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Ginkgo – *Ginkgo biloba* : Eldest & Last

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There is one genera of trees witness to the rise and fall of all the dinosaurs. This same tree genera barely survived the last ice-age. Ginkgo has become a tree without a home — an exotic wanderer scattered across the globe. Every botanical garden and arboretum worthy of its title has at least one ginkgo tree. Cited as a living fossil, a cultural icon of the Orient, and a tree both bizarre and fascinating, ginkgo shares our world today due solely to human cultivation. Its botanical uniqueness, food content, and medicinal values assure people will continue to cultivate this most antique of trees.

This publication collects curiosity surrounding ginkgo from its name to its wood. Appreciating a living ginkgo standing in the sun can be enhanced by understanding its ecological history, biology, and structure. Here myths will be discarded and rumors quenched regarding a ginkgo tree in order to grasp the priceless and timeless genetic qualities of Ginkgo biloba, a last survivor of an ancient family and of an ancient age.

The Ginkgo Age

The ginkgo family line stretches back beyond 225 million years. The fossil record places one or two species of ginkgo at this beginning. Over time there has been at least 20 species of ginkgo, possibly as many as 50 species, in at least four genera. The ginkgo family reached its height of ecological success about 150 million years ago when there were approximately five common, widespread species. This family covered many parts of what is now the Northern Hemisphere of Earth. Catastrophe struck 65 million years ago.

The same global changes which initiated loss of dinosaurs and allowed for rise of mammals, also decimated ginkgo forests. Only one ginkgo species survived. Surrounded with more effective competitors and seed predation, ginkgo began a long decline into extinction. Ginkgo disappeared from North America around 7 millions years ago, Europe around 3 million years ago, and its last few refuges in Asia evaporated across the last million years. Successive waves of global cooling snuffed out almost all the scattered remnants of ginkgo. Petrified wood and leaf fossils of ginkgo are the only remains found in a number of sites across North America.

Genetic Relationships

Ginkgo biloba is unique among trees in occupying its own taxonomic division, class, order, family, and genus. It has outlived its relatives by large genetic distances and millions of years. Ginkgoes are seed plants, but not flowering plants. Ginkgo is one of four primary subdivisions of seed plants

called gymnosperms which include: cycads (9 genera and ~100 species); conifers (48 genera and ~500 species); Gnetales (3 genera and ~64 species); and, ginkgo (1 genera with 1 species).

In gymnosperms, Gnetales are considered developmentally advanced and cycads are considered primitive. Conifers are considered a main-line and dominant group defining gymnosperms. Ginkgoes share traits intermediate between cycads (with similar reproductive traits) and conifers (with similar growth and structural traits). Ginkgoes are an advanced cycad or a primitive conifer. Ginkgo represents a genetic way-station on the road to modern trees.

By Any Other Name?

The given scientific name for this tree is Ginkgo biloba. The meaning of this scientific name is a "two-lobed-leaved silver apricot." The word *ginkgo* is derived from Chinese and Japanese terms *ginkyo* meaning silver apricot. The common name is greatly confused by translation and cultural differences. The most used common name follows the scientific name of *ginkgo* (*ginkgo* being singular and *ginkgoes* being plural.) Other common names used are: duck-foot leaf tree, duck-foot tree, gingkyo, ginkgobaum, ginko, ginkyo, grandfather-to-grandson tree, icho, maidenhair tree, nut apricot, noyer du japon, silver apricot, spirited eye, temple tree, white eye, and white fruit.

In beginning to determine ginkgo taxonomy, the common term ginkyo was mis-translated and mis-spelled by Latin-based taxonomists as ginkgo. Ginkgo biloba was the designated name established in 1771. Renaming and reorganizing the tree's taxonomic position occurred at least twice with scientific names Salisburia adiantifolia (1797) and Pterophyllus salisburiensis (1866) being proposed. The oldest name (Ginkgo biloba) remains the proper scientific name.

Native Land?

Ginkgo was first found by modern humans in China. Mature ginkgo grows in low density, disturbed, mixed forests. Ecologically, ginkgo is an early-successional species which colonizes sunny, open soil areas without much competition. Cut stream banks, soil slide areas, and large forest gaps are prime seed germination and seedling establishment areas. Mid-slope positions in heavily flooding river valleys, and well-drained, non-saturated mineral soil sites are ideal. Ginkgo can vegetativly reproduce as a strategy for holding onto a site for hundreds of years.

Ginkgo can be found in naturalized stands within mixed species forests on lower mountainsides of Tien Mu Shan in Eastern Anhui province and in adjacent Zhejing province, West of Shanghai, China. It is unclear if any of the remaining four old stands of ginkgo in China are true natives to their sites, or were naturalized and cultivated by man over the last two millennia.

The value of ginkgo was first recognized as a food and medicine source. Historically, ginkgo was conserved for only the royal household. Information about the tree slowly escaped palaces, and ginkgo trees were cultivated within protected gardens and monasteries. The reverence and veneration of ginkgo occurred not because of religious or spiritual reasons, but because of its uniqueness, food cash value, and perceived medicinal properties.

World Travels

As more seeds became available, and as more trees were planted to supply the royal court, more seedlings escaped, cultivated by merchants and peasants. Around 800 years ago ginkgo trees were first recorded as a part of trade to Japan and Korea. Europeans first saw the tree in Japan in 1691 and noted its unique qualities. Upon further searches through the middle 1700's, Europeans found ginkgo growing

in China, Japan, and Korea. Ginkgo was first mentioned botanically in continental Europe in 1712. The Dutch introduced the tree to continental Europe in 1727 near Utrecht. Cultivation in England began in 1754.

A botanist and collector named Hamilton planted the first two trees in the United States near Philadelphia in 1784. Both of these trees are now gone. The oldest living ginkgo tree in the United States was planted in 1785 or shortly thereafter by the Bartram brothers, also near Philadelphia. A planting fad erupted among upper middle class and wealthy households in the Northeastern part of the United States in early 1800's and again in the 1890's continuing until the first world war. A curiosity and strangeness factor still propels planting ginkgoes around the world – in yards, schools, streets and parks.

Size, Reach, & Extent

Ginkgoes come with many variations in growth. There are ginkgo cultivars in many sizes and shapes. The "normal" ginkgo traits are reviewed here. Ginkgo is a large, broad, tall tree when mature. Many people have mistakenly used ginkgo for street-side plantings and around buildings where there is little below or above ground space for trees to colonize. Naturally shaped, typic ginkgoes are considered too large for narrow street or tree lawn plantings.

Crown spread is highly variable and has been selected for in various cultivars. Ginkgo trees can reach 50-90 feet in height with a 30 to 60 feet wide crown spread on a trunk 2-3 feet in diameter. The largest ginkgoes occur in China and reach maximum confirmed sizes of approximately 140 feet tall and 16 feet in trunk diameter. Note true height and trunk diameter are estimates due to mountainous terrain exposing root collars and root base areas, and to adventitious roots and special aerial root growths, all clouding where to take measurements.

Life-Form & Life-Span

Ginkgoes can reach large sizes on good sites away from site disturbances and highly competitive plants. Juvenile trees have regularly spaced but sparse branches forming an upright and open crown. As trees mature, crowns become more spreading with branches colonizing more resource space and becoming more dense. With age, branches fill-in the open crown areas of youth. The noticeable, single-leader dominant, young tree crowns are usually overtaken by other branches resulting in a multi-leader tree with age. Final mature form is an elongated wide oval crown. There is a difference in crown shape between a more upright and narrow crown shape in male trees, and more spreading and shorter female trees. Reliable sources cite maximum existing tree age to be 1,200 years old. Unsubstantiated reports cite 3,000 years maximum age.

In the species Ginkgo biloba there are seven primary crown and leaf forms (besides "normal" or "typical") which humans have cultivated: a weeping or pendulous form; a highly upright or fastigiate form; a dwarf type; a branch type with many aerial root bulges; and, three foliage variations — rolled tubular leaves, variegated leaves, and leaf/seed-stem fused foliage.

Growth Rate

There are many highly variable citations for growth rate. Many measures are confused by cultivar traits, gender, biological age, and site resources available. Without isolating each factor, a simple growth rate value means little. As a general rule, ginkgo has a moderate growth rate compared with other specimen trees in an established landscape. An establishment period of 2-5 years is usually a

time of extremely slow growth. After establishment until approximately 40 years of age, growth rate can be rapid. As active sexual reproduction accelerates, growth rates decline.

As female trees reach sexual maturity (20-40 years of age), elongation and crown expansion rates decline as more resources are dedicated to seed production. After 150 years, growth rates are usually considered slow, although ancient ginkgoes on sites with great resources can sustain rapid growth for centuries. The fastest, long-term growth occurs in males on the best resource-available and stress-reduced sites, and where roots are infected with mycorrhizae fungi (endo — VAM type – Glomus spp.).

Figure 1 provides an extremely rough estimate of mortality and normal expected lifespan for ginkgo based only upon information cited in the scientific and popular literature. Note established ginkgo should grow for at least 45 years, and can be expected to live to be 110 years of age. Figure 2 provides an extremely rough estimate of ginkgo diameter growth over time. Note a normal ginkgo at 110 years of age should have a diameter of 2.1 feet. Height data presented across the literature is confounded much more than diameter and age due to storms and site constraints. In general, a 110 year old ginkgo, 2.1 feet in diameter would be roughly 62 feet tall.

Tree Health Issues

Ginkgoes are easy to transplant and establish if a large root ball with healthy roots are planted. Because of seed production litter and associated mess, plant only males for shade and street tree uses. Approximately 0.5% of male ginkgoes will generate some isolated seeds (monecious-like). Females should be planted as specimens away from walking trails and public areas, if at all. Tree health care is minimal except for providing good moisture in a well-aerated, well-drained soil.

Ginkgo has few primary pests and share key stresses with all other trees – water availability in the growing season. Ginkgo is tolerant of air pollutants at low to moderate levels. Seeds are susceptible to fungal attack. Many different parts of the tree contain a variety of anti-biological compounds targeted primarily at animal systems. One major concern in ginkgo is a failure to effectively deal with wounds. Ginkgo does not react quickly in compartmentalizing injuries. This is especially noticeable in CODIT wall four (i.e. next year's increment) problems generating small to large cavities.

Ginkgo should not be green-wood pruned when young. Allow a tree to grow naturally until it is larger, and then do not use crown cleaning or thinning. Use crown raising and terminal abridging to control crown spread. Light nitrogen fertilization, once a tree is established, will be essential for good tree performance. Beware of nitrogen fertilizer over-dose, especially when soils are compacted or drainage is poor.

Site Preference

Ginkgo is an early successional pioneer onto open mineral soils in full sun. They can establish and grow on disturbed areas if viable seeds can reach the site. As with most trees, temperature and water availability regimes override most other site constraints. In general, ginkgo requires 90% to full sun, moist but well-drained soils, and neutral to acidic soils. Ginkgo requires North American winter hardiness zones of 4-8. Elevational limits are below 6,000 feet above sea-level. Ginkgo is cited as being urban site and air pollution tolerant. This is a relative rating and growth rate is significantly sacrificed for any resource poisoning or resource availability constraints.

Identification

What is a ginkgo? What are the features which differentiate a ginkgo from other trees? Although identification of ginkgo is usually not a problem because of its striking attributes, there are

many peculiarities which have interest and help people appreciate ginkgo as an ancient tree whose family members have sheltered both man and dinosaurs. Note the following descriptions are not intended to be taxonomically comprehensive but educational.

Leaves

Ginkgo leaves are bright green with a touch of grey color, simple, flat and broad. Figure 3. Under high fertilization levels or flooded conditions, leaves can be a dark green. Leaves can be considered "broad-leaved" even though ginkgo is a gymnosperm. Figure 4. Leaves are fan-shaped, with a smooth surface except for rare trichomes (plant hairs) in axils of veins. Leaves appear ribbed from clearly delineated veination lines, but veins are only slightly raised. Leaf veins can be traced from the initial two veins at the blade base apically, always splitting into two veins and widening the leaf blade. Veins have an open, non-interconnected or non-crossing architecture. Leaf surfaces are waxy. Figure 5.

Leaf shape is highly variable. The wide end or tip of a leaf can be complete (entire) or have a variety of clefts and splits. A single cleft leaving two partially separated lobes is by far the most usual (i.e. species name biloba or two-lobed.) Next most common is two clefts through the leaf blade. Leaves are 2.0 to 3.5 inches long with leaf blade about 1.3 times wider than long (2.5 to 4.5 inches wide). Stomates are recessed and almost completely concentrated on the underside of a leaf.

Falling Leaves

Leaves are attached to a tree with a long flexible leaf stalk (petiole), up to three inches long, which has a small groove running its length. Leaves tend to flutter and turn in small breezes generating a unique rustling sound. Leaves absorb the usual chlorophyll activating wavelengths of light, but relatively large amounts of both usable and unusable light pass through a leaf and canopy. Light filtering and blockage impacts on lower leaves are reduced by petiole flutter, loose open crowns, and limited absorption giving ginkgo an open, light-filled understory. One of the most desirable and noticed attributes of ginkgo leaves is the golden-yellow to clear solid yellow Fall leaf color. Leaves and seed coats of ginkgoes contain several insecticides, toxins, and physiologically active compounds reducing insect, fungi, and bacterial pests.

Fallen leaf decomposition is initially fast because of residual nitrogen, phosphorus, and other elements which were not remobilized in senecense remaining in discarded leaves. Leaves are deciduous and tend to senescence, and then abscise all together in one event. Leaves and reproductive parts grow from thick, short shoots or spurs (modified shoots with extremely short internodes) which occur alternately along twigs and branchlets. Each short shoot usually carries 3-5 leaves. Figure 6. Terminal growth which has not developed spurs, carry leaves alternately along newly expanded shoots.

Gender Roles

Ginkgo is a dioecious tree, meaning each tree is either a male or a female. Tree gender can have serious implications when female trees begin to heavily generate seed. Approximately 0.5 % of all male trees can bear some seeds (approaching a monecious system on a single tree where both functional sexual parts occur on the same tree). Both male and female reproductive organs are held on stalks growing from short shoots along branches. In rare natural events, which have now been accentuated by breeding, stalks are sometimes formed as part of a leaf blade or can appear to be winged.

Male trees have soft greenish-yellow cone-like / catkin-like spiral clusters of pollen sacs which appear in Spring near the end of branches on short shoots. There are usually 3-6 pollen cones per short

shoot which are 0.5 to 0.75 inch in length on slender stalks. Pollen is released when female trees are receptive – usually in March to early April. Ginkgo pollen is light, buoyant, and spindle-shaped when released. Upon capture and enclosure by female tissues, pollen grains swell to a spherical shape. One male tree is needed in close proximity to every five female trees for good pollenation and viable embryo production. Male reproductive parts are generated over the entire crown.

Female trees generate reproductive tissues at the end of slender stalks growing from the ends of short shoots on branches in March to early April. Figure 7. Figure 8. Each stalk has two collared ovules at its tip, and there are 2-5 stalks per short shoot. Figure 9. Figure 10. Under stressful conditions only one stalk may succeed in generating a seed. Under good conditions paired seeds develop. Female trees are not sexually mature until about 20 years of age (the range is 17 to 40 years of age before seed production). There is one female cited as not commencing to bear seed until 45 years of age. Grafted female branches tend to produce seed in 1/5 the time as female seedlings. Female reproductive structures are generated in localized patches within a tree crown, not all over.

Fertilization

Pollenation is by wind blowing pollen to the wet end (pollenation droplet) of female reproductive tissue. Once pulled into female tissue on a water droplet surface, pollen rests among female cells until late Summer. As pollen rests, female tissues grow rapidly in preparation for fertilization and embryo development. Female tissues pass through four primary stages of development: a rapid growth period until the first of July; a resting phase till mid-August when the seed coat is hardened; a slow growth stage until early September when fertilization is taking place; and, rapid embryo development through to seed abscission in late September to early October (with seeds falling before leaves.)

Fertilization of the egg cell buried in a seed occurs in late Summer. Once female tissues are ready, a pollen grain germinates quickly, producing two swimming sperm cells (a highly unusual cell type in plants), and one fertilizes the egg. Embryo development is rapid and sustained either on the tree or on the ground. Pollenation, fertilization and embryo development occur within the same growing season, with seed germination readied for the following Spring.

Seeds

Ginkgo seeds are composed of three functional parts: a fleshy outer coating comprising 75% of green seed weight; a hard, smooth, cream-colored, shell-like inner coating; and, farthest within a seed, an embryo with nutritive materials (2-3 cotyledons) to support seedling establishment and growth. To many people, the fresh seed looks like a small drupe (apricot or cherry), or a ripe olive fruit of angiosperms. Ginkgo does not generate a fruit, but a seed with a simple fleshy coating. The term “fruit” should not be used for the reproductive unit of ginkgo. Figure 11.

The seed is smooth, oval, and approximately 1 to 1.5 inches long and 0.9 to 1.1 inches in diameter. There are usually 1-2 seeds generated on each 2 - 3.5 inch long, greenish-orange, seed stalk. One vegetative type of ginkgo cultivated for its strangeness has seed stems and leaves morphed into one unit. The immature seed coat is greenish with casts of orange and a white waxy surface coating. When ripe, the seed coat is greenish-yellow with tan and orange streaks or patches. The white waxy surface coating (bloom) covers the seed coat and is easily removed with your fingers. The seed coat has a small apical scar or dot on its end.

Stench!

The fleshy seed coat of ginkgo is truly malodorous and messy. The scent is similar to canine feces, rancid butter, vomit, and/or rotting flesh. Chemicals responsible for the smell, and corrosive qualities of the seed coat on flesh, are butyric and hexanoic acids. These acids can cause skin damage. The fleshy seed coat completely surrounds a seed and minimizes oxygen flow to the embryo, preventing germination. Seed germination and seedling growth require seed coat removal, and contact with moist but well-drained mineral soil under full sunlight.

Seed coat odor was thought to have developed to attract carnivores to consume, scarify, and transport seeds to new locations. Today animals which make use of ginkgo seeds as a food source are opossums, squirrels, racoons, skunks, large birds, and rodents. Some seeds consumed will survive to germinate after passage through an animal's digestive system.

Male Bias

Because of the revulsion many people have to ginkgo seed coat odor, female trees are usually not planted in the United States. Because of this preference for male trees, few people have seen a female tree or a ginkgo seed. Ginkgo is usually propagated by male cuttings grafted onto seedling root stocks. Where viable seed are needed, male branches can be grafted onto female trees in various places to assure pollenation.

Sexing Seed?

There is no means for easily distinguishing male from female embryos or seedlings until they become sexually mature and start to generate pollen and seeds. At the cellular level, ginkgo appears to have chromosomal markers similar to humans in that two X chromosomes generate females trees and an XY chromosome set generate male trees. A DNA test for sexing ginkgo is difficult and not usually completed. Seeds tend to have an evenly distributed ratio between being male and female.

Developing Embryo

As late Summer and early Fall arrive, fertilization is completed and the embryo rapidly developes. Seeds found on the ground or in a tree in late Summer may or may not contain a fertilized egg. By early Winter, fertilization is complete in most seeds. Female cell initials which generate the embryo are unique among trees in being photosynthetically active in the seed. The embryo also can harbor symbiotic simple algae cells which function to stimulate germination under proper light and oxygen conditions.

Seeds begin to fall in early Autumn with both unfertilized eggs and rapidly developing embryos inside. Usually, any naturally abscised mature seed with mature male trees in the area will have developing embryos present. From early Fall to late Fall, embryos develop. This development and growth period for the embryo is essential for seed viability. Seed selection for viability should be made from either the tree, or the ground beneath, in early Winter. Ginkgo usually bears a heavy seed crop every other year with some seed produced every year. Heavy seed crops weight branches to the breaking point under good fertilization and soil health, leading to branch damage. Many seeds are usually abscised in September to October, falling just before leaves.

Seed Coat Dangers

The seed coat chemicals producing putrid smells are high levels of butyric and hexanoic acids. Butyric acid can be symbolically described as $C_4H_8O_2$. Butyric acid is a thick, colorless, water soluble

liquid which is flammable in pure form. It is a natural fatty acid which can be synthesized and used in manufacturing some types of plastics. Butyric acid is found chemically bound in animal generated products like butter or in human sweat. As bacteria free the acid, it generates a distinctive scent. Symptoms of being exposed to the odor are: nausea; skin, eye, and lung burning; and, severe respiratory tract irritation. The acid is easily absorbed through skin. Personal safety demands use of gloves, eye protection, and protection of bare skin from contact. Respirator use is recommended for prolonged diffuse exposure and in sensitive individuals.

Hexanoic acid can be symbolically described as C6H12O2. Hexanoic acid is a thick, oily-looking, colorless liquid, which is flammable in its pure form. This acid has a distinct, unpleasant odor like butyric acid. Hexanoic acid is corrosive to the skin, an irritant to the respiratory system, and can cause burning pain in eyes. It is harmful to aquatic system health. Ginkgo seeds should not be allowed to fall into or collect in ponds, streams, pools, or other water features.

Twigs / Buds / Periderm

Ginkgo has thick twigs with many short, thick, greyish-tan short shoots or spur twigs 0.5 to 1.5 inches long. Short shoots generate leaves and reproductive parts. Buds are brown and rounded with scruffy looking scale edges. Leaf scars are half round in shape. Ginkgo periderm is light brown to brownish grey in color. Periderm is corky, low density, and deeply furrowed with flattened shiny ridge tops. Periderm contains many druses or crystals of calcium oxalate.

Burly

Large lower branches on some older ginkgoes can develop (naturally or in response to wounding) drooping bulbous burls or wood masses on their undersides generically called “chichi.” The literal translation of this term and this growth trait include teats, tits, nipples, breasts, or stalactites. These growths are aerial roots derived from suppressed shoot growing points which grow downward and reach soil generating roots, and afterwards the burl upperside generates shoots. This development process can lead to expanded structural support of tree tops and serve as an asexual propagation means.

This trait has also been selected for use in some cultivars. These growths have in the past been used to generate bonsai plantings by cutting the growth off of a branch, inverting the section and placing it in moist soil. New roots and shoots are generated and an old mature-looking ginkgo is produced on a small scale.

Wood

Ginkgo wood is light, soft-textured, fine-grained, and lustrous with a pale yellowish color. There are many intercellular spaces in the wood, making it much less dense than many other gymnosperm woods. Tracheids are thin-walled and rays are narrow. Ginkgo wood has primary and bordered pits in xylem on radial walls like conifers. Wood contains scattered druses or calcium oxalate crystals. These crystals in living portions of a tree are physiologically active surfaces for warehousing excess calcium, especially in high pH / high calcium soils.

Sapwood is easily and quickly colonized by wood staining fungi around wounds or when harvested. Lumber should be promptly dried. Use of antifungal agents may be required to preserve wood appearance. Ginkgo wood is used for trinkets, furniture parts, household items, carvings, handicrafts, and bowls.

Medicinal Uses

In modern life, most people first hear of ginkgo through marketing of herbal food supplements and medicines. Ginkgo extracts are a large health chemical business. Some Asian nations tend to use the medicinal values of ginkgo found in seeds, while Western nations tend to use medicinal extracts from ginkgo leaves. Compounds taken from ginkgo have been cited through testimonials (Note: there is a lack of clinical trials supporting a number of claims) to help alleviate symptoms or cure causes of everything from cancer to asthma.

Based on a number of different claims, digestive and urinary tract problem solutions and increased blood flow are the most common medicinal citations. Receiving less publicity on the internet and within the general public information systems are a number of negative side-effects, some extremely serious. Some ginkgo parts extracted or treated in one way may have different impacts on health than the same part treated in another way. Dosage and content of active ingredients (and carriers) can be a problem. Deaths from poisonings and allergic reactions have occurred.

Food Use

One use of ginkgo seldom highlighted in the United States is seed production for food. Ginkgo seeds have been cited as human food for more than 2,100 years. The first food uses were reserved for the elite and wealthy. Ginkgo seed consumption was not considered common until about 700 years ago. Cleaned ginkgo seeds can be boiled, baked, roasted, or steamed. Ginkgo seeds are similar to pistachios because the fleshy seed coats discolor hard seed coat surfaces requiring bleaching or colorants be used to hide stains (or seeds can be harvested promptly and seed coats immediately removed). Seeds split open slightly after cooking. The thin papery inner seed coat inside the hard shell can be easily removed like a peanut skin. Cleaned seeds have been eaten raw in extremely limited quantities for medicinal purposes, but this is considered dangerous and life-threatening.

When the hard seed covering of a roasted seed is cracked open, seed meat inside is similar in taste and texture to a starchy pine seed or a chestnut. Ginkgo seeds are most often purchased without the fleshy seed cover and lightly roasted. Cleaned roasted seeds are most commonly served salted with rice wine (sake) or other alcoholic drinks, or as part of desert foods. Cleaned seeds can be dyed red and treated like pistachios for celebrations and weddings. Seeds have about 115 calories per ounce. Seeds have about 4% protein, 1.5% fat, 0.75% fiber, and 35% carbohydrate, primarily as starch. Seeds are a good source of niacin, and contain vitamins A, B1, B2, B6, and C. Figure 12.

Collected Seeds Summary

Ginkgo (Ginkgo biloba) seeds require special cleaning and preparation for use as a food product or for use in growing seedling ginkgoes. Most of the preparation concerns revolve around seed collection and removal of the fleshy seed coat.

Removing the seed coat is critical for proper roasting and safe consumption. The fleshy seed coat carries an unpleasant or repulsive odor. The same chemicals which are responsible for the odor cause serious skin dermatitis and skin corrosion. These chemicals, and the associated brew of allergens and other compounds in the seed coat, can be left to rot away or mechanically removed from seed. Always use long latex or vinyl gloves, with full eye protection, for collection and cleaning.

Think Before Eating!

Before trying to process ginkgo seeds for human consumption, purchase commercially processed seed in a specialty food store for an example of taste, texture, and appearance. Ginkgo seeds have many

chemicals and substances which can be damaging to skin, eyes, mouth, and respiratory systems through inhalation and contact. In addition, green seeds, dry seeds, and cooked seeds can generate a number of allergic reactions. Green seeds should not be consumed.

Get A Bucket

Undamaged and full sized seeds should be collected in a plastic bucket. If a food use is planned, early Fall (mid-September) collection is suggested for peak starch content. If viable seeds for planting is planned, late Fall or early Winter collection is recommended. Minimize all skin and clothing contact with the fleshy seed coats. Always wear eye protection and gloves.

Place seeds in a plastic bucket, fill with water, and then squeeze and rub the seed coat off. Seeds can be left in water for many days to allow the fleshy seed coat to rot away. Wash and rinse water, and wet seeds, should not be allowed to touch unprotected skin or to soak into clothing. Consider seeds a skin and eye hazard until completely cleansed of the seed coat remnants and fully sun-dried.

Get Some Water

Clean seeds in fresh water outside in a grassy area or over native soil. Discard any floating seed during the cleansing process. Due to chemicals in the fleshy seed coat, a very small amount of dish washing detergent can be added to the first few batches of wash water. A combination of setting and waiting, and stirring and squeezing, can be used to remove all traces of the fleshy seed coat from seeds.

Carefully squeeze and scour seeds, trying not to spill any water on skin or clothing. Long forearm-length dish washing gloves are recommended. Eye and skin protection is essential! Repeat this process with fresh water as many times as needed to remove the fleshy seed coat. Usually 3-4 cleaning passes are needed, plus several rinses. Working with cold or iced water will minimize odor.

Be Careful Where You Dump

Spread the water / seed coat slurry over soil or grass surfaces away from public areas, play areas, pet areas, or any area close to standing or flowing water. When seed cleaning is finished, spray area with fresh water to remove seed coat residue from plant surfaces. Prevent use of the cleaning area for several weeks until seed coat residue is decayed. A number of insects will be drawn to this site by residues.

Scrub & Dry

For large amounts of seed, some type of metal screening and scrubbing device could be fabricated to aid in processing. The purpose of seed cleaning is to remove the fleshy seed coat in its entirety and any of its residues. Once you see all the fleshy seed coat has been completely removed from seeds, use one last fresh water rinse to cleanse safety equipment and to rinse seeds. With safety equipment still in place, pour out seeds in a single layer in the sun and allow to air dry. Beware of animals stealing drying seeds if placed in the open. Discard any open seed. Allow the hard seed surface to dry completely (1-7 days). Stirring or turning seeds (with gloves and eye protection) can facilitate complete drying. Prevent seeds from being re-wetted.

Nibbles?

If seed food use is planned, collect seeds in September (early collected seeds) and cook the cleaned seeds immediately to preserve the highest seed nutrition quality. Light roasting or boiling are the most common cooking methods, and then salt to taste. Seeds can be boiled, baked, roasted, or steamed. Seeds will start to open upon cooking like pistachios. Because the fleshy seed coat discolors

seed, some commercial seed products are bleached or colored. Prompt harvesting will minimize staining.

Remember to rinse and clean anywhere non-cooked seeds have touched to minimize any skin or eye irritation. Once cooked, taste one seed and wait four hours before trying another to test your sensitivity. Ginkgo seeds are a dessert or delicacy used in small portions, not as a primary food. Cleaned and shelled seeds are called white seed or baiguo.

Seedlings?

If seedling production is the objective of seed collection, early collected seeds (early to mid-Fall) can be cleaned and stored at 60oF temperature for six weeks to assure fertilization and proper embryo development has occurred. Late collected seeds (late Fall to early Winter) can be cleaned and go directly into cold storage. Put seeds in moist (not wet) and cold (not freezing) conditions for two months. Be observant to prevent fungal growth in cold storage.

New Trees

To plant seeds for seedling trees, gather seeds hanging from trees or on the ground at the time of abscission or slightly later (early Winter). Scrub seed coats off with water and rinse multiple times. Allow seeds to air dry for several days to a week. Cleaned seeds can be stored dry at 40 to 45oF until early Spring. Seeds can germinate in 8-10 weeks after a late Fall or early Winter collection and sowing.

Plant cleaned seeds the second week of February in North American winter hardiness zone 8. Delay planting for two weeks for each hardiness zone farther North you plant. Remove cleaned seeds from cold storage and sow seeds two inches apart in a well aerated seedbed of mineral soil and cover with an inch of mineral soil. A thin layer (<1 inch) of coarse organic mulch can be applied over the top of soil. Protect seeds from animal theft. Keep soil well watered and well drained. Do not keep soil or seeds saturated.

Germination is slow and should occur between 15 and 40 days from sowing. Germination percent is dependent upon effective pollen distribution from surrounding mature male trees, as well as the care given seeds in cleaning and storage. About 90% of all cleaned, undamaged seeds from females trees which have male trees in close proximity will germinate the following Spring, if they were collected no earlier than early Winter. Patience is required to wait for all seeds to germinate. Survival rates over the first two years can be expected to be 40-50% for all germinating seeds. Fungal attack, seed predation by animals, and drying of newly elongated roots and shoots generate significant mortality. Transplant seedlings to a well-aerated, moist mineral soil in full sunlight without weed and grass competition

Different Forms

Ginkgo (Ginkgo biloba) in nature is a tall tree with a wide mature crown spread. Across many centuries, a number of unique traits have been recognized and cultivated. As mentioned previously, ginkgo can be divided into seven primary crown and leaf types besides “normal”: a weeping or pendulous form (first described in 1887); a highly upright or fastigiate form; a dwarf type; a branch type with aerial root bulges or burls; and, various modified foliage types sub-divided into three main foliage variations — rolled tubular leaves, variegated leaves (first described in 1887), and leaf and seed-stalk fused foliage. Other special variations are being created every year by active breeding and selection programs around the world. There are many ginkgo cultivars now available. These cultivars come in a host of sizes, shapes, and appearances.

Some landscape forms are listed in Figure 13. This is not a comprehensive list of all cultivars available. No scientific determination of quality or value is suggested by inclusion or exclusion on this list. Only a few traits are provided to introduce different selection concepts and cultivar names. This list should not be used as a purchasing guide. Information contained here was gleaned from the literature, some of which was marketing and sales materials. The accuracy of this material could not be confirmed.

Cultivar Concerns

The list of cultivars has a number of problems beside lack of comprehensive coverage:

— First, the smaller a tree and the more ornamental the leaves, the slower a tree tends to grow.
— Second, variegated leaves are usually unstable selections of green and yellow colors which require continuous pruning to maintain. Many variegated leaves are on small females trees.
— Third, there are great discrepancies in mature tree heights listed in the literature. Height values, especially shorter ones, should be used with caution.
— Fourth, new cultivars continue to be developed while many old cultivars are no longer available in the marketplace, but can be seen in various collections.
— Fifth, literature and catalogs still hold some confusion regarding different cultivar genders, as demonstrated by the same cultivar name used for both a male or female tree.
— Finally, in addition to this selected list of shade and street tree cultivars, there are a number of Chinese cultivars grouped by fruit shape (round, oblong, or fat oval with a round lip on one end) with most managed for seed production. Among these trees there are many interesting translated names such as Buddha's finger, large horse's bell, abacus bead, and duck's buttocks. These seed cultivars are not reviewed here.

Conclusions

Ginkgo is a witness to Earth's ecological history. Ginkgo represents the oldest seed plant lineage easily seen in our surroundings. Ginkgo forests sheltered the beginning and the end of dinosaurs, and the rise and fall of many dynasties. Across the ages, ginkgo has declined until it now serves as a pet, companion, and service provider for people – not domesticated, just driven into ecological submission.

Imagine a tree which was both one of the only living survivors of Hiroshima's atomic blast (from root sprouts), and one of the few trees descended from the age of reptiles virtually unchanged. Ginkgo is worth planting, if only for it rarity of form and ancient lineage, and is worth cultivating for its historic and modern values. Cleaned, dried, and roasted seeds are worth a taste knowing it has come to us from the Jurassic. Plant a piece of ancient history in the form of a tree which has survived for the equivalent of seven million human generations and has teetered on the very edge of the extinction abyss.

Citation:

Coder, Kim D. 2024. Ginkgo – *Ginkgo biloba*: Eldest & Last. University of Georgia, Warnell School of Forestry & Natural Resources Outreach Publication WSFNR-24-5C. Pp.29.

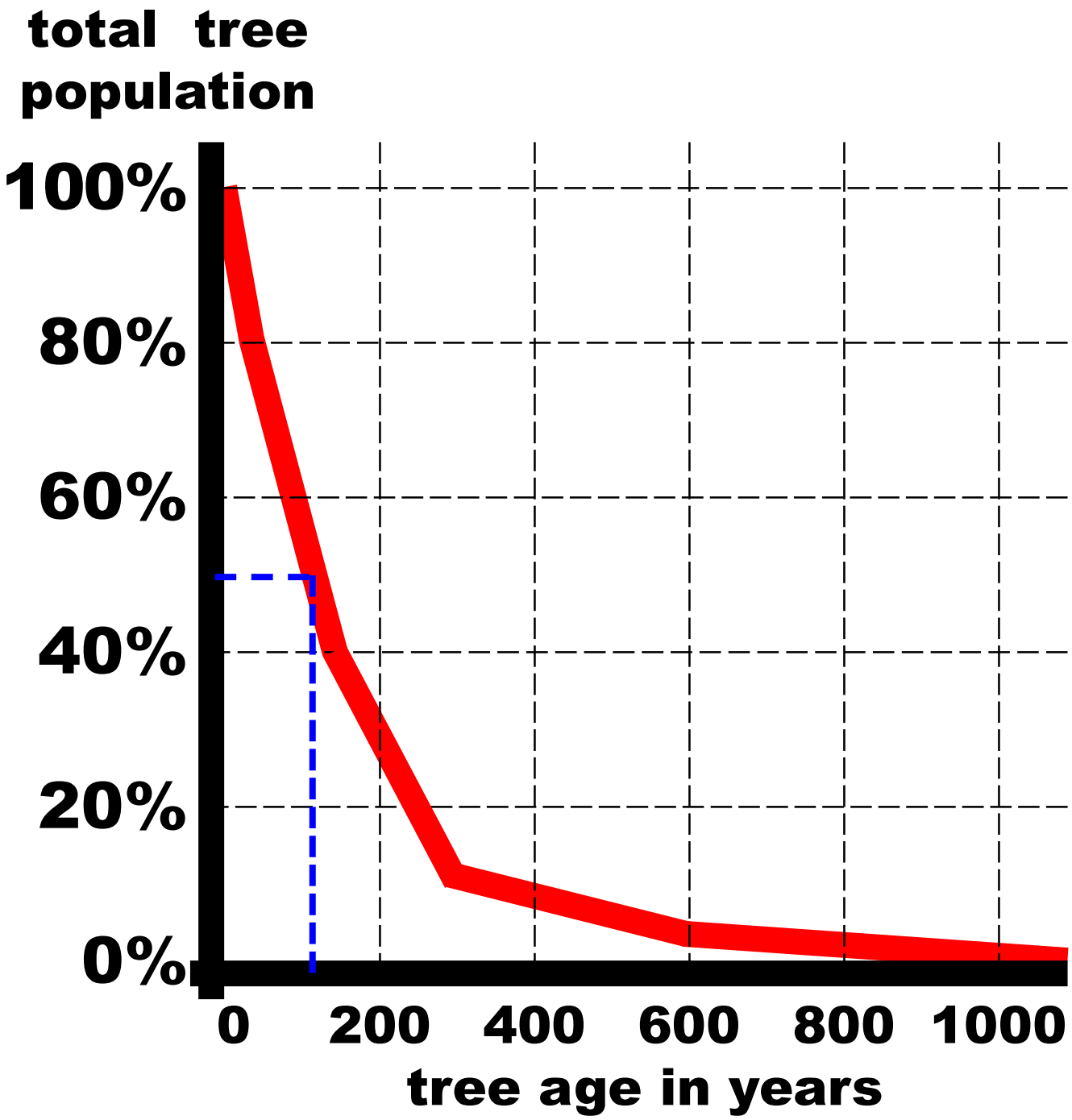

Figure 1: Mortality curve for undisturbed ginkgo trees from literature. Expected 50% mortality in 110 years.

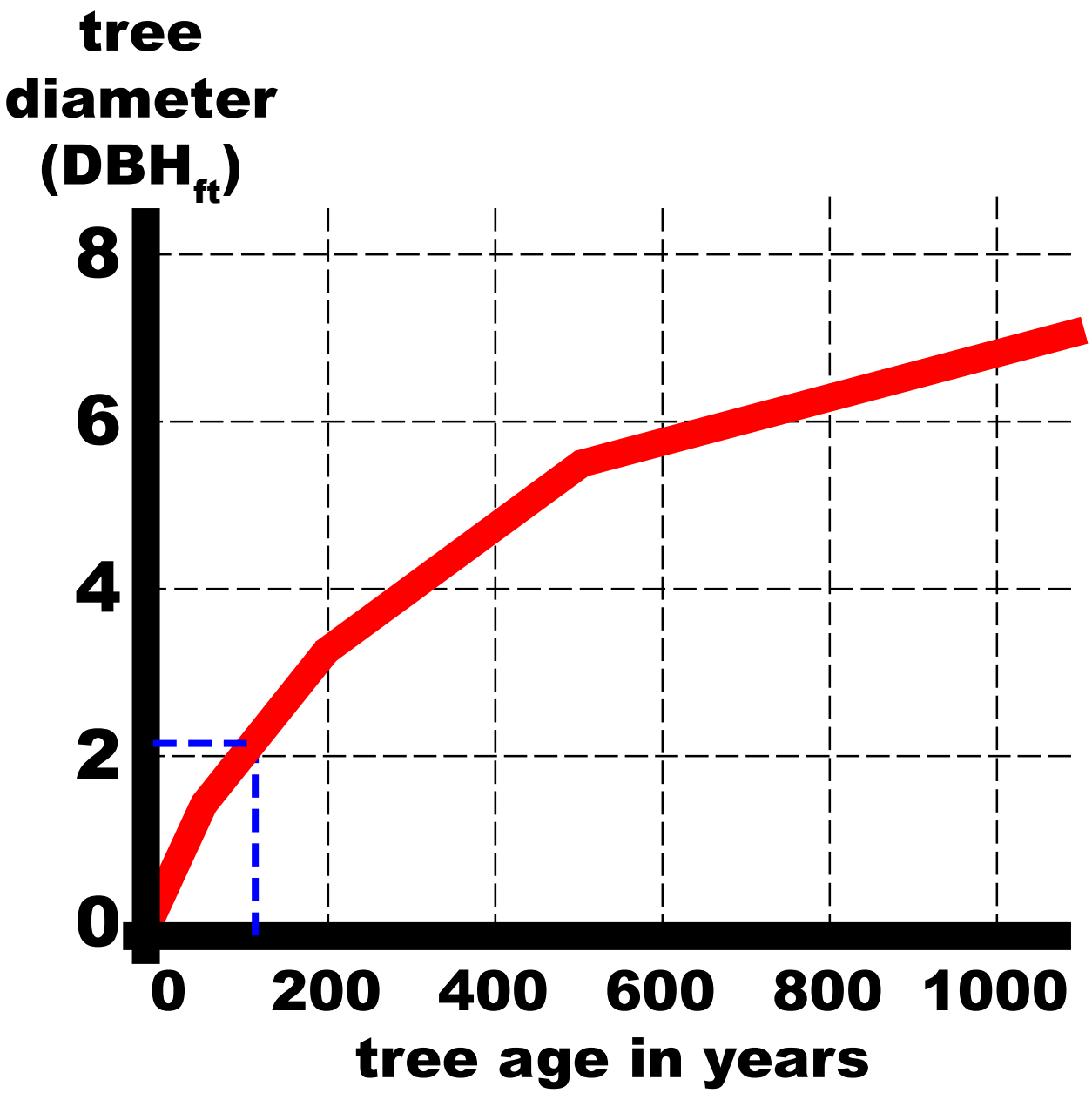

Figure 2: Diameter growth over time for undisturbed ginkgo trees from literature. Expected diameter at 110 years of age is 2.1 feet.

Figure 3: Ginkgo leaves. (mid-April in Athens, GA)
(photo credit Dr. Kim D. Coder)

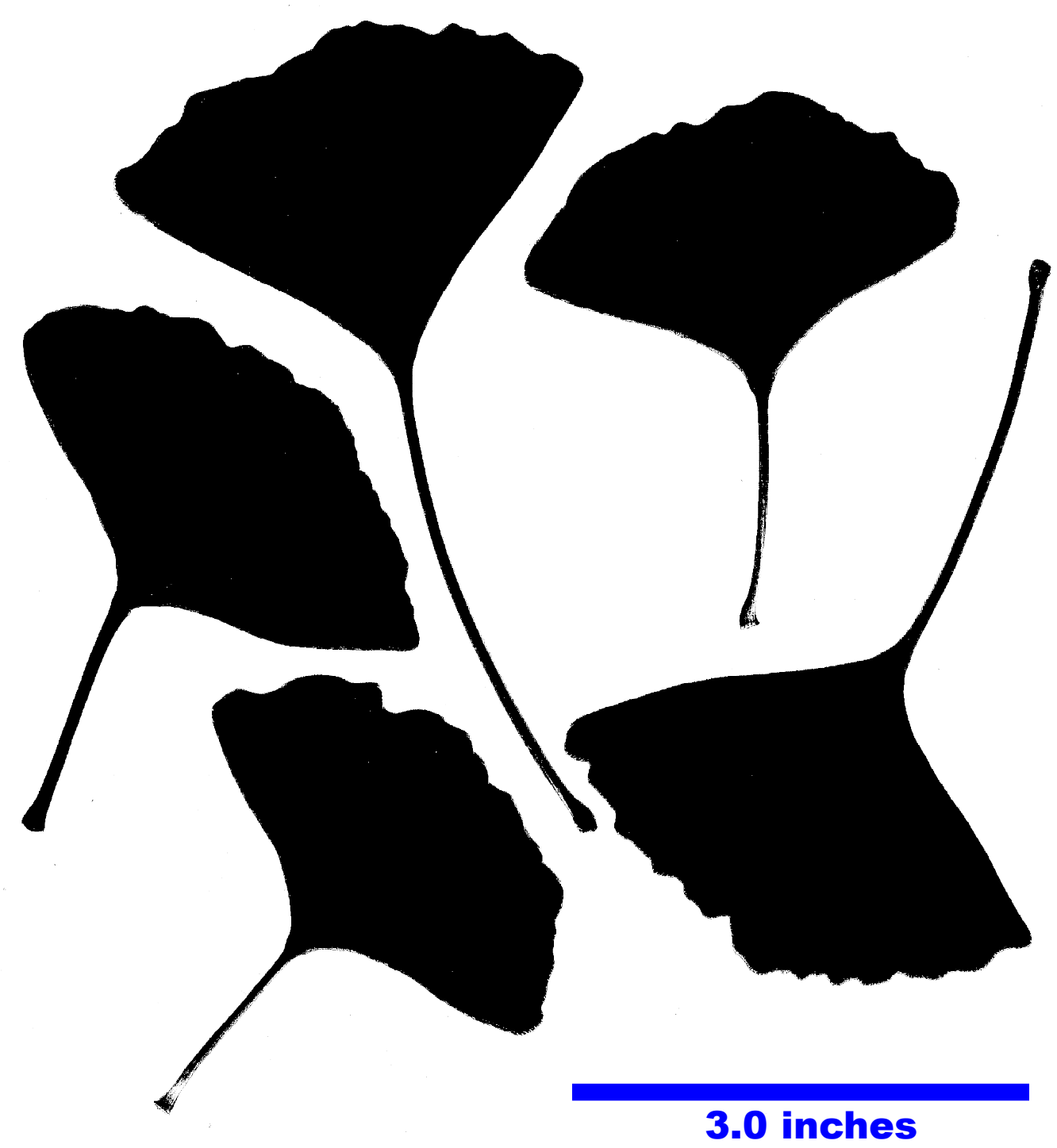

Figure 4: SilhouetteFigure 5: Upper side of ginkgo leaf. (mid-April in Athens, GA)

Figure 5: Upper side of ginkgo leaf.
(mid-April in Athens, GA)

(photo credit Dr. Kim D. Coder)

Figure 6: Ginkgo short shoots on a branch. (mid-April in Athens, GA)

(photo credit Dr. Kim D. Coder)

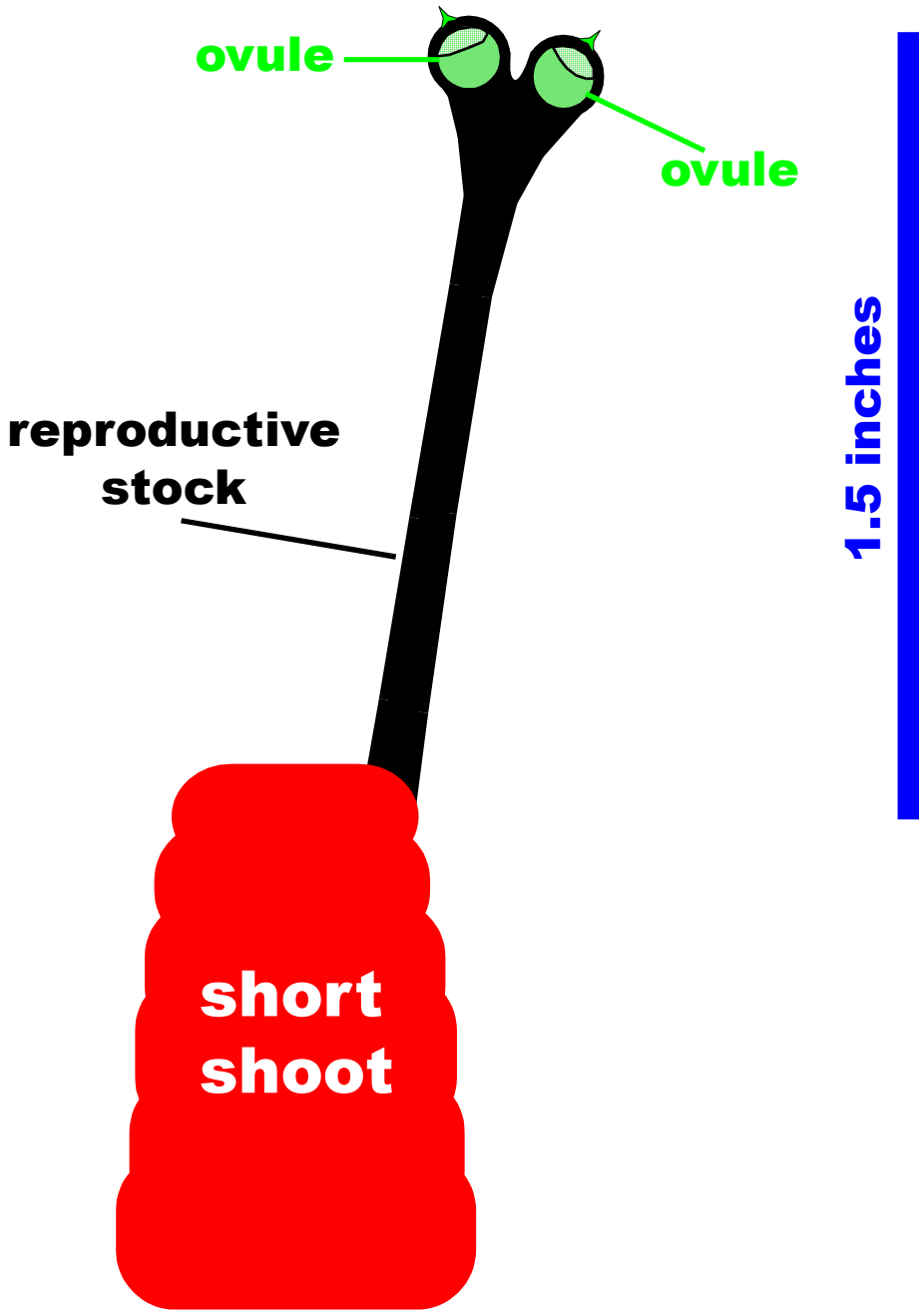

Figure 7: One isolated Ginkgo biloba female reproductive stalk with paired collared ovules at tip on short shoot. One or both ovules can generate a seed if fertilized. Each short shoot could produce 4-8 female reproductive stocks.
(Note this reproductive structure is not a flower, potential fruit, or cone.)

Figure 8: Ginkgo leaves and female reproductive structures generated from a short shoot. (mid-April in Athens, GA)

(photo credit Dr. Kim D. Coder)

Figure 9: Female reproductive structures of ginkgo. (mid-April in Athens, GA)

(photo credit Dr. Kim D. Coder)

Figure 10: Close-up of paired collared ovules on tip of reproductive stalk of ginkgo generated on end of short shoot. (mid-April in Athens, GA)

(photo credit Dr. Kim D. Coder)

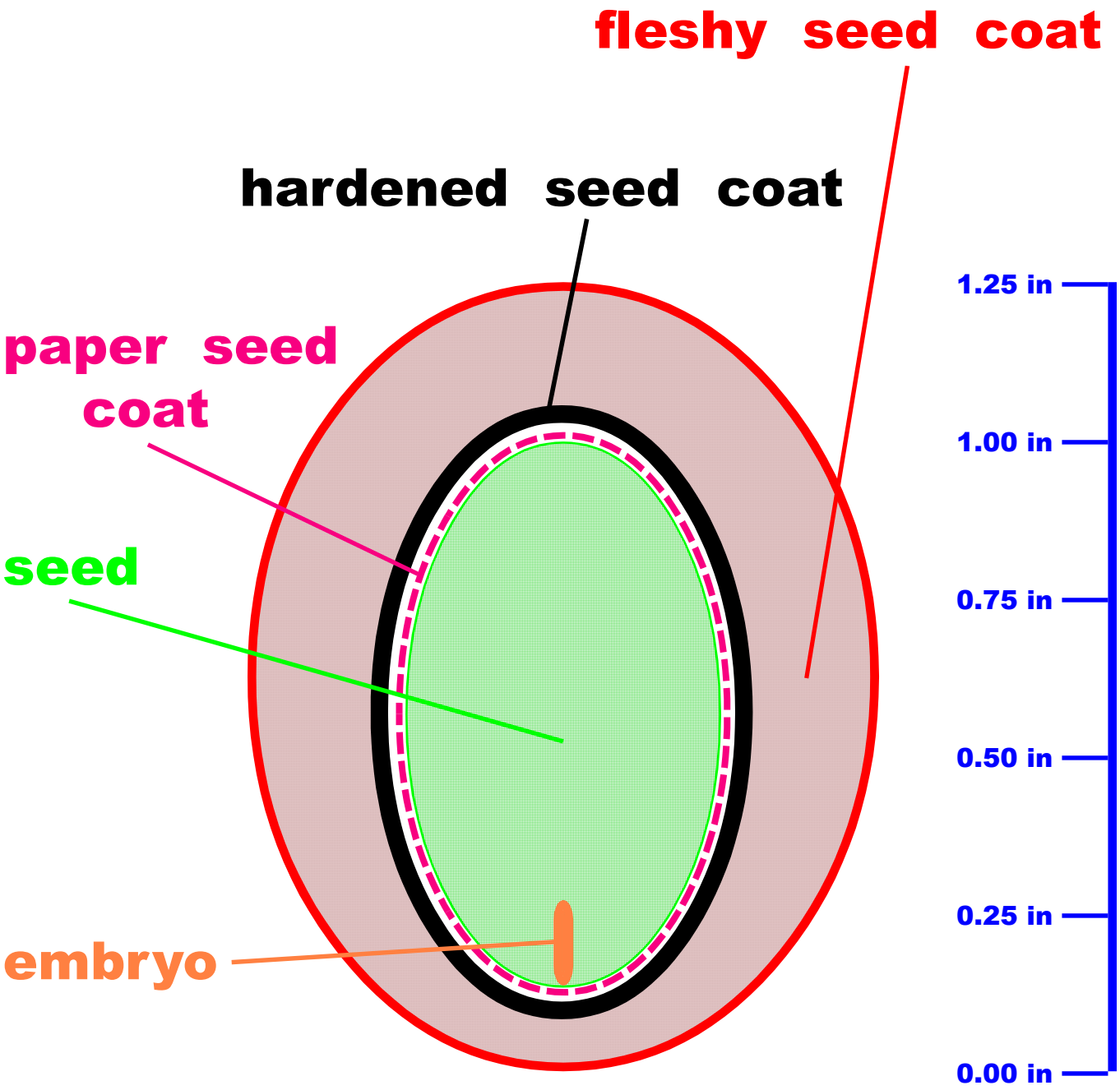

Figure 11: Ginkgo seed cross-section through the long axis showing seed and various protective coats.
(seed measured September 1)

Figure 12: Ginkgo seeds without fleshy outer layer on a 1x1 inch grid. (stored three years)

Figure 13: Select list of Ginkgo biloba cultivars.

cultivar name (other names)	selection group	sex	ht (ft)	comments
Akeboro	UP			
Alberta	UP/DWARF	M	9	
Autumn Gold		M	40	compact crown
Barabits Nana		M	9	
Beijing Gold	DWARF		12	yellow leaves
Bergen op Zoom	DWARF	M	15	
Bernheim	DWARF	M	10	
Broom With Tubes	DWARF/TUBE			
Bryson City	UP	M	16	
Bush Form	DWARF	M	6	
Canopy		M	30	umbrella shaped
Chase Manhattan (Bon's Dwarf)	DWARF	M	11	tiny leaves
Chi-Chi (Chichi) (Chi Chi Icho) (Icho) (Tit) (Tschi Tschi)	CHICHI	M	25	branch drooping protuberances (also in dwarf form ~5' tall)
Chotek	DWARF/TUBE /WEEP	M	4	
Chris (Munchkin)	UP/DWARF		6	dense tiny leaves
Ding-A-Ling	CHICHI	M	8	long narrow growths
Emperor (Woodstock)		M	60	

Figure 13: Select list of Ginkgo biloba cultivars.

cultivar name (other names)	selection group	sex	ht (ft)	comments
Epiphylla (Ohazuki) (Ohatsuki)	EPI / DWARF	F	14	early seeder
Fairmount (Fairmont)	UP	M	60	big leaves
Fastigiata	UP	M	60	
Girard's Spreader		M		wide crown
Gnome	DWARF	M	4	
Golden Colonnade	UP	M	45	narrow crown
Golden Glober		M		broad round crown
Green Pagoda	UP	M		dense crown
Gresham		M	35	wide spread crown
Halka		M	45	broad oval crown
Heksenbezem Leiden (Witches Broom) (Hekt Leiden)	DWARF	M	10	
Hunnewell	DWARF/TUBE	M	7	spreading
Jagged Jade		M		
Jade Butterflies (Jade Butterfly)	DWARF	M(F)	10	
Jehosephat	DWARF	M	3	
Jerry Verkade	UP	M	40	
Kew		M	30	
King of Dongting Mountain		F	40	large seeds

Figure 13: Select list of Ginkgo biloba cultivars.

cultivar name (other names)	selection group	sex	ht (ft)	comments
Laciniata (Macrophylla) (Longifolia) (Largeleaf) (Triloba) (Dissecta) (Cutleaf)		M	60	large, deeply lobed, incised leaves
Lakeview	UP	M	50	
Liberty Splendor		F	45	
Long March	UP	F		
Magyar	UP/TUBE	M	55	
Majestic Butterflies	VARI / DWARF		15	
Mariken	DWARF/ WEEP	F(M)	3	
Mayfield	UP	M	35	
Ohasuki (Epiphylla) (Ohatsuki) (Ohazuki)	EPI / DWARF	F	15	
Palo Alto		M	60	
Pendula	WEEP			
Prague (Pragense) (Pragensis)	WEEP/ DWARF	M	12	
President (Presidential Gold)		M	50	
Princeton Gold		M	60	
Princeton Sentry	UP	M	50	
Pyramidalis		M	50	

Figure 13: Select list of Ginkgo biloba cultivars.

cultivar name (other names)	selection group	sex	ht (ft)	comments
Rainbow	VARI / DWARF	F	10	yellow striped
Robbie's Twist	UP	M		twisted branches
Robin		M	65	
Roosevelt		M	65	
Ross Moore	WEEP/ DWARF	?	15	
Saint Cloud (St. Cloud)		M	60	dense crown
Salem Lady		F	60	good seed producer
Santa Cruz (Umbrella) (Umbraculifera)	WEEP/ DWARF	F	12	
Saratoga	~UP	M	35	
Shangri-la		M	40	
Sinclair		M	60	
Slim Jim	UP	M	50	
Spring Grove	DWARF	M	7	round crown
Stupka Brown (Joe's Broom)	DWARF	M	4	
Thelma	DWARF/TUBE	M	8	multiple leaf types
Todd's Dwarf (Todd's Broom)	DWARF	M	3	dense crown
Tremonia		F	35	large leaves
Troll	DWARF	M	5	dense round crow
Tubiforme (Tubeleaf) (Tubifolia) (Tubiformis)	TUBE / DWARF / UP		10	

Figure 13: Select list of Ginkgo biloba cultivars.

cultivar name (other names)	selection group	sex	ht (ft)	comments
Varigata (Variegata)	VARI / DWARF	F	10	yellow variegated, reverts to green
WB (Witches Broom)	DWARF	M	7	dense crown
Weeping Wonder	DWARF/ TUBE/ WEEP	M	6	
Windover (Windover Gold)		M	50	
Woodstock (Emperor)		M	60	

Key To Codes

Crown Form Variations from Normal Type

- WEEP = weeping, pendulous, or umbrella-like
- UP = upright or fastigiate
- DWARF = dwarf to semi-dwarf size
- CHICHI = branches with aerial root bulges or burls

Foliage Variations from Normal Type

- TUBE = rolled tubular leaves
- VARI = variegated leaves
- EPI = leaf and seed stalk fused together (epiphylla / ohazuki)

Sex / Gender

- M = predominately male
- F = predominately female