

Ginkgo biloba L.

ginkgo

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Other common names. maidenhair-tree, Kew-tree.

Growth habit, occurrence, and use. *Ginkgo* is a monotypic genus native to China, the sole survivor of the ancient family of Ginkgoaceae (Bailey 1923; Dallimore and Jackson 1948; Seward and Gowan 1900). Geologic records indicate that ginkgos have grown on Earth for 150 million years (AGINFO 1994). This tall (<35 m) deciduous, sparsely branched, long-lived tree has been cultivated extensively in the Far East and Europe (AGINFO 1994; Bailey 1923, 1947; Seward and Gowan 1900). The foliage of this broad-leaved gymnosperm consists of alternate, simple, fan-shaped, leathery leaves 2 to 5 cm long, with forking parallel venation. Ginkgo trees grow in an upright pyramidal form, becoming broader and regular with age (AGINFO 1994). Ginkgo was introduced into North America in 1784 and has generally been successful on good sites in the moist temperate zone of the midwestern and eastern United States and along the St. Lawrence River in Canada (Bailey 1947; Rehder 1940). Ginkgo trees prefer full sunlight and well-drained conditions and are adaptable to many soils, but they are slow to recover from transplanting (AGINFO 1994). It is valued as an ornamental and shade tree, particularly as a park and street tree (Bailey 1947). Ginkgo is highly resistant to air pollution and could be grown in areas within its introduced range where air pollution damages other species. The cooked seeds are used for food by the Chinese, but the fleshy layer can cause dermatitis (AGINFO 1994; Porterfield 1940).

Flowering and fruiting. The species is dioecious. The catkin-like male flowers appear in late March or early April, and the pistillate flowers appear later in April before leafout (Sakisaka 1927). A single naked ovule ripens into a drupe-like seed with a fleshy outer layer smelling of rancid butter and a thin, smooth, cream-colored, horny inner layer (figures 1 and 2). The fleshy-coated seeds are frequently called fruits. They are cast in the fall after the first frost, but at this time a larger percentage of the seeds have immature embryos and cannot be germinated under normal test conditions (Alexander 1974; Eames 1955; Willan 1985). Embryo development continues while seeds on the ground are exposed to temperatures normally encountered during fall and early winter. Embryo maturation is usually complete about 6 to 8 weeks after the seeds drop (Lee 1956; Maugini 1965). Because of the offensive odor of the outer layer of the seeds, only male clones are recommended for landscape use (AGINFO 1994).

Ginkgo is also capable of reproducing vegetatively. Del Tredici (1992) describes the origin and development of basal chichi, tuber-like callus growths on the lower trunk that originate from superficial meristematic buds located in the cotyledonary axils of all ginkgo seedlings and allow

clonal regeneration. Within 6 weeks of germination, these buds become embedded in the cortex of the stem and develop below the bark surface. If a traumatic event damages the tree, these buds grow down from the trunk to form basal chichi from which both aerial shoots and adventitious roots can grow. Up to 40% of mature trees Del Tredici observed at 1 location in China were multi-stemmed, with 2 or more secondary stems originating from 1 or more basal chichi. This form of vegetative regeneration may have played a role in the remarkable survival of ginkgo since the Cretaceous Period.

Collection, extraction, and storage. Ginkgo trees begin bearing seeds when they reach 30 to 40 years of age (Hadfield 1960; Ponder and others 1981). The flesh-coated seeds may be collected on the ground as they ripen or picked by hand from standing trees from late fall through early winter. Seeds may be prepared for cleaning by covering them with water for several days until the flesh begins to soften (Munson 1986). Food processing blenders can be used to macerate the softened fruits after their metal blades are replaced with plastic tubing propellers. Fruits should be covered with water, then macerated thoroughly in a blender cup using short bursts of the motor. The pulp is then floated away by slowly adding additional water and allowing filled seeds to sink to the bottom of the cup (Munson 1986). About 12.5 kg (27.5 lb) of cleaned seeds can be obtained from 50 kg (110 lb) of seeds with fleshy layers (Swingle 1939). Cleaned seed density varies from 400 to 1,150 seeds/kg (180 to 520 seeds/lb) (Alexander 1974; Swingle 1939). Cleaned seeds have been kept in ordinary dry storage in both open and closed containers at 5 to 21 °C without any apparent adverse effects (Davis and Henery 1942; Hatano and Kano 1952; Swingle 1939).

Germination. Recommended germination test conditions for ginkgo call for the placement of the seeds, with their coats removed, on the top of or between moist blotters at alternating day/night temperatures of 30 and 20 °C for 30 days (ISTA 1993). Germination tests conducted in moist sand for 60 days using 20 °C. nights and 30 °C days ranged from 46% germination for seed collected in October to 90% germination for seed collected in December (Alexander 1974). Germination of untreated seed planted in a soil medium varied from 32 to 85% (Davis and Henery 1942; Swingle 1939). A stratification period of 30 to 60 days at 5 °C before planting has been recommended (Ponder and others 1981), however 1- to 2-months of warm stratification before cold stratification is also advised to allow seeds to fully mature (Dirr and Heuser 1987; Willan 1985).

Nursery practice. Seeds should be sown in the late fall (November), preferably in furrows, and covered with 5 to 8 cm (2 to 3 in) of soil and a sawdust mulch (Heit 1967; Alexander 1974). About 50% of the viable seed that are sown will produce usable 2+0 seedlings (Alexander 1974). Ginkgo seedlings grown in artificial growth chambers were able to grow continuously for a 20-week period under a 32 to 25 °C day/night regime (16-hour day-length). This regime produced similar-sized plants as those grown under a 24/17 °C regime for 40 weeks (Flesch and others 1991).

Ginkgo can also be propagated in the nursery from cuttings, although rooted cuttings are slow growing. Cuttings 10 to 15 cm (4 to 6 in) long should be collected from mature trees in midsummer, treated with 8,000 ppm indole-butyric acid (IBA) in solution or in talc, and misted for 7 to 8 weeks (Dirr and Heuser 1987).

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Figure 1C *Ginkgo biloba*, ginkgo: seeds enclosed in their fleshy outer layers and cleaned seeds with fleshy layers removed, $\times 1$.

Figure 2C *Ginkgo biloba*, ginkgo: longitudinal section through a seed, $\times 2$.