumeria* spp.** Plumeria. Leafy cuttings 15 to 20 cm (6 to 8 in) long of this tender tropical Hawaiian shrub will root readily under mist if treated with 2,500 ppm IBA.

**Plums (Flowering, Mexican)**. See *Prunus*.

***Podocarpus* spp.** Podocarpus. These evergreen trees and shrubs have foliage resembling the related yews (*Taxus*) and make good container plants. Generally they are seed-propagated. They can be propagated by stem cuttings taken in late summer and early fall. Rooting of *P. marophyllus* is slow, even with a 3,000 to 8,000 ppm IBA talc application.

**Poinsettia**. See *Euphorbia*.

**Poplar**. See *Populus*.

***Populus* spp.** Poplar, Cottonwood, Aspen.

**Seed.** These trees can be propagated by seeds; they should be collected as soon as the capsules begin to open in spring, and planted at once, because they lose viability rapidly, and should not be allowed to dry out. However, if held in sealed containers near 0°C (32°F), seeds of some species can be stored for as long as 3 years. There are no dormancy conditions and seeds germinate within a few days after planting. The seedlings are highly susceptible to damping-off fungi and will not tolerate excessive heat or drying. Poplars are difficult to propagate in quantity by seed.

**Cuttings (323).** Hardwood cuttings of *Populus* root easily (except the aspens) when propagated in the spring. Treatment with IBA is likely to improve rooting. Leafy softwood cuttings (of some species at least) taken in midsummer also root well. *P. tremuloides*, quaking aspen, can be propagated by removing root pieces, root suckers, and layering—inducing adventitious shoots to form from these propagules in vermiculite and then rooting these adventitious shoots as stem cuttings under mist with IBA treatments.

**Micropropagation.** Many *Populus* species are micropropagated (435).

***Potentilla* spp.** *Potentilla*, Cinquefoil. Propagation is usually by cuttings, but seed and division can be used. Cuttings are taken from early summer through fall (168). Rooting is best under light mist with bottom

heat; mist should be reduced as soon as rooting occurs. Softwood cuttings of *P. fruticosa* root readily with 1,000 ppm IBA. *Potentilla* is commercially micropropagated.

**Privet**. See *Ligustrum*.

***Prosopis* spp.** Mesquite. A landscape shrub or small tree for arid and semi-arid regions. Seed germination is hindered by external seed dormancy due to a water-impermeable seed coat. Mechanical scarification and hot-water treatment enhance seed germination of *P. alba* and *P. flexuosa* (85). Auxin has been used to enhance the rooting of *P. alba* cuttings (249). A thornless variety of Chilean mesquite (*P. chilensis*) is propagated by cuttings, and also by air-layering (42). *Prosopis* has been micropropagated (9).

***Protea* spp.** *Protea*. This South African native, popular for its cut flowers, is propagated by seed, cuttings, and grafting. Cuttings are difficult to root, but some species respond to auxin treatments (320).

***Prunus* spp.** Flowering Apricot (*P. mume*), Flowering Cherries (cultivars of *P. campanulata*, *P. sargentii*, *P. serrulata*, *P. sieboldi*, *P. subhirtella*, and *P. yedoensis*), Plums (*P. cerasifera*, *P. mexicana*), Almonds (*P. dulcis*, *P. glandulosa*, *P. tenella*), Cherry Laurel, English Laurel (*P. caroliniana*, *P. laurocerasus*). *Prunus* are classified as evergreen and deciduous shrubs, flowering and fruiting trees.

**Seeds.** Seed from most *Prunus* species require cold stratification for 1 to 3 months, but some species (like *P. cerasifera*, *P. cerasus*, and *P. virginiana*) may require longer stratification durations up to 5 months. If cross-pollination with other species can be avoided, *P. sargentii*, *P. campanulata*, and *P. yedoensis* will reproduce true from seed.

**Cuttings.** As a general rule, ornamental *Prunus* shrubs are propagated by cuttings (e.g., *P. xcistena*, cultivars of *P. laurocerasus*, *P. lusitanica*), while ornamental *Prunus* trees are grafted (e.g., cultivars of *P. cerasifera*, *P. serrulata*). Leafy cuttings of some of the flowering cherry species can be rooted under mist in high percentages if treated with IBA, but subsequent survival and overwintering are sometimes difficult. Rooting is enhanced in *P. tenella* semi-hardwood cuttings collected in July (Ireland), quick-dipped in 1,250 ppm K-IBA + 1,250 K-NAA; IBA alone was ineffective (243).

*P. serrulata* 'Kwanzan' is successfully own-rooted from softwood cuttings by wounding and using a 10,000 ppm IBA and 5,000 ppm NAA quick-dip (273). Dwarf flowering almond (*P. glandulosa*) is easily rooted from softwood summer cuttings with 1,000 ppm IBA. In Georgia, cuttings of *P. mume* are collected early in the





season, when growth is just starting to firm, and treated with 3,000 ppm K-IBA (126); with later, firmer wood cuttings, no auxin, or a low dosage of 1,000 ppm, is used. Mexican plums (*P. mexicana*) are propagated by softwood cuttings (May and June in Texas), treated with 1,000 to 1,500 ppm IBA, or they are produced as seedlings. *P. caroliniana* are rooted from softwood or semi-hardwood cuttings treated with 3,000 to 8,000 ppm IBA. *P. laurocerasus* are rooted from semi-hardwood cuttings treated with 1,000 to 3,000 ppm IBA.

In Florida, *P. campanulata* (Taiwan flowering cherry) is propagated from green, softwood cuttings, preferably terminal tips, taken in April. Cuttings are trimmed to 10 to 20 cm (4 to 8 in) in length, quick-dipped in 1,000 to 3,000 ppm IBA, and stuck into thirty-eight-cell trays. Cuttings are misted only to keep the tips from wilting, and the mist should be reduced as soon as roots are 2.5 to 5 cm (1 to 2 in) in length (285).

**Grafting.** Cultivars of oriental cherry (*P. serrulata*) are grafted onto seedling or clonal rootstocks of the Mazzard cherry (*P. avium*); T-budding, either in the fall or in the spring, is also done. *Prunus dropmoreana* is a suitable rootstock for *P. serrulata* 'Kwanzan.' In England, *P. mume* is bench grafted in February and chip budded in August onto *P. cerasifera* rootstock (126). Seedling 'Nemaguard' peach rootstock is used in California. Mature scions of micropropagated *P. avium* can be top cleft grafted onto seedling rootstock (367).

**Micropropagation.** *Prunus* species are commercially micropropagated (58, 367, 388).

***Pseudotsuga menziesii.*** Douglas-fir. This important lumber and Christmas tree species is normally seed-propagated, but clonal regeneration with cuttings is becoming important with Christmas tree selection and the production of elite timber trees (347). Limited seed from elite, control-pollinated plants (full-sib families) are collected and sown. Each seedling is used as a stock plant (ortet) and is sheared, and cuttings (ramets) are taken and rooted. The rooted cuttings are combined so that many clones are mixed together, thus avoiding monoculture production. **Bulking** refers to the mixing of many elite clones together in the nursery and plantation—for example, a few clonal copies are made of a large number of genotypes; when a large number of copies are produced from only one or a few genotypes, it's called **cloning** (347, 348).

**Seeds.** Seeds exhibit varying degrees of embryo dormancy (43). For prompt germination, it is best to sow the seeds in the fall or stratify them in moist perlite for 2 months at about 4°C (40°F).

**Cuttings.** Douglas-fir cuttings are rather difficult to root, but by taking them in late winter, treating them with IBA, and rooting them in a sand and peat-moss mixture, it is possible to obtain fairly good rooting. Cuttings from young trees root much more easily than those from old trees, and cuttings from certain source trees are easier to root than those from others. Cuttings are taken in December and January from sheared or hedged stock blocks, and treated with 5,000 ppm NAA + 5,000 ppm IBA. One timber company uses a 3-year propagation regime with greenhouse production of stock plants (ortets) from elite seed; the cuttings of the ortets are rooted under fog, then transplanted and finished off in an outdoor bare-root nursery (347). Rooting of cuttings for Douglas-fir Christmas trees is strongly related to clonal variation and seasonal fluctuation. NAA is more effective than IBA in stimulating rooting (333). Cuttings taken from stockplants in a juvenile condition, maintained by hedging, serial propagation, and grafting have a higher rooting success. Rooting decreases markedly with increasing stockplant age. Some success treating softer cuttings with 5,000 ppm IBA and more lignified cuttings with 10,000 ppm IBA (84). Plagiotropism (horizontal growth) can be a problem with rooted cuttings and grafts. Douglas-fir is a difficult species to propagate by cuttings.

**Micropropagation.** Micropropagation was successful with cotyledon explants (91).

**Pygmy Pea Shrub.** See *Caragana*.

***Pyracantha* spp.** *Pyracantha*, Firethorn. Seeds require a 3-month cold stratification, however, propagation is almost always by cuttings. Partially matured, leafy, current-season's growth is taken from late spring to late fall and rooted either in the greenhouse or under mist for good results. Treatments with a 2,500 ppm IBA quick-dip are beneficial (38). Semi-hardwood cuttings collected in fall rooted well when wounded and treated with 8,000 ppm IBA talc or quick-dip (131).

***Pyrus calleryana.*** Bradford Pear (*P. calleryana* 'Bradford'). Can be rooted with 8,000 ppm IBA talc, quick-dips of 10,000 ppm IBA + 5,000 ppm NAA, or a 10,000 ppm K-IBA. Semi-hardwood cuttings are taken June to August (after the terminal bud has formed), and rooted under mist (2, 131). There are some reports of poor performance of 'Bradford,' which is being replaced by better-performing *P. calleryana* cultivars, such as 'Capital,' 'Cleveland Select,' 'Redspire,' and 'Whitehouse.' These cultivars are grafted on seedling *P. calleryana* rootstock by T-budding. Bench grafting



can also be done with a whip-and-tongue graft. 'Bradford' is commercially micropropagated (62).

***Pyrus kawakamii*.** Evergreen Pear. Propagated by cuttings or, more commonly, by grafting on *P. calleryana* seedling rootstock. Bench grafting is done in midwinter using the cleft graft. The grafts can be planted in containers or in the nursery row.

### ***Quercus* spp.** Oak.

**Seed.** Seed propagation is generally practiced. Wide variations exist in the germination requirements of oak seed, particularly between the black or red oak (acorns maturing the second year) and white oak (acorns maturing the first year) groups. Seeds of the white oak group have little or no dormancy and, with few exceptions, are ready to germinate as soon as they mature in the fall. Seeds of the following species will germinate without a low-temperature stratification period: *Quercus agrifolia*, *Q. alba*, *Q. arizonica*, *Q. bicolor*, *Q. chrysolepis*, *Q. douglassii*, *Q. garryana*, *Q. lobata*, *Q. macrocarpa*, *Q. montana*, *Q. petraea*, *Q. prinus*, *Q. robur*, *Q. stellata*, *Q. suber*, *Q. turbinella*, and *Q. virginiana*. Germination of *Q. nigra* is maximized when the fruit (nut) covering is removed (3). Seeds of most species of the black oak group have embryo dormancy, requiring either stratification [0 to 2°C (32 to 35°F)] for 1 to 3 months, or fall planting to allow natural stratification.

Acorns are often attacked by weevils, but soaking in water held at 49°C (120°F) for 30 minutes will rid the acorns of this damaging pest. However, research with *Q. virginiana* indicates no commercial advantage with heat treatment for weevil control. In fact, there can be a loss of seed viability.

Seeds are usually floated in water, and those seeds that float are discarded. With seeds of stratified *Q. rubra*, the presence of a split pericarp following a ten-day aerated water-soak treatment is a nondestructive method for identifying high-quality seed before sowing (103). Acorns of many species tend to lose their viability rapidly when stored dry at room temperature. Seeds of some northern species can be stored for several years without losing viability by holding them at 1 to 3°C (34 to 37°F) in polyethylene bags. The seeds should have a 60 to 70 percent moisture level at the start of storage (154). Consider treating seeds with an insecticide or heat treatment to prevent weevil damage during long-term storage.

Oaks are strongly taprooted and seedling roots will quickly encircle containers. To obtain lateral root branching—which makes the seedlings more adaptable

to transplanting—the acorns can be planted in bottomless flats or small liner containers. The bottoms of the containers are covered by a screen mesh or placed on an open wire bench, which allows for air-pruning of the taproot. The tip of the taproot, upon contacting this mesh, is air-pruned and killed, forcing development of many lateral roots. Copper-based paints are being used to coat the inside of liner pots and larger production containers to prevent root girdling (397). A system for speeding up red oak whip production in containers has been described (396).

**Cuttings.** Attempts to propagate oaks by cuttings or layering is frequently difficult, and species specific. Rooting of oaks depends on the species, with no consistent patterns between red and white oak groups (138). Evergreen types of *Quercus* species tend to root better than deciduous forms (201). Cuttings from younger trees root more readily than those from older trees.

Some success has been obtained in rooting leafy softwood cuttings of *Quercus robur* 'Fastigiata' under outdoor mist in midsummer after treatment with IBA at 20,000 ppm (159). Long [90 cm (35 in)], semi-hardwood cuttings of *Q. robur* 'Fastigiata Koster' rooted well when treated with 5000 ppm IBA and propagated under high pressure fog systems. Rooting was enhanced and production time reduced with the larger propagules (389). Etiolating *Q. bicolor* and *Q. macrocarpa* stockplants can enhance rooting of softwood cuttings (5).

Commercial propagation of *Q. virginiana* and *Q. laurifolia* has been done by taking July semi-hardwood cuttings (Florida) at 6 cm (2 to 3 in), wounding, quick-dipping in 12,000 ppm K-IBA salt, and rooting under mist; rooting takes 7 to 9 weeks (106). *Q. shumardii* cuttings taken in July (Florida) are quick-dipped in 10,000 ppm K-IBA and also root in 7 to 9 weeks. Some success has occurred with serial propagation of rooted *Q. virginiana* maintained under accelerated growth techniques in a greenhouse and used as stock plants for future propagules (300). *Q. virginiana* can be rooted from rhizomic shoots produced at the crown of the tree, which are treated with a five second quick-dip of IBA in 50 percent ethanol (425).

A Florida nursery that has success with propagating *Q. virginiana* 'Cathedral Oak' and other clonal selections collects cutting wood early in the morning from 2- to 4-year old trees, since juvenility optimizes adventitious root formation (343). Rooting percentages decrease as the tree ages, even with rootable selections (clones). Cuttings are taken from branches in the first 2 m (6 to 7 ft of the stock plant), collecting only



long and straight terminal tips that are 15 to 30 cm (6 to 12 in). Cuttings are taken from the first and second flush, just when the new wood and foliage hardens. The wood should have turned from green to gray (May through August in northeast Florida). During the processing, the lower 3 to 4 cm (1 to 1.5 in) of the cutting base is removed, the remaining cutting base is wounded vertically 3 to 4 cm (1 to 1.5 in) by dragging the cutting clippers along the side of the base. Only the basal 2.5 to 5.0 cm (1 to 2 in) of the cutting is quick-dipped in a 10,000 ppm K-IBA + 6,000 ppm K-NAA; these potassium salt formulations of auxin are dissolved in 3 parts distilled water and 1 part isopropyl alcohol; other clones may require 8,000 to 12,000 ppm K-IBA and 4,000 to 8,000 ppm K-NAA. Propagation media is Canadian peat and perlite (1:4, v/v). Sticking depth is 2.5 to 4 cm (1 to 1.5 in) with one cutting per container. Bottomless and/or liner containers 6.4 cm (2.5 in) in diameter and 7.6 cm (3 in) or more in depth are used for maximizing fibrous and branched root systems. The propagation polyhouses are 50 percent shaded. Mist is controlled by solar misting controllers, to automatically compensate for changes in light intensity. Once 50 to 60 percent of the cuttings have initiated roots, the mist is reduced 20 percent. *Some drought stress stimulates the callused cuttings to form primorida and start to root* (343). When a majority of cuttings have rooted, the mist is reduced another 50 percent for 4 weeks to harden-off cuttings. Then, rooted liners are watered as needed until the root system is finished as desired for potting-up. Sanitation is important with clippers periodically disinfected. During the first week of propagation, cuttings are drenched with Subdue and Captan, then biweekly with Phyton 27 (fungicide and bactericide) (343). Liquid fertilizer is applied when the cuttings begin to root.

*Q. phillyreoides* (ubame oak) can be rooted from softwood cuttings treated with a 3,000 ppm IBA talc (290). There are strong clonal differences in rooting success. *Q. palustris* × *Q. phellos* can be rooted from semi-hardwood stem cuttings (July in South Carolina) treated with 10,000 ppm K-IBA (201).

Girdling of stock-plant shoots prior to collecting cuttings and treating cuttings with a rooting powder of auxins, sucrose, and fungicide increased rooting (76 percent) and survival of 19- to 57-year-old water oak (196). Rooting of *Q. bicolor* and *Q. macrocarpa* was enhanced when cuttings were taken from pot-bound (root-restricted) and etiolated stock plants (29).

Forcing epicormic shoots from woody stem segments [0.5 m (1.5 ft) long with a 2.5 to 25 cm (1 to 10 in) caliper] under mist and rooting the softwood

cuttings can be used to propagate *Q. bicolor* and *Q. rubra* (332). Softwood cuttings are treated the same as if collected from a field-grown stock plant. Drench weekly with Banrot 40% WP fungicide.

**Grafting.** Bench grafting of potted seedling rootstocks in the greenhouse in late winter or early spring is moderately successful. Side or whip-grafting is ordinarily used, with dormant 1-year-old wood for scions. Seedlings in place in the nursery row are occasionally crown grafted in the spring, after the rootstock plants start to leaf out. Scions are taken from wood gathered when dormant and stored under cool, moist conditions until used. Various grafting methods are satisfactory—whip, cleft, or bark. A modified bark graft has been successfully used for topworking established rootstock in the field (403). Budding generally has been unsatisfactory. In grafting, only seedlings of the black oak group should be used for scion cultivars of the same group and, in the same manner, only seedlings of the white oak group should be used as rootstocks for other members of the white oaks. The use of seedlings of the same species is preferable. Although some distantly related species of oak will unite satisfactorily, incompatibility symptoms usually appear later.

*Quercus virginiana* is the recommended rootstock for the southeastern United States. Researchers at North Carolina State University report that it tolerates the heavier wet clay soils, and temperature of the South.

Root grafting has been done with a white oak *Q. macrocarpa* scion on a *Q. robur* root piece (rootstock) (268). Root grafting with a side-veneer graft on *Q. robur* has been reported to produce plants with more uniform growth and no suckering; this technique was not successful with *Q. rubra* or *Q. palustris* (267).

**Micropropagation.** Single-node-stem sections of *Q. shumardii* were successfully micropropagated (37). Juvenile and mature explants of *Q. robur* have been micropropagated and rooted successfully *in vitro* (419, 420). Embryoid germination and plant regeneration have been done with *Q. bicolor* micropropagated from male catkins (178).

**Quince, Flowering.** *See Chaenomeles.*

**Redbud.** *See Cercis.*

**Redwood (Coast redwood, Giant Sequoia, Sierra Redwood).** *See Sequoia.*

**Redwood (Dawn).** *See Metasequoia.*

**Raphiolepis indica.** Raphiolepis, India Hawthorn. Seed germination is easy after the pulp has been removed. The cultivars of *R. indica* are commercially





propagated by cuttings. *R. indica* 'Jack Evans' is best rooted when quick-dipped in 50 percent ethanol solutions of 5,000:2,000 ppm or 9,000:1,000 ppm IBA:NAA (258). Auxin response will vary with cultivar. Semi-hardwood cuttings taken from lower portions of stems rooted slightly better than those from upper portions (California). The patio tree form, *R. indica* 'Monrey,' is top grafted on clonal rootstock propagated from cuttings.

***Rhamnus* spp.** Buckthorn. Can be propagated by planting seed out-of-doors in the fall. Macerate fruits and clean seeds. Some species may germinate better if scarified for 20 minutes with sulfuric acid before sowing. *R. frangula* cultivars are propagated by softwood cuttings treated with 8,000 ppm IBA under mist.

***Rhapidophyllum hystrix*.** Needle palm. *See Palms.*

***Rhododendron* spp.** Rhododendron, Azalea (415, 437). Azaleas are no longer a separate genus and are incorporated within the genus *Rhododendron*. *Rhododendron* are normally propagated by cuttings or tissue culture, but seeds and grafting are an option. All parts of *Rhododendron* and azalea plants are poisonous if ingested.

**Seeds.** Seedlings may be used as rootstocks for grafting or for propagation of ornamental species. *Rhododendron ponticum* is one of the principal rootstocks for grafting. The seed should be collected just when the capsules are beginning to dehisce, and may be stored dry and planted in late winter or early spring in the greenhouse. Seed to be kept for long periods should be put in sealed bottles and held at about 4°C (40°F). A good germination medium is a layer of shredded sphagnum moss or vermiculite over a mixture of sand and peat. The very small seeds are sifted on the surface of the medium and watered with a fine spray. The flats should be covered with glass or propagated under mist (438). Careful attention must be given to provide adequate moisture and ventilation as well as even heat: 15 to 21°C (60 to 70°F). The plants grow slowly, taking 3 months to reach transplanting size. After two or three true leaves form, they are moved to another flat and spaced 2.5 to 5 cm (1 to 2 in) apart, where they remain through the winter in a cool greenhouse or in cold frames. In the spring, the plants are set out in the field in an acid soil, and by fall they are ready to be dug and potted preparatory to grafting in the winter. Seeds of *R. carolinianum* should not be covered during propagation because of their extremely small size [825,000 seeds per 28 g (1 oz)] and light requirement for germination (52). Likewise, seeds of *R. chapmanii*

(Chapman's *Rhododendron*) are easy to germinate and should be dusted on the surface of the propagation media because of their small size and light requirement to germinate (10). Seeds of *R. catawbiense* and *R. maximum* should be subjected to light to maximize germination (51).

**Cuttings (184, 223, 415).** Rooting cuttings is the chief method of *Rhododendron* propagation. Cuttings are best taken, midsummer to fall, from stock plants grown in full sun. However, stem cuttings—or leaf-bud cuttings—of some hybrids taken in midwinter will root well. Any flower buds should be removed from the cuttings. Treatments with IBA at relatively high concentrations are required—an IBA talc or quick-dip of 8,000 to 20,000 ppm works well, depending on cultivars. Most standard large-flowered evergreen *Rhododendron* types root readily with 8,000 ppm IBA or less; slightly more difficult cultivars respond to 10,000 ppm, and some of the more difficult red cultivars respond to 20,000 ppm IBA. Wounding the base of the cutting on both sides is a strong stimulus to rooting in *Rhododendrons* (see Fig. 10–28). A rooting medium of two-thirds sphagnum peat moss and one perlite or 1 peat:1 perlite (v/v) is suitable. Bottom heat at 24°C (75°F) should be used. *Rhododendron* cuttings are best rooted under mist in the greenhouse or in a closed polytent, and should be lifted soon after roots are well formed (about 3 months) or the roots will deteriorate.

In California, *Rhododendrons* are direct-rooted into liners (small rose pots) (362). After rooting and transplanting (into peat moss, with added fertilizers), the cuttings should be held at 4°C (40°F) for about 20 days, after which the night temperature can be raised to a minimum of 18°C (65°F). Supplementary light at this stage to extend the daylength will give good growth response. Plants started from cuttings usually develop rapidly and are free of the disadvantage of suckering from rootstock, which occurs with grafted plants.

In Alabama, spring cuttings of Azalea cultivars are cut to 7 to 10 cm (3 to 4 in) and tender tops removed. Basal ends are quick-dipped in 3,000 ppm K-IBA or 5,000 ppm K-IBA for more difficult-to-root cultivars (189).

For native azaleas, butter-soft cuttings are taken in early spring (Louisiana). Cuttings are harvested, dropped into water, placed in Ziploc bags, and labeled. Cuttings are kept refrigerated until stuck, and no rooting compounds are used. Cuttings are placed under mist. After rooting it is important to keep rooted cuttings well watered in thirty-six-cell flats under shade,



fertilize them once per week, and leave roots undisturbed until shifting up into larger container during the following spring after new growth has occurred (232).

**Grafting.** A side-veneer graft is most successful. The best scionwood is taken from straight, vigorous current season's growth. After grafting, the plants are kept in closed frames under high humidity at a temperature near 21°C (70°F) until the union has healed. Then the plants should be moved to cooler conditions—10 to 15°C (50 to 60°F)—and the top of the rootstock removed above the graft union. After the plant has hardened, it is transplanted to the nursery row and grown for 2 years, after which it is ready to dig as a salable nursery plant. A modified chip-bud method using leaf buds in early summer (Rhode Island) was successful for grafting difficult-to-root *Rhododendron* cultivars (292).

**Micropropagation.** Many *Rhododendron*, evergreen, and deciduous azaleas are commercially micropropagated (6, 62, 145, 241, 262). There have been some micropropagation problems with reproducing *Rhododendrons* that are true-to-type. See Chapters 17 and 18 for discussion.

***Rhus* spp.** Sumac.

**Seed.** Commonly propagated by seeds, which are collected in the fall. For prompt germination the seeds should be scarified in concentrated sulfuric acid for 1 to 6 hours, depending upon the species—then either fall-planted out-of-doors or stratified for 2 months at about 4°C (40°F) before planting. Seeds of *R. virens* (evergreen sumac) need to be acid scarified with concentrated sulfuric acid for 50 minutes and then cold-stratified for 73 days (219, 407). To ensure fruiting, only plants bearing both male and female flowers should be propagated asexually.

**Cuttings.** Leafy softwood cuttings of some species, such as *R. aromatica*, taken in midsummer, root well if treated with 10,000 ppm IBA. For those species that sucker freely, such as *R. typhina* and *R. copallina*, root cuttings are planted in the nursery row in early spring. In Minnesota, root cuttings of *R. typhina* are trimmed to 10 cm (4 in), with a 6- to 19-mm (1/4- to 3/4-in) diameter and the ends dipped in talc containing 3,000 ppm IBA; the root cuttings are allowed to callus at 10 to 16°C (50 to 60°F)—then are stored and field-planted. It is important to maintain proper polarity of the root cuttings.

***Ribes sanguineum.*** Red Flowering Currant. An attractive flowering deciduous shrub native to the Pacific Northwest. Easily propagated by softwood cuttings

taken during summer to early September (Vancouver, B.C.), or by hardwood cuttings made with a “heel” of 2-year-old wood (410). Both cutting types do best with basal heat [21°C (70°F)] and 8,000 ppm IBA talc. Currant is commercially micropropagated.

***Robinia pseudoacacia.*** Black Locust. Readily propagated by seeds, which are soaked in concentrated sulfuric acid for 1 hour, followed by thorough rinsing in water, before planting. A hot-water scarification followed by a 24-hour soak prior to sowing can also be used. Black locust can be propagated by root cuttings and by grafting using a whip, side-veneer, cleft, or wedge (“V”) graft, (316, 427) or chip budding (215). Black locust is micropropagated (88).

***Rosa* spp.** Rose. All rose cultivars selected are propagated by asexual methods (199, 253). T-budding on vigorous rootstocks is most common, although the use of softwood or hardwood cuttings, chip budding, simultaneous budding and rooting (stenting), layering, the use of suckers, and micropropagation are also practiced.

**Seed.** Seed propagation is used in breeding new cultivars, in producing plants in large numbers for conservation projects or mass landscaping, and in growing seedling rootstock of certain species, such as *R. canina* and *R. multiflora*. Some commercial rose-bush producers prefer propagating rootstock by seed to avoid virus transmission through conventional asexual techniques (80).

As soon as the rose fruits (“hips”) are ripe but before the flesh starts to soften, they should be collected and the seeds extracted. It is best to stratify them immediately at 2 to 4°C (35 to 40°F). Six weeks is sufficient for *Rosa multiflora*, but others—*R. rugosa* and *R. hugonis*—require 4 to 6 months, and *R. blanda* 10 months. *Rosa canina* germinates best if the seeds are held at room temperature for 2 months in moist vermiculite and then transferred to 0°C (32°F) for an additional 2 months.

Hybrid rose seeds usually respond best to a stratification temperature of 1 to 4°C (34 to 40°F) for 60 to 90 days, although some seeds may germinate with no cold stratification treatment. Germination is probably prevented in rose seeds by inhibitors occurring in the seed coverings, as well as by the mechanical restriction imposed by the pericarp (fruit) covering the seed. Acid scarification as well as macerating enzymes have promoted germination in some cases substituted for the need for warm stratification. The seeds may be planted either in the spring or in the fall in seed beds or in the nursery row. In areas of severe winters, seedlings are likely to be winter-killed if they are smaller than 10 cm (4 in).



**Hardwood Cuttings.** Hardwood cuttings are widely used commercially in the propagation of rose rootstocks, and to some extent for propagating the strong-growing polyanthas, pillars, climbers, and hybrid perpetuals on their own root systems. The Meidiland series of hybrid roses are own-rooted and require no budding (203). The hybrid teas and other similar ever-blooming roses also can be started by cuttings, but more winter-hardy and nematode-resistant plants are produced if they are budded on selected vigorous rootstocks.

In mild climates (Texas, California, Spain), the cuttings are taken and field propagated in the nursery in the fall (191). In areas with severe winters, cuttings may be made in late fall or early winter, tied in bundles, and stored in damp peat moss or sand at about 4°C (40°F) until spring, when they are planted in the nursery row; rootstocks are ready to bud by the following spring, summer, or fall. The cuttings are made into 15 to 20 cm (6 to 8 in) lengths from previous season's canes of 6 to 9 mm (1/4 to 1/8 in) diameter. Commercially, large bundles of canes are run through band saws to cut them to the correct length. Disbudding ("de-eying") is done in rootstock propagation; all axillary buds except the top two or three are removed to prevent subsequent sucker growth in the nursery row. The use of auxins and other rooting pretreatments are of little benefit in the commercial propagation of *Rosa multiflora* hardwood cuttings (111).

**Softwood Cuttings.** Softwood cuttings are made from current season's growth, from early spring to late summer, depending upon the time the wood becomes partially mature. Rooting is fairly rapid, occurring in 10 to 14 days. At the end of the season the cuttings may be transplanted to their permanent location, potted, and overwintered in a cold frame, or transferred to the nursery row for another season's growth. Some desired cultivars are budded to rooted rootstock. Cultivars of most miniature roses are easily propagated by softwood or semi-hardwood cuttings under mist.

**Budding.** T-budding is the method ordinarily used. The buds are inserted into 5- to 10-mm (3/16- to 3/8-in) diameter rootstock plants. In mild climates, budding can be done during a long period, from late winter until fall, but mostly in the spring. Early buds will make some growth during the summer and produce a salable plant by fall. Some propagators partially break over the top or "cripple" the rootstock about 2 weeks after budding to force the bud out. After the bud has reached a length of 10 to 20 cm (4 to 8 in), the top of

the rootstock is entirely removed. In areas with shorter growing seasons, budding is done during the summer. Buds inserted late in the summer either make little growth or remain dormant until the following spring. In this case, the rootstock is cut off just above the bud in late winter or early spring, forcing the inserted bud into growth. Shoots from buds started in the fall are cut back to 13 mm (1/2 in) in the spring. The shoot then grows through the following entire summer, producing a well-developed plant by fall. After the shoot has grown about 15 cm (6 in), it is generally cut back to 5 to 7.5 cm (2 or 3 in) to force out side branches.

In California, Texas, and Spain, commercial landscape rose bush producers collect budwood in late fall (prior to digging 2-year-old rose bushes), store the budwood at 29°F (-2°C), and then T-bud in the following spring (112). The budwood is collected in late fall after the flowers are shed and the thorns become dark. The leaves are removed by hand, or "sweated-off" under high humidity, and the thorns are left intact. Sticks 15 to 25 cm (6 to 10 in) long are put up in bundles of 30 or 40 each. The bundles are wrapped as tightly as possible in moist paper and then placed in polyethylene bags.

From spring to early summer, the budwood is taken out of storage, the thorns are removed, and shield buds from the budwood are T-budded by inserting them into the medial, de-eyed portion of the original cuttings (rather than into new growth arising from the rootstock).

There has been an interest in simultaneously grafting (budding) and rooting landscape roses through bench chip budding and direct rooting in the field (112)—and using the stenting system in grafting and rooting greenhouse cut-flower roses (see Figs. 12-52 and 12-53) (414).

**Rootstocks and Interstocks for Rose Cultivars (65).** Most rose rootstock clones have been in use for many years, propagated by cuttings. Many of the clones are virus-infected, and will infect the cultivar top after budding. However, these clonal rootstocks are available with the viruses eliminated by heat treatments. Holding potted rose plants at a dry heat of 37 to 38°C (98 to 100°F) for 4 to 5 weeks will rid infected rootstocks of viruses. Again, seed propagation of rootstocks helps avoid most virus problems.

*Rosa multiflora.* This is a useful rootstock, especially in its thornless forms for landscape roses. Several cultivars have been developed, some giving better bud unions and bud development than others. Cuttings of this species root readily, develop a vigorous root system,





and do not sucker excessively. It is adaptable to a wide range of soil and climatic conditions. Seedlings are used in the eastern part of the United States, Great Britain, and Australia, and cuttings are used on the Pacific Coast and Texas. The bark often becomes so thick late in the season that budding is impossible.

*Rosa canina*. Dog rose. Although this species has not done well under American conditions, the rootstock is commonly used in Europe. It is usually propagated by seed, which are difficult to germinate. While it is generally difficult to root, long [50 to 150 cm (20 to 59 in)] semi-hardwood cuttings of *R. canina* rooted well when treated with 5000 ppm IBA and propagated under high pressure fog systems. Rooting was enhanced and production time reduced with the larger propagules (389). The prominent thorns make it difficult to handle, and it also tends to sucker. Young plants on this rootstock grow slowly, but they are long-lived. *Rosa canina* is adaptable to drought and alkaline soil conditions, and is used as greenhouse rootstock for cut-flower rose production in the Netherlands.

*Rosa chinensis*. 'Gloire des Rosomanes,' 'Ragged Robin.' This old French rootstock is popular in California for outdoor roses, resisting heat and dry conditions well. It is also resistant to nematodes and does not sucker if the lower buds on the cuttings are removed. This rootstock grows steadily through the summer, permitting budding at any time, under irrigated conditions. The fibrous root system is easy to transplant but requires good soil drainage. In some areas, however, it is difficult to propagate and is injured by leaf spot.

*Rosa 'Dr. Huey'*. This is the principal rootstock in Arizona and the southern San Joaquin Valley, California, rose districts, replacing 'Ragged Robin' to a large extent. It has also performed well in Australia (351). It is useful for late-season budding because of its thin bark. It is very vigorous and well adapted to irrigated conditions, and its cuttings root readily. It is very good as a rootstock for weak-growing cultivars. Defects include injury from subzero temperatures and susceptibility to black spot, mildew, and verticillium.

*Rosa xnoisettiana 'Manetti'*. This is an old rootstock, very popular for greenhouse forcing roses. It is also of value for dwarf roses and for planting in sandy soils. It is easily propagated by cuttings, produces a plant of moderate vigor, and is resistant to some strains of verticillium.

*Rosa odorata (Odorata 22449)*. Tea rose. This rootstock is excellent for greenhouse forcing roses. Cuttings root easily under suitable conditions, and

produce a large symmetrical root system. It is adapted to both excessively dry and wet soil conditions. Since it is not cold-hardy, it should be used only in areas with mild winters. Some propagation stock of this clone is badly diseased and does not root well. The plants are not adaptable to cold-storage handling, and this variety is more susceptible than *R. manetti* to verticillium.

*Rosa IXL (Tausendschon/Veilchenblau)*. This interstock is used primarily as a trunk for tree roses. It is very vigorous and has no thorns. The canes tend to sunburn and are somewhat susceptible to low-temperature injury.

*Rosa Multiflore de la Grifferaie*. This interstock is useful as a trunk for tree roses, producing desirable straight canes. It is vigorous, extremely hardy, and resistant to borers, but very susceptible to mite injury.

*Rosa rugosa*. This form, which is used as a rootstock, bears single, purplish-red flowers. It is propagated by cuttings for bush roses, and by seed for tree roses. The root system is shallow and fibrous and tends to sucker badly, but the plants are very long-lived. It is also used as the upright stem in producing standard (tree) roses.

**Propagating Tree (Standard) Roses.** A satisfactory method of producing this popular form of rose is to use *Rosa multiflora* as the rootstock, which is budded in the first summer to *IXL* or, preferably, the *Grifferaie* interstock (see Fig. 11–12). These plants are trained to an upright form and kept free of suckers. In the second summer, at a height of about 0.9 m (3 ft), three or four buds of the desired flowering cultivar are inserted into the interstock trunk. During the winter, the cane above the inserted buds is removed. The buds develop the following summer, as do buds from the rootstock, which must be removed. In the fall, the plants may be dug and moved to their permanent location. Tree roses are sometimes dug as balled and burlapped plants because an extensive root system is formed during the 2 years in which the top is being developed.

**Propagation of Miniature Roses (299).** Soft or semi-hardwood cuttings are taken year round and rooted under mist, after dipping in an IBA quick-dip or talc. Miniature rose cultivars are especially bred for their ease of rooting.

**Micropropagation.** Selected rose cultivars are commercially micropropagated (198, 423).

**Rose of Sharon.** See *Hibiscus*.

*Rosmarinus officinalis*. Rosemary. This ground cover with aromatic leaves is easily propagated by seed and leafy cuttings under mist.



**Rosemary.** *See Rosmarinus.*

**Rosewood, Arizona.** *See Vauquelinia.*

**Royal Poinciana.** *See Delonix.*

**Rubber Plant.** *See Ficus.*

**Russian Olive.** *See Elaeagnus.*

**Sage (Texas, Purple).** *See Leucophyllum.*

**Salix spp.** Willow.

**Seed.** Seeds must be collected as soon as the capsules mature (when they have turned from green to yellow) and planted immediately, since they retain their viability for only a few days at room temperature. Even under the most favorable conditions, maximum storage is 4 to 6 weeks. Willows are difficult to propagate in quantity by seed.

**Cuttings.** *Willows root so readily by either stem or root cuttings that there is little need to use other methods.* Hardwood cuttings planted in early spring root promptly. Summer cuttings from hardened new growth also perform well.

**Grafting.** Top grafting of *Salix* standards (*S. caprea* 'Kilmarnock,' *S. purpurea* 'Pendula,' and *S. integra* 'Hakuro-nishiki') is done with a whip-and-tongue or side-veneer graft (261). Other miniature standard *Salix* are also top-grafted on unrooted rootstock (279). The rootstock is *Salix xsmithiana*, which are clonally propagated from hardwood cuttings. After bench grafting, the unrooted, grafted cuttings are dipped in IBA talc, stuck directly in pots, and rooted under mist in a greenhouse (February in Canada) (261).

**Micropropagation.** *Salix* can be micropropagated (303).

**Sambucus spp.** Elderberry. Seed propagation is difficult because of complex dormancy conditions involving both the seed coat and embryo. Probably the best treatment is a warm [21 to 30°C (70 to 85°F)], moist stratification period for 2 months, followed by a cold [4°C (40°F)] stratification period for 3 to 5 months. These conditions could be obtained naturally by planting the seed in late summer, after which germination should occur the following spring. Since softwood cuttings root easily if taken in spring or summer, this method is generally practiced. Cuttings are treated with 7,500 ppm IBA. Disease control can be a problem, so preventative fungicides are used.

**Sapindus drummondii.** Soapberry (Western). Western soapberry is a deciduous landscape tree with a bright yellow fall color and a low water requirement

that performs well on highly calcareous soils. For maximum germination, fall or winter collection of seeds followed by a 60-minute acid scarification and 3-month cold stratification is recommended (301). May and June cuttings can be rooted when treated with 16,000 ppm IBA (131).

**Sarcococca spp.** *Sarcococca*, Fragrant Sweetbox (*S. ruscifolia*). Attractive, broad-leaf evergreen ground cover that tolerates shade conditions. *Sarcococca* species can be propagated from firm cuttings. A 3,000 ppm IBA quick-dip enhanced rooting of *S. hookerana* (129).

**Sassafras albidum.** Sassafras. An eastern North American native tree with spectacular fall color. Seeds require a long period (4 months) of cold stratification and should be sown in the nursery early in the fall or use stratified seeds for spring planting. Sassafras can be propagated from root cuttings. Shoots from the root cuttings can be rooted. Can also be propagated by layering and by chip-budding.

**Schizophragma hydrangeoides.** A vine in the Hydrangeaceae family that climbs to 12 m (40 ft) on the bark of trees and bears a mass of creamy-white flowers with reddish new shoots. Can be propagated from seed stratified at 1 to 3°C (34 to 38°F) for 10 to 12 weeks. The seeds are very small and can be difficult to handle. Can be propagated asexually by nodal tip cuttings or single nodal cuttings with two opposite buds using talc applications of 5,000 ppm IBA (275). The most easily rooted cuttings are those obtained from nonflowering shoots near the base of the plant, which often have preformed root initials. *Schizophragma* is commercially micropropagated.

**Sciadopitys verticillata.** Umbrella pine. A columnar, slow-growing, conical, evergreen conifer with attractive, peeling red-brown bark. Seed germination is poor and seedling growth is very slow. While there are many cultivars, rooting is difficult, and there are advantages of using mycorrhiza in combination with auxin application to enhance rooting (136). A 24-hour soak in water (to remove latex sap at the cut ends of the stems), before applying auxin enhanced rooting success and root mass, particularly with hardwood cuttings (50 percent rooting), compared to softwood cuttings (40 percent rooting) (136); a quick-dip of 2000 ppm IBA + 1000 ppm NAA was used. Cuttings from shade-grown sources had greater rooting than when taken from full-sun trees. Age or height of stock plants did not affect rooting.

**Sea Grape.** *See Coccoloba.*

**Senecio cineraria.** *See Senecio* (see Chapter 21).



**Sequoia spp.** Coast Redwood (*Sequoia sempervirens*), Giant Sequoia or Sierra Redwood (*Sequoiadendron giganteum*). Both genera are ordinarily propagated by seed; however, some cultivars are propagated by cuttings.

**Seed.** Seeds of *Sequoia sempervirens* are mature at the end of the first season, but those of *Sequoiadendron giganteum* require two seasons for maturity of the embryos. Cones are collected in the fall and allowed to dry for 2 to 4 weeks, after which the seeds can be separated. Seeds may be kept for several years in sealed containers under 4°C (40°F) storage without losing viability. Stratification for 10 weeks at about 4°C (40°F) promotes germination of *Sequoiadendron giganteum* seed. Seeds of *Sequoia sempervirens* will germinate without a stratification treatment, however, a 24-hour water soak followed by 4 weeks of stratification can improve germination.

Fall planting also may be done, sowing the seed about 3 mm (1/8 in) deep in a well-prepared seed bed. The young seedlings should be given partial shade for the first 60 days.

**Cuttings.** Introduction of vegetatively propagated ornamental cultivars of *S. sempervirens* has resulted in vast improvement over highly variable seed-propagated specimens. Hardwood cuttings (February in southern California) were trimmed to 12 cm (5 in) in length so that the outer tissue on the main stem of the cutting was brown at the base and green above. Cuttings were propagated in 9 perlite:1 peat media, placed in cutting flats on outdoor heated beds [21°C (70°F)] and rooted with mist under full sun for 5 months. The cultivar 'Majestic Beauty' rooted best with 3,000 ppm IBA and 3,000 ppm NAA liquid; 'Santa Cruz' rooted best with 16,000 ppm IBA talc, and 'Soquel' rooted best with 6,000 ppm IBA and 6,000 ppm NAA quick-dip (53). *Sequoiadendron giganteum*, grown for Christmas trees, roots easily if cuttings are taken from young trees and treated with IBA under mist (158).

**Micropropagation.** Both genera are micropropagated (41, 220).

**Sequoiadendron giganteum.** See *Sequoia*.

**Serviceberry.** See *Amelanchier*.

**Seven Son Flower (Tree).** See *Heptacodium*.

**Shepherdia spp.** Buffaloberry. Hardy deciduous and evergreen shrubs. Seeds of *S. canadensis* and *S. rotundifolia* have been reported to exhibit seed-coat and internal dormancy. Seeds should be scarified in sulfuric acid for 30 minutes, followed by a minimum 30-day cold

stratification. *S. canadensis* can be rooted with hardwood cuttings treated with 3,000 ppm IBA. *S. rotundifolia* can be micropropagated with WPM (252).

**Shrub-Althea.** See *Hibiscus*.

**Silk Tree.** See *Albizzia*.

**Silverbell.** See *Halesia*.

**Skimmia spp.** Skimmia. Hardy, woody ornamental shrubs in the citrus family (Rutaceae).

**Seed.** *S. japonica* ssp. *reevesiana*, though bisexual, can be propagated by seed since over 99 percent of the progeny will be male (259). As soon as the fruit becomes ripe, the fruit is pulped and the seeds collected via flotation. Seeds are then sown in seedling flats and allowed to naturally stratify during the winter in a non-heated greenhouse (England).

**Cuttings.** *S. japonica* (Japanese skimmia) and *S. reevesiana* (Reeves skimmia) are easy-to-room, and are propagated from semi-hardwood cuttings 6 to 8 cm (2.5 to 3 in) long, wounded 1.5 cm (0.5 in) from the base and treated with 8,000 ppm IBA talc or quick-dip solution (259). Cuttings are rooted in a low polyethylene tent, not mist, and given bottom heat [20°C (68°F)].

**Smoke Tree.** See *Cotinus*.

**Snowberry.** See *Symphoricarpos*.

**Soapberry (Western).** See *Sapindus*.

**Sophora spp.** Sophora. For uniform seed germination, seed of Texas Mountain Laurel (*S. secundiflora*) must be scarified, regardless of the seed age (young, soft seeds with yellow seed coats or mature, firm seeds with red seed coats) (426). Scarifying with sulfuric acid from 35 to 120 minutes, or nicking the seed coat with a saw, work well (395). *S. japonica* (syn. *Styphnolobium japonicum*) (Japanese pagoda tree) is generally seed-propagated. Seed must be cleaned by soaking fruit for 48 hours; generally, no scarification or stratification treatments are needed (131). Cuttings are not a successful method for propagating *S. secundiflora* and *S. japonica*. However, cultivars of *S. microphylla* are rooted successfully by taking semi-hardwood cuttings in winter (New Zealand), which are stripped of lower leaves, wounded, dipped in 8,000 ppm IBA talc, and inserted into 1 bark:1 pumice medium under mist with 20°C (68°F) bottom heat (71). *S. microphylla* can be grafted by T-budding or with a side graft. *Sophora japonica* (syn. *Styphnolobium*) can be T-budded in summer, side-grafted on seedling rootstock during late





spring. Weeping forms of *S. japonicum* are top grafted on seedling rootstock. *S. secundiflora* can be micropropagated, which offers potential for clonal selection (170).

**Sorbus spp.** Sorbus, Mountain Ash.

**Seed.** Seeds should be collected as soon as the fruits mature; fleshy parts are removed to eliminate inhibitors. Seed is usually cold stratified at 1 to 4°C (34 to 40°F) with the best germination occurring at the cold stratification temperatures. However, germination at these temperatures can take up to 4 months. For *S. glabrescens*, the best germination was a 4-month cold stratification [1°C (34°F)] followed by germination at 10°C (50°F). For some species, a period of 3- to 5-month warm dry storage prior to the cold stratification/germination period can shorten the germination time. Exposing stratified seeds to warm germination temperatures above 25°C (77°F) can induce secondary dormancy (402).

**Cuttings.** Cuttings are generally difficult to root; however, 6 to 10 cm (2 to 4 in) softwood cuttings of *S. aucuparia* and *S. hybrida*—which had been severed from forced stock plants at the junction between the growth of the current year and that of the previous year—root well (193). A talc formulation of 3,000 ppm IBA improved rooting of the softwood cuttings.

**Grafting.** Either fall chip budding or bench grafting (whip grafting) is successful. Selected cultivars are best worked on seedlings of their own species, although *S. aria*, *S. aucuparia*, and *S. cuspidata* (European mountain ash) seedlings seem satisfactory as a rootstock for other species.

**Micropropagation.** *S. aucuparia* (88) and *S. domestica* are micropropagated (11).

**Spiceberry.** See *Ardisia*.

**Spicebush (Japanese, American).** See *Lindera*.

**Spiraea spp.** Spirea. Usually propagated by cuttings, although some species, such as *S. thunbergi*, are more easily started by seeds, which should not be allowed to dry out. Leafy softwood cuttings taken in midsummer are generally successful. Treatments with auxin at 1,000 ppm aid rooting. Some species, such as *S. xvanhouttei*, can be started readily by hardwood cuttings, planted in early spring. Spirea is commercially micropropagated.

**Spruce.** See *Picea*.

**Spurge (Japanese).** See *Pachysandra*.

**St. John's Wort.** See *Hypericum*.

**Stangeria eriopus.** See *Cycas*.

**Stewartia spp.** Stewartia. Desiccation causes a very rapid decline in seed viability, so seed should be harvested when the capsules are still green and indehiscent (309). For Japanese stewartia (*S. pseudocamellia*)—harvest seed capsules when they turn from green to brown, maintain seed under nondesiccating conditions. Seed dormancy is overcome by a 3- to 5-month warm stratification followed by a 3- to 7-month cold stratification (123, 309).

Due to the difficulty of seed propagation, softwood and semi-hardwood cuttings are the most common form of propagation (306). Semi-hardwood cuttings collected in early summer root well when treated with 5,000 to 8,000 ppm IBA, or 2,500 ppm IBA × 2,500 ppm NAA. Problems occur with winter survival. Rooted cuttings should be hardened-off and not transplanted during the fall. It is best not to fertilize until the cuttings leaf out the following spring. In Louisiana, *S. malacondendron* cuttings are taken from new growth in mid-May. The 15 cm (6 in) cuttings are treated with 1,000 ppm IBA talc and rooted under mist. Plants in rooted thirty-six-cell trays are placed under shade and fertilized weekly for cuttings to break growth. Roots are left undisturbed until the following spring when the rooted liners are shifted up into larger containers after new growth has occurred (232). In Oregon, 15 to 20 cm (6 to 8 in) cuttings taken in mid-July are treated with 2,000 ppm IBA + 1,000 ppm NAA and direct-stuck in small liner pots under mist. Rooted cuttings are not transplanted until after one full year of growth (149). *S. pseudocamellia* can be propagated by softwood and semi-hardwood stem cuttings dipped in low IBA (100 ppm) with 0.1 M ascorbic or caffeic acid; rooted cuttings can be overwintered successfully (398).

**Micropropagation.** *S. pseudocamellia* can be micropropagated (289).

**Sumac.** See *Rhus*.

**Sweetshrub.** See *Calycanthus*.

**Swietenia mahagoni.** Mahogany. A salt-tolerant, semi-deciduous landscape tree in southern Florida. Seeds are collected when mature in late winter and germinate easily without soaking or pregermination treatments (317). While seed propagation is the preferred method, propagation by cuttings is important for clonal propagation and as a research tool. The inclusion of older growth in stem cuttings is necessary for successful rooting. Good rooting was obtained from a 20-year-old tree (South Florida). Cuttings are trimmed to 10 to 20 cm (4 to 8 in) with four to five fully expanded leaves, succulent terminal growth removed,



treated with 1,000 ppm IBA + 300 ppm NAA, and rooted under mist (216).

**Sycamore.** *See Platanus.*

***Symphoricarpos* spp.** Snowberry. Seed propagation is difficult because of a hard, impermeable endocarp and a partially developed embryo at harvest. Give seeds a 3- to 4-month warm, moist stratification followed by cold stratification at 5°C (41°F) for 6 months before planting. Softwood and semi-hardwood cuttings of *S. albus* root easily when treated with 1,000 to 3,000 ppm IBA. *Symphoricarpos xchenaulti* semi-hardwood cuttings root when treated with 8,000 ppm IBA talc (131).

***Syringa* spp.** Lilac. *Syringa vulgaris* cvs. and other *Syringa* species are either micropropagated or propagated from cuttings.

**Seeds.** Seedlings are used mostly as rootstock for grafting or in hybridization. Lilac cultivars will not reproduce true from seed. Seeds require fall planting out-of-doors or a stratification period of 40 to 60 days at about 4°C (40°F) for good germination.

**Cuttings.** Cuttings can be rooted, if attention is given to proper timing. Ordinarily, good rooting of lilacs can be obtained only if terminal leafy cuttings are taken within a narrow period shortly after growth commences in the spring. When the new, green shoots have reached a length of 10 to 15 cm (4 to 6 in) they should be cut off and trimmed into cuttings. Since they are very succulent at this state it is difficult to prevent wilting. Rooting can be obtained in a polyethylene-covered bed in the greenhouse with bottom heat, or in indoor and outdoor mist beds.

Chinese lilac (*S. chinensis*) roots well in late spring (before the terminal bud has set), when treated with a 4,000 ppm IBA quick-dip. Korean lilac (*S. patula*) cuttings rooted well when taken from plants forced in a greenhouse and treated with 8,000 ppm talc (131). Softwood cuttings of *S. henryi*, *S. josikaea*, and *S. villosa* root easily with a 3,000 ppm IBA talc. With *S. vulgaris*, optimal rooting occurs with softwood cuttings treated with 1,500 to 3,000 ppm IBA, depending on the cultivar. One nursery buys in unrooted microcuttings (stage II) of *S. vulgaris*, roots them in a growing chamber. The rooted cuttings are planted in small liner pots and then treated with 1000 ppm Florel (an ethylene-generating chemical) at 10 to 15 cm (4 to 6 in) to encourage more basal buds to develop and increase propagule numbers (137). Treated plants are overwintered in unheated greenhouses covered with black and white poly to exclude light. Temperature is gradually raised in late winter (Minnesota) and the first harvest of softwood

cuttings is taken in April. Cuttings are quick-dipped in 750 ppm IBA, stuck in 128-cell trays and rooted under mist. Up to 4 crops are harvested and rooted during the year, a new juvenile stand of *S. vulgaris* is treated with Florel Brand Pital, and the process is repeated for the next year (137).

Cuttings of hybrid *S. vulgaris* cultivars showed improved rooting with prior etiolation of stock plants, and the period over which lilac cuttings could be propagated successfully was lengthened considerably. IBA talc of 3,000 to 8,000 ppm enhanced rooting.

**Grafting.** Today, grafting is less popular due to the expense, graft incompatibility problems, suckering of the rootstock, reduced plant life, and poor growth renewal. Also, tissue culture production of *Syringa* is much more broadly utilized. Grafting or budding on rootstock of California privet (*Ligustrum ovalifolium*) or Amur privet (*L. amurense*) cuttings, or on lilac or green ash (*Fraxinus pennsylvanica*) seedlings, has been used in lilac propagation (100, 192, 433).

**Micropropagation.** Lilacs are commercially micropropagated (208, 287).

***Tabebuia argentea.*** Gold Tree, Silver Trumpet Tree. Has a cork-like light-colored bark with spectacular golden yellow flowers. It is generally seed-propagated without any pregermination treatment (317). It is important that the propagation medium be drenched with fungicides to control damping-off. This species can also be produced by cuttings and air layering.

**Tamarisk.** *See Tamarix.*

***Tamarix* spp.** Tamarisk, salt cedar. Seed has no dormancy and germinates within a few days at warm temperature [20°C (68°F)]. Tamarix (*T. aphylla*) is a salt tolerant plant and has become an invasive plant in the southwest United States. These plants are easily rooted by hardwood cuttings, usually made about 30 cm (12 in) long and planted deeply. Softwood cuttings taken in early summer also will root readily under mist. Cuttings of *T. ramosissima* (*T. pentandra*) will root during any season.

***Taxodium distichum.*** Bald Cypress. Bald cypress is propagated by seeds, which should be fall-planted or stratified at 5°C (41°F) for 90 days. Soaking the seeds for 24 to 48 hours enhances germination. Difficult to root by cuttings. Softwood cuttings treated with 1000 ppm IBA and hardwood cuttings with 8000 ppm (131). Bench grafting is done using a whip and tongue graft. *T. mucronatum* (Mexican bald cypress or Montezuma cypress), which is the national tree of



Mexico, can be propagated by seed, which has a 2-month cold stratification requirement. Seed should be cleaned of its resinous coating prior to germination. Some limited success with cuttings collected from lower branches, wounded and treated with 3,000 to 8,000 ppm IBA (391).

**Taxus spp.** Yew. These ornamental trees and shrubs are also valued for the anticancer drug, taxol, which is found in various parts of the plant.

**Seeds.** Seedling propagation is little used, because of variation in the progeny, complicated seed dormancy conditions, and the slow growth of seedlings. Seedling propagation is almost entirely confined in commercial practice to the Japanese yew (*T. cuspidata*), which comes fairly true from seed if isolated plants can be located as sources of seed. Seed imported from Japan is believed to produce uniform offspring. Plant growth habit and basal branching is better with seedling-grown plants than cutting-grown.

For good germination, seeds should be given a warm 20°C (68°F) stratification period in moist peat moss or other medium for 3 months, followed by 4 months of cold stratification [5°C (41°F)]. Seedling growth is very slow. Two years in the seed bed, followed by 2 years in a lining-out bed, then 3 or 4 years in the nursery row are required to produce a salable-size plant of Japanese yew.

**Cuttings.** Most clonal selections of yews are propagated by cuttings, which root without much difficulty (355, 378). *Taxus* cuttings can be rooted outdoors in cold frames or in the greenhouse under mist, the latter giving much faster results. For the cold frame, fairly large cuttings, 20 to 25 cm (8 to 10 in) long, are made in early fall from new growth with a section of old wood at the base. Many species and cultivars respond best when they are stripped of needles at the base of the cutting (wounding) and treated with 8,000 ppm IBA talc or an IBA quick-dip of 5,000 to 10,000 ppm. Cuttings may be kept in closed frames through the winter. Rooting takes place slowly during the following spring and summer.

In Ohio and Rhode Island (291), spring-rooted *Taxus* were equal to or superior to cuttings taken in late fall, rooted on bottom heat, and spring-planted. With bottom heat, there is no need to strip needles from the basal end of the cuttings, and cuttings propagated on bottom heat are ready to plant sooner than those without heat. Cuttings are initially quick-dipped in 2,000 to 2,500 ppm IBA and 1,000 to 1,250 ppm NAA combinations. Mycorrhizal fungi in the rooting substrate

enhances rooting of stem cuttings of Hick's yew (*Taxus xmedia* 'Hicksii') (366).

For greenhouse propagation, cuttings should be taken in early winter, after several frosts have occurred, and rooted under mist in a 90 percent sand and 10 percent peat mixture with bottom heat at about 21°C (70°F) and an air temperature of 10 to 13°C (50 to 55°F). Rooting in the greenhouse takes only about 2 months, but cuttings should not be dug too soon. Allow time for secondary roots to develop from the first-formed primary roots. There may be advantages of a 2-month cold period after cuttings have rooted and before planting out liners. Cuttings from male plants (at least in *T. cuspidata expansa*) root more readily than cuttings from female plants (those that produce fruits).

Side or side-veneer grafting is practiced for those few cultivars that are especially difficult to start by cuttings, with easily rooted cuttings used as rootstock. *Taxus* can be micropropagated (94).

**Teloepa speciosissima.** Waratah. Seeds of this Australian native shrub with beautiful chrysanthemum-like flowers germinate easily, but the seedlings are difficult to transplant and grow outside their native environment. Waratah requires soil of extremely low phosphorus content.

**Ternstroemia gymnanthera.** Japanese ternstroemia (clevera). An evergreen shrub with alternate, glossy, dark green leaves. New growth is red, and changes to dark green as it matures. The shrub grows upright but full and rounded, and a mature specimen can attain a height of 2.4 to 3 m (8 to 10 ft) with a 2 m (6 ft) spread. Fruit is collected in mid-September (Mississippi) (217). The pulp of the fruit is removed and seed is washed. Seed is sown directly and emerge after 30 to 60 days without pregermination treatment (217). Semi-hardwood cuttings are started in late summer.

**Thuja spp.** Arborvitae. American (*Thuja occidentalis*), Oriental [*Platycladus orientalis* (*Thuja orientalis*)], Korean (*T. koraiensis*), and Western Arborvitae (*T. plicata*).

**Seeds.** Germination is relatively easy, but stratification of seeds for 60 days at about 4°C (40°F) may be helpful. *T. plicata* seed generally does not require stratification. *T. occidentalis* are fall-planted and *Platycladus orientalis* are spring-planted.

**Cuttings.** Hardwood cuttings of *T. occidentalis* can be rooted in midwinter under mist in the greenhouse. Best rooting is often found with cuttings taken from older plants that are no longer making rapid growth. The cuttings should be about 20 cm (6 in) long and may be taken either from succulent, vigorously





growing terminals or from more mature side growth several years old. Wounding and treating with 3,000 to 8,000 ppm IBA quick-dip or talc is beneficial. No shading should be used. Cuttings may also be made in mid-summer and rooted out-of-doors in a shaded, closed frame.

Cuttings of *P. orientalis* are often more difficult to root than those of *T. occidentalis*. Small, soft cuttings several centimeters long, taken in late spring, can be rooted in mist beds if treated with 8,000 ppm IBA talc. Cuttings of 10 to 15 cm (4 to 6 in) can be taken in summer or winter, treated with a 5,000 ppm IBA quick-dip, and rooted under mist (Texas). *T. plicata* roots easily from fall cuttings treated with 3,000 ppm IBA talc (123). In southern California, conifers are rooted outdoors in full sun; cuttings are taken in November and December before spring rains, since these species have cultural problems with too much water.

*Thuja* × 'Green Giant' ('Green Giant' arborvitae) can be rooted from softwood, semi-hardwood, or hardwood terminal cuttings (tips of first order laterals) or laterals cuttings (187). Lateral cuttings (side shoots removed from those portions of terminal cuttings inserted into the rooting media) root better than terminal cuttings. Rooting of hardwood cuttings was enhanced with 3,000 ppm IBA (187).

**Grafting.** The side graft is used in propagating selected clones of *P. orientalis*, with 2-year-old potted *P. orientalis* seedlings as the rootstock. Grafting is done in late winter in the greenhouse. After making the grafts, the potted plants are set in open benches filled with moist peat moss just covering the union. The grafted plants should be ready to set out in the field for further growth by mid-spring. Selected cultivars of *T. occidentalis* can also be side-veneer grafted. *P. orientalis* is generally own-rooted, rather than grafted.

***Tilia* spp.** Linden, Basswood.

**Seed.** Seeds are used primarily for seedling rootstock for budding and grafting; it is difficult to get good germination and seedling production. The seeds have a dormant embryo plus an impermeable seed coat which, in some species, is surrounded by a hard, tough pericarp. Such seeds are slow and difficult to germinate (160, 416). Removing the pericarp, either mechanically or by soaking the seeds in concentrated nitric acid for 1/2 to 2 hours, rinsing thoroughly and drying, then soaking the seeds for about 15 minutes in concentrated sulfuric acid to etch the seed coat, followed by stratification for 4 months at 2°C (35°F), may give fairly good

germination; otherwise, warm [15 to 27°C (60 to 80°F)], stratification for 4 to 5 months, followed by an equal period of cold stratification at 2 to 4°C (35 to 40°F), can be used. Collecting the seed from the tree just as the seed coats turn completely brown (but before the seeds drop and the seed coats become hard and dry), followed by immediate planting, has given good germination.

**Cuttings.** *T. americana* and *T. cordata* softwood and semi-hardwood cuttings, wounded, and treated with 20,000 to 30,000 IBA quick-dips will root successfully (Kansas). Cuttings should be very soft and taken before the terminal bud hardens (Pennsylvania). Leaf abscission under mist is a problem. Suckers arising around the base of trees cut back to the ground have been successfully mound layered, and softwood cuttings taken from stump sprouts have been rooted. Long [62 cm (24 in)], semi-hardwood cuttings of *T. cordata* rooted well when treated with 5,000 ppm IBA and propagated under high pressure fog systems. Rooting was enhanced and production time reduced with the larger propagules (389).

**Budding.** T-budding or chip budding (England) in late summer on seedling rootstocks of the same species gives good results (160).

**Micropropagation.** *T. cordata* is commercially micropropagated (88).

**Toyon.** See *Heteromeles*.

***Trachelospermum asiaticum.*** Asiatic jasmine. An important ground cover that can be rooted any time of the year (Texas). Cuttings are quick-dipped in 3,500 ppm IBA and rooted under mist or under heavy shade in outdoor beds. They root easily from the nodes and can be direct-stuck in any suitable rooting media. In Alabama, four to five cuttings are stuck in the center of a small pot, which results in less time to produce a full liner plant. *T. asiaticum* can be micropropagated (8).

***Trachelospermum jasminoides.*** Star or Confederate Jasmine. Leafy cuttings of partially matured wood root easily, especially when placed under mist and treated with 1,000 to 3,000 ppm IBA quick-dip or talc.

**Tree of Heaven.** See *Ailanthus*.

**Tree Tea.** See *Leptospermum*.

**Trumpet Creeper.** See *Campsis*.

***Tsuga* spp.** Hemlock.

**Seed.** Hemlocks are propagated by seed without difficulty. Seed dormancy is variable; some lots exhibit embryo dormancy, but others do not. To ensure good



germination it is advisable to stratify the seeds for 2 to 4 months at about 4°C (40°F). Fall planting outdoors generally gives satisfactory germination in the spring. The seedlings should be given partial shade during the first season.

**Cuttings.** The preferred method of propagating hemlock cultivars is by cuttings. *T. canadensis* cultivars can be rooted with either hardwood cuttings (bottom heat plus 5,000 ppm each of IBA and NAA, or a 10,000 ppm IBA quick-dip) or softwood cuttings treated with 8,000 ppm IBA talc plus wounding the cuttings. Softwood cuttings have a lower rooting percentage, but once rooted have a greater growth rate than hardwood cuttings (119). Moisture stress will cause needles to drop, so do not store the cuttings prior to rooting. Rooting varies widely among cultivars.

**Grafting.** Weeping cultivars of *T. canadensis* have been grafted. Bench grafting is done with seedling rootstock in small liner pots which are brought into the greenhouse and maintained at 18°C (65°F) for 6 weeks. Dormant scions are collected as needed during the winter and a side-tongue graft is used (131).

**Tulip Tree.** See *Liriodendron*.

***Ulmus* spp.** Elm.

**Seeds.** Seed propagation is commonly used. Elm seed loses viability rapidly if stored at room temperature, but can be kept for several years in sealed containers at 0 to 4°C (32 to 40°F). Seed that ripens in the spring should be sown immediately, and germination usually takes place promptly. For those species that ripen their seed in the fall, either fall planting or stratification for 2 months at about 4°C (40°F) should be used. To obtain tree uniformity, selected clones are propagated by budding on seedling rootstocks of the same species.

**Cuttings.** Softwood cuttings of several elm species can be rooted under mist when taken in early summer. Semi-hardwood cuttings have been rooted without mist or auxin treatments (363). Softwood cuttings taken from new growth arising from cut-off stumps root readily if treated with IBA and placed under mist. *Ulmus* 'Frontier' (*U. capinifolia* × *U. parvifolia*), *U. parvifolia* 'Pathfinder,' and *U. wilsoniana* 'Prospector'—all of which are highly adaptable to tough urban sites and have resistance to Dutch elm disease—are propagated with softwood cuttings, treated with an 8,000 ppm IBA quick-dip.

*U. parvifolia* can be rooted by softwood cuttings, treated with 5,000 ppm IBA or 1,250 ppm, each,

of IBA + NAA. However, hardwood cuttings treated with 10,000 ppm IBA are preferred, since there is greater growth of the rooted cutting in the same season, and winter protection is not required, as it is with softwood cuttings (Kansas) (314). *U. hollandica* can be propagated by hardwood cuttings taken in late winter, treated with IBA at 1,500 ppm, then placed in a bin over bottom heat for 6 weeks before planting (439). Long [62 cm (24 in)], semi-hardwood cuttings of *U.* 'Regal' rooted well when treated with 5000 ppm IBA and propagated under high pressure fog systems. Rooting was enhanced and production time reduced with the larger propagules (389).

**Micropropagation.** *Ulmus* is commercially micropropagated.

**Umbrella Pine.** See *Sciadopitys*.

***Ungnadia speciosa.*** Mexican buckeye. An outstanding native of central Texas and northern Mexico which grows as a tree or a large multistemmed shrub. Propagation is by seed, which is collected in late summer and needs no pregermination treatment (219). Seeds turn from green to dark brown and become mature in July (Texas). Seedlings require full sun (392).

***Vaccinium* spp.** Blueberry, Cranberry, Huckleberry. Evergreen huckleberry (*V. ovatum*) is similar to Japanese holly, but with reddish-colored new growth and pale pink flowers in profusion.

**Seed.** Most *Vaccinium* species have no seed pregermination requirements. Exceptions are lingonberry or mountain cranberry (*V. vitis-idaea*)—its seed is separated from the fruit and cleaned, then cold stratified for 90 days at 4°C (40°F). A higher percentage of seed will germinate with stratification than without (350). *Vaccinium* seed require light for germination.

**Cuttings.** *V. ovatum* is propagated by cuttings from fully matured shoots taken in fall and winter; cuttings made from previous year's growth taken the third week in April root readily (Vancouver, B.C.). Basal heat [21°C (70°F)] and 3,000 to 4,000 ppm IBA talc enhance rooting (410). Rabbiteye Blueberry (*V. ashei*) and Highbush Blueberry (*V. corymbosum*) are propagated by terminal softwood cuttings treated with 8,000 ppm IBA talc or 4,000 ppm NAA. American cranberry (*V. macrocarpon*) is easily rooted with 1,000 ppm IBA talc (131). Many blueberry species root best when very soft cuttings are taken and not treated with auxins.

**Micropropagation.** Blueberry cultivars are commercially micropropagated. Cascade huckleberry (*V. deliciosum*), mountain huckleberry (*V. membranaceum*),



and oval-leaf bilberry (*V. ovalifolium*) are also micro-propagated (24).

**Vauquelinia spp.** Arizona rosewood (*V. californica*). This is a drought-tolerant, rosaceous evergreen shrub, which is one of the most popular landscape plants used in semi-arid regions of the southwestern United States. Seed propagation is highly variable (384). Cuttings taken from 6- to 10-year-old stock plants root best when propagated from May to June (Arizona) under mist and bottom heat [32°C (90°F)]. An IBA quick-dip at 8,000 ppm is of some benefit, but clonal variability (0 to 95 percent rooting) and season timing are the most important factors.

**Veronica.** See *Hebe*.

**Viburnum spp.** Viburnum. This large group of desirable shrubs can be propagated by a number of methods, including seeds, cuttings, grafting, and layering (44). At least one species (*V. dentatum*) is readily started by root cuttings.

**Seeds.** The viburnums have rather complicated seed dormancy conditions. Seeds of some species, such as *V. sieboldii*, will germinate after a single ordinary low-temperature [4°C (40°F)] stratification period, but for most species, a period of 2 to 9 months at high temperatures [20 to 30°C (68 to 86°F)], followed by a 2- to 4-month period at low temperatures [4°C (40°F)] is required. The initial warm temperatures cause root formation, and the subsequent low temperature causes shoot development. Cold stratification alone will not result in germination. Such rather exacting treatments may best be given by planting the seeds in summer or early fall (at least 60 days before the onset of winter), thus providing the initial high-temperature requirement; the subsequent winter period fulfills the low-temperature requirement. The seeds should then germinate readily in the spring. Often, collecting the seeds early, before a hard seed coat has developed, will hasten germination. Viburnum seed can be kept up to 10 years if stored dry in sealed containers and held just above freezing. *V. lantana*, *V. opulus*, and *V. rhytidophyllum* are commonly propagated by seed.

**Cuttings.** Although some viburnum species (*V. opulus*, *V. dentatum*, and *V. trilobum*) can be propagated by hardwood cuttings, softwood cuttings rooted under mist are successful for most species. Soft, succulent cuttings taken in late spring root faster than those made from more mature tissue in midsummer, but the latter are more likely to develop into sturdy plants that will survive through the following winter. Treatments

with 8,000 ppm IBA talc and a 2,500 ppm IBA quick-dip have been recommended (38). In Illinois, cuttings of *V. carlesii* taken in June root best when treated with 10,000 ppm K-IBA. Cuttings are direct-rooted in small liner pots in a heated quonset house, left in place, and allowed to go dormant and maintained throughout the winter at a minimum temperature of 2°C (28°F) (325).

One of the chief problems with viburnum cuttings is to keep them growing after rooting. Cuttings made from succulent, rapidly growing material often die within a few weeks of being potted. This problem may be overcome by not transplanting the cuttings too soon, and allowing a secondary root system to form, which will better withstand the transplanting shock. It may help to fertilize the rooted cuttings with a nutrient solution about 10 days before the cuttings are to be removed. It is best not to fertilize rooted cuttings of *V. carlesii* until new growth has started. Placing the rooted cuttings under supplementary lighting to increase daylength is also helpful. Cuttings of some species root more easily than others. *Viburnum carlesii*, for example, is difficult to root, while *V. burkwoodii*, *V. rhytidophylloides*, *V. lantana*, *V. sargentii*, and *V. plicatum* root readily.

**Grafting (21).** Selected types of viburnum are often propagated by grafting on rooted cuttings, layers, or seedlings of *V. dentatum* or *V. lantana*. Often, grafted viburnums will develop into vigorous plants more quickly than those started as cuttings. *V. opulus* 'Roseum' (Snowball) is dwarfed when grafted onto *V. opulus* 'Nanum' cuttings. It is important that all buds be removed from the rootstock so that subsequent suckering from the rootstock does not occur. The rootstocks are potted in the fall and brought into the greenhouse, where they are grafted in midwinter by the side-graft method, using dormant scionwood. After grafting, the potted plants are placed in a closed, glass-covered or poly frame with the unions buried in damp peat moss.

Grafting can be done in late summer also, using potted rootstock plants and scion material that has stopped growing and become hardened. *V. carlesii* 'Compactum' is grafted on *V. dentatum* rootstock during mid-September (Rhode Island) using a conventional side-veneer graft (213). The grafted plants are buried in slightly damp peat moss in closed frames in the greenhouse until the unions heal, after which they are moved to outdoor, poly-covered cold frames for hardening-off over the winter.

**Micropropagation.** Viburnums are commercially micropropagated.

**Victorian Smokebush.** See *Conospermum*.





**Virginia Creeper.** See *Parthenocissus*.

**Walking Stick.** See *Aralia*.

**Waratah.** See *Telopea*.

**Waxflower.** See *Chamelaucium*.

**Wax Myrtle.** See *Myrica*.

**Weigela spp.** Weigela. This shrub is easily propagated either by hardwood cuttings planted in early spring or by softwood tip cuttings under mist taken any time from late spring into fall. Rooting is promoted by treating softwood cuttings with a 1,000 to 3,000 ppm IBA quick-dip, and hardwood cuttings with a 8,000 ppm IBA talc (England). Weigela is commercially micropropagated.

**Willow.** See *Salix*.

**Willow, False Willow.** See *Baccharis*.

**Winterhazel.** See *Corylopsis*.

**Wisteria spp.** Wisteria. It may take 8 to 12 years for seed-propagated wisteria to flower, which is why it is vegetatively propagated. Seeds and pods are poisonous. Wisterias may be started by softwood cuttings under mist taken in midsummer. IBA often aids rooting.

Some species can be started by hardwood cuttings set in the greenhouse in the spring. *W. sinensis* can be propagated with 6 to 8 cm (2.5 to 3 in) root cuttings without auxins (283). It is important to maintain polarity of root cuttings and to plant vertically with tops of cuttings level with the surface of a porous rooting medium. Simple layering of the long canes is quite successful. Choice cultivars are often grafted on rooted cuttings of less desirable types. Suckers arising from roots of such grafted plants should be removed promptly. Wisteria is commercially micropropagated.

**Witch Hazel.** See *Hamamelis*.

**Xylosma congestum.** This is propagated by rooting leafy cuttings taken in late summer or early fall, using the first and second subterminal cuttings on the shoot. Cuttings are treated with a 5,000 ppm IBA quick-dip and propagated under mist with bottom heat [21°C (70°F)]. Rooted cuttings should be hardened in a cool, humid greenhouse.

**Yellow Poplar.** See *Liriodendron*.

**Yew.** See *Taxus*.

**Zamia.** See *Cycas*.

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