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Edmund A. Schofield, Editor

Peter Del Tredici, Associate Editor

Front cover. The flower of *Liriodendron tulipifera* 'Fastigiatum'. (See "What's in a Leaf?," by Peter Del Tredici, page 3) Photograph by Michael A Dirr. *Opposite* 'Ito Fukurin', a variegated cultivar of *Ardisia japonica.* (See "Cultivars of Japanese Plants at Brookside Gardens—II," by Barry R. Yinger and Carl R Hahn, page 7). Photograph by Robert Rinker. *This page* The flower and mature leaves of the tulip tree (*Liriodendron tulipifera,* as depicted in *Curtis' Botanical Magazine* in 1794. (See "What's in a Leaf?," by Peter Del Tredici) *Inside back cover.* Two bunches of 'Thompson Seedless' grapes, one of which was sprayed with gibberellic acid (right), the other of which was not treated. (See "Chemicals that Regulate Plants," by John W. Einset, page 28) Photograph by Abbott Laboratories *Back cover·* *Rhodotypos scandens, Clethra alnifolia,* and *Acanthopanax sieboldianus* in the forest border of Central Park, Fifth Avenue between Seventy-second and Seventy-sixth streets (See "Replacing the Understory Plantings of Central Park," by Geraldine Weinstein, page 19.) Photograph by Geraldine Weinstein.

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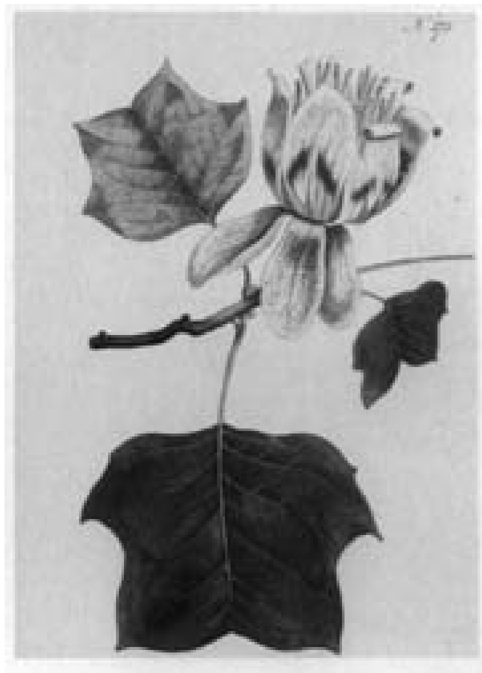
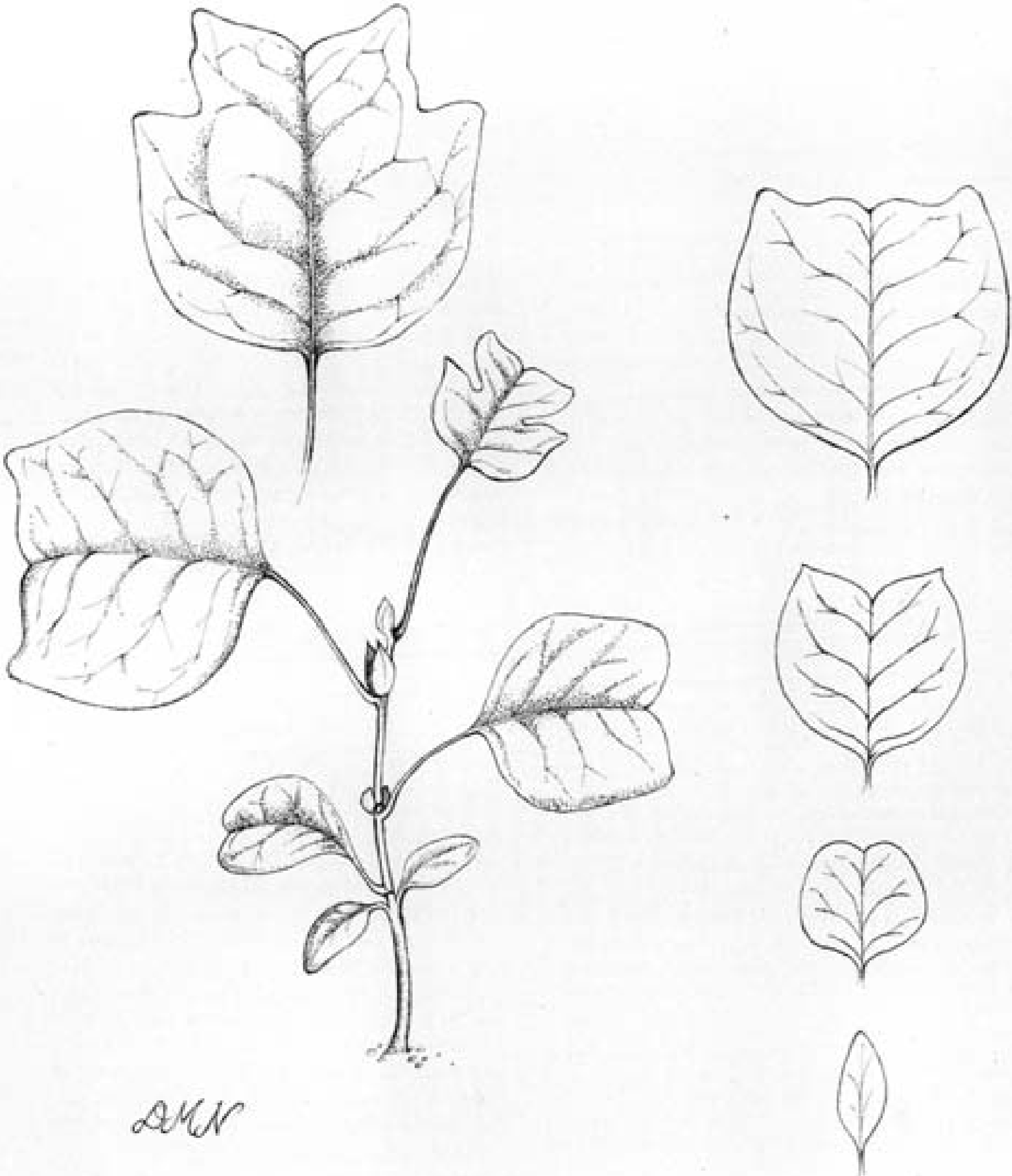



DMN

The shape of the mature leaf of the tulip tree is the result of a process that began with the seed leaves, or cotyledons

What's in a Leaf?

Peter Del Tredici

The tulip tree, *Liriodendron tulipifera,* is unusual among the trees growing in the forests of eastern North America in combining stately massiveness with delicate beauty. Its unbranched trunk, often as much as six feet in diameter, rises straight up out of the ground like a pillar and seems to hold up the sky above the forest in which it grows. I have never seen another tree, save the redwoods of California, that can evoke such an impression. These magnificent trees have managed to escape destruction by growing on the hard-to-reach slopes of mountain ravines throughout the eastern half of our continent. In the moist coves of the Great Smoky Mountains of Tennessee and North Carolina, they can reach 150 to 200 feet in height.

It is the absolutely straight, unbranched bole of the tulip tree that makes it instantly recognizable in the forest. Many other trees are equally straight when they are young, but few maintain such straightness into maturity the way *Liriodendron* does. The lower branches seldom get thick enough to produce forked trunks, even those of specimens growing in full sun. In the dense shade of the forest, the tree usually sloughs off its lateral branches before they get much more than an inch thick, and the columnar trunk extends far up into the crown. This habit of self-pruning, as it is called, makes the tulip tree particularly desirable to the forester, who wants good, straight lumber, and a bit bothersome to the homeowner, who wants a neat front yard.

In contrast to the great size of the tulip tree is the delicateness of its flowers, which come out in May or June, depending on the latitude in which the tree grows. They are quite large as tree flowers go—about two inches long and equally wide when fully opened—and very beautiful. The petals are of an unusual light, bright green and have a conspicuous orange splash at their bases. The central core of the flower—the anthers and the gynoecium—is a clear yellow. Unfortunately, the petals and the leaves are so nearly the same color that you have to look closely to tell whether a tree is in bloom. Indeed, not until you actually have removed a flower from the background of leaves can you fully appreciate its beauty. The blossoms are faintly fragrant and, like those of other members of the magnolia family, are pollinated by flies, beetles, and bees.

As if its trunk and flower weren't enough to recommend the tulip tree, its leaf is noteworthy for its graceful, elegant shape. While normally there is a high degree of variability in form from one leaf to the next on the same tree, all leaves share a feature that makes them unmistakable—notched, rather than pointed, tips. So fixed in most people's minds is the idea that leaves should taper to a point, that many nineteenth-century botanists described the *Liriodendron* leaf as having three lobes, with the tip of the middle lobe cut off. Even those botanists who correctly described the leaf as having four lobes noted that the leaf's apex was "missing" or "chopped off." Evidently they had a preconceived notion about what a leaf should look like—some sort of archetype, from which modern forms are de-

Figure 1. Progressive variation in the shape of the tulip tree leaf, beginning with the simple, lance-shaped cotyledon (lower right) and culminating in a miniature version of a mature, four-lobed leaf (upper left). A seedling (lower left) bears all five variations Drawing by Dawn M. Nunes.

rived—and tried to make *Liriodendron* fit the mold.

A better way to view the shape of the *Liriodendron* leaf is to follow its development in the germinating seedling. My own research in this regard suggests that the shape of the mature leaf is the result of a progressive, not a degenerative, process. The first structures the germinating tulip tree seedling produces are the seed leaves, or cotyledons, which are simple, lance-shaped structures that taper to blunt points. After the cotyledons, the next leaf is much simpler than those that the mature tree will produce. Almost round in its shape, it has a shallow notch at its tip. On the third leaf, two lobes begin to take shape on either side of this notch; on the fourth leaf, two lower lobes make their debuts. In healthy greenhouse-grown plants the next leaf, the fifth, has fully developed lower lobes and is a miniature version of the mature leaf. In effect, the plant is performing a kind of developmental dance in its progressive movement from one leaf to the next (Figure 1).

There is nothing unique about *Liriodendron* in its progressive leaf development. Botanists have recorded similar patterns in many other species. No one did it as early or as well as the great German poet–naturalist, Johann Wolfgang von Goethe, however. In 1790, Goethe published a little book entitled *Essay on the Metamorphosis of Plants,* in which he describes the life of a plant from the seed stage to the seed-producing stage as a series of internally regulated contractions and expansions. In his book, the leaf is considered the basic building block of the plant, and all other structures (except for the stem and the root, which he does not discuss) can be seen as modifications of the leaf. The key idea in *The Metamorphosis* is that plants are not static in their growth patterns but that, as they develop and grow, they change. Development, according to Goethe, is by its very nature dynamic, and the structures that a plant produces—the leaves and flowers—take on different forms depending upon whether they are produced during a phase of contraction or a phase of expansion. Regardless of what one feels about the correctness or accuracy of Goethe's ideas, his conception of growth as a dynamic process that results in a great deal of variation in leaf and flower structure would not be denied by anyone who works with plants. Goethe viewed the progressive development of the leaves of seedlings as part of the very first expansion phase in plant development:

> At each successive node the form of the [seedling] leaf attains greater perfection; the midrib lengthens, and the side ribs, which arise from it, extend more or less towards the margin. The different relations of the ribs to each other are the principal cause of the various shapes we observe in leaves which are notched, deeply incised, or formed of many leaflets, looking like little branches. The Date Palm is a striking instance of the most simple form of leaf becoming gradually but deeply divided. As the leaves succeed each other, the midrib lengthens, till at last it tears asunder the numerous compartments of the simple leaf, and an extremely compound, branch-like leaf is formed.

While the date palm shows increasing dissection of its leaves with each new leaf produced, the seedling leaves of the tulip tree show a dramatic change in their shape from one to the next. This can be seen most clearly by laying out the *Liriodendron* leaves in sequence. When I did this for the first time, I was reminded of Ernst Haeckel's famous nineteenth-century adage, "Ontogeny recapitulates phylogeny." In plain English, this means that the embryonic development of an individual organism encapsulates, summarizes, or repeats the whole evolutionary history of the species. While Haeckel's conception is not accepted as biological fact, it can help a person grasp the basic principles of growth and development. And so it is with the tulip tree. In arriving at the mature form of the leaf, the seedling must undergo a stepwise developmental process that may actually reflect the historical evolution of the leaf's shape. While this hypothesis is unprovable, it points out the dynamic nature of plant growth and evolution, much as Goethe's expansion–contraction theory does.

The pattern of change in the development of the *Liriodendron* leaf does not stop at seedling leaf number five, but continues throughout the life of the tree. As the plant matures, it produces larger and larger leaves. These reach their maximum size during the plant's juvenile stage—roughly between five and ten years of age. During this period, the tree can, and does, produce perfectly shaped four-lobed leaves up to twelve inches long and ten inches wide (Figure 2). (Why some trees produce larger than normal leaves during their adolescence is not certain, but enough different species do so to suggest that these larger than normal juvenile leaves serve some function.)

As the tree approaches sexual maturity in ten to twenty years, the leaf size shrinks to six inches by six inches. And in fully mature trees, the leaves are usually only about five inches by five inches. Curiously, these mature leaves often have one or two extra pairs of lobes at their bases (Figure 3).

The developing bud in *Liriodendron* is no less fascinating than the developing leaf. The careful anatomical work of W. F. Millington and J. E. Gunckel, in 1950, showed that the intriguing stipules that grow together to form the outermost bud covering should be considered lobes of the leaf, or more precisely, as "products of leaf base rather than of stem" (Figure 4). We thus have the rather unusual situation (found also in the genus *Magnolia*) where the lower lobes of one leaf are modified during development to protect the next leaf in line. Interestingly, these leaf-protecting stipules do not make their appearance until the second seedling node, those at the first node being little more than rudimentary flaps of tissue incapable of surrounding anything. This fact suggests that the stipules, like the other lobes of the leaf, develop in a stepwise fashion.

In addition to being of botanical interest, *Liriodendron* buds are aesthetically fascinating, particularly in the spring when they burst apart to reveal their contents. The great French naturalist, François Michaux, described this process better than anyone in his classic, *The North American Silva,* published in 1818:

> On the Tulip Tree, the terminal bud of each shoot swells considerably before it gives birth to the leaf: it forms an oval sack which contains the young leaf, and which produces it to the light only when it appears to have acquired sufficient force to endure the influences of the atmosphere. Within this sack is found another, which, after the first leaf is put forth, swells, bursts, and gives birth to a second. On young and vigorous trees, five or six leaves issue successively in this manner from one sack Till the leaf has acquired half its growth, it retains the two lobes which composed its sack, and which are now called stipulae.

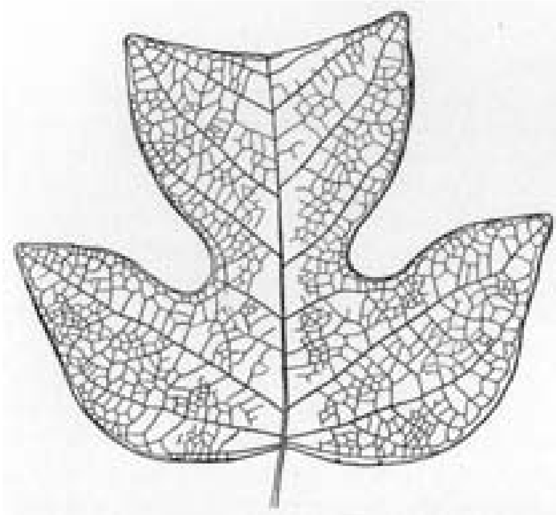
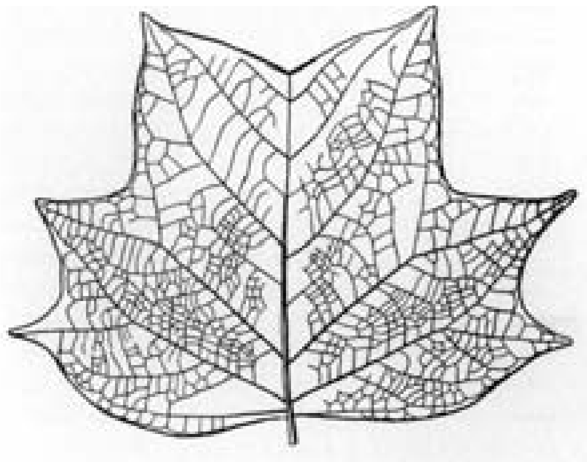


Figure 2. A four-lobed tulip tree leaf. This figure (and Figure 3) from *Proceedings of the U S National Museum,* Vol 13 (1890) Both figures courtesy of the Museum of Comparative Zoology, Harvard University.

Figure 3. The leaf of a fully mature tulip tree.



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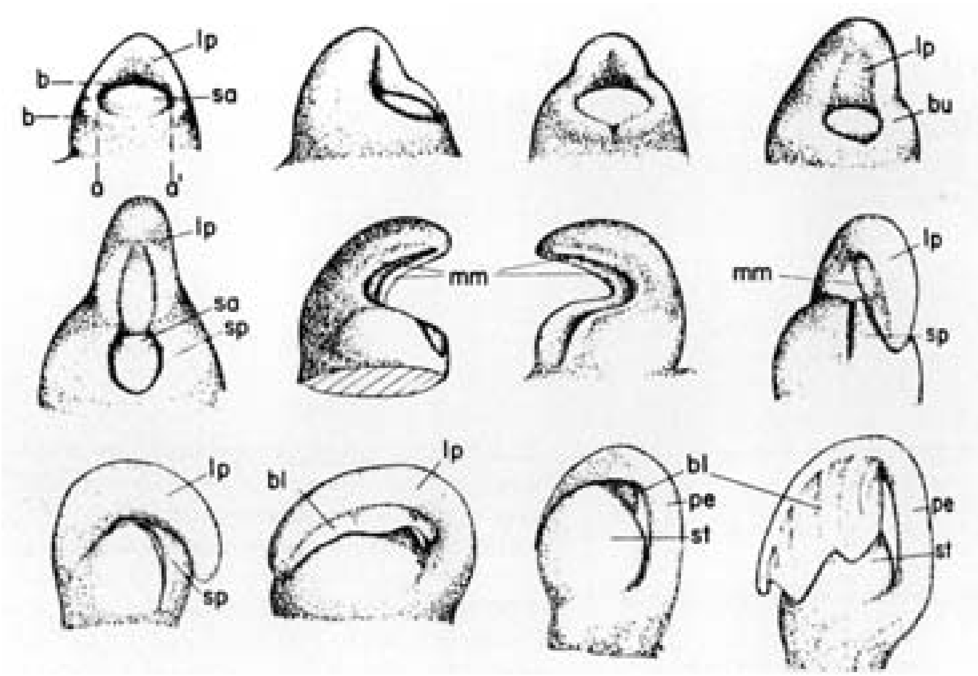


Figure 4 Development of leaf primordia and stipules of the tulip tree. From the research of W. F. Millington and James E Gunckel, reported in the *American Journal of Botany* Used with permission

The *Liriodendron* bud is like a series of boxes within boxes—Russian dolls, if you will—that nest together perfectly. Unfolding one by one, the leaves seem to have no limit to their numbers. Although Michaux doesn't describe it, the buds usually stop producing leaves in June with the beautiful green, yellow, and orange flowers. The whole process is a bit like a symphony, slowly building up through a crescendo of larger and larger leaves to a floral fortissimo.

After all of this, are we close to describing the leaf of the tulip tree? The answer depends on when one chooses to look at its leaves: seedling leaves differ from adolescent leaves, which differ from the leaves on mature trees. The simplistic drawings found in most field guides do not do justice to the variation shown by an individual tree, let alone that shown by the species as a whole. While such variation may be difficult for the taxonomist to reckon with, it can be a source of delight and inspiration for the poet and the curious naturalist.

Related Readings

A. Arber. Goethe's botany. *Chronica Botanica 10,* No. 2, pages 67–124 (1946).

J. W. von Goethe. *Essay on the Metamorphosis of Plants*. Translated by Emily M. Cox. *Journal of Botany 1,* pages 327–345 and 360–74 (1863).

T. Holm. Notes on the leaves of Liriodendron. *Proceedings of the U.S National Museum 13,* pages 15–35 (1890).

W. E. Millington and J. E. Gunckel. Structure and development of the vegetative shoot tip of *Liriodendron tulipifera* L *American Journal of Botany 37,* No 4, pages 326–335 (1950).

Peter Del Tredici is the Arboretum's assistant plant propagator and associate editor of Arnoldia. *He has written many articles for* Arnoldia *in the past several years.*

Second in a series

Cultivars of Japanese Plants at Brookside Gardens—II

Barry R. Yinger
Carl R. Hahn

Koten Engei

The Japanese employ a unique system of horticulture called *koten engei*, a term that resists easy translation but whose meaning is approximated by "cultivation of classical plants." In this traditional style of horticulture:

□ The plants grown are groups of variants of species that, in their original form, are of modest demeanor. Most of the species are native to Japan and have insignificant or scarcely showy flowers.

□ The variants are usually selections of mutated forms rather than hybrids. In most cases variations are of leaf shape and color rather than of floral characteristics.

□ The kinds and degrees of variation are carefully classified and named, and certain kinds of variation are judged more valuable than others. A weak constitution is usually a "plus."

□ The plants are always grown in pots instead of in the garden. The pots are thin, porous *raku* ware, usually with rough surfaces, shiny black glazes, and simple, fanciful decorations. Certain styles are appropriate for certain cultivar groups.

□ Cultivars are assigned names that often allude to people, places, or events in classical Chinese or Japanese history.

□ The cultivars are evaluated and ranked by societies devoted exclusively to variants of single species. The rankings are published periodically on a chart called a *meikan*, which recalls in its format the classical ranking board (*banzuke*) of *sumo* wrestling. The societies stage public exhibitions of the plants.

□ Interest in the various species groups of cultivars is cyclical, being accompanied by recurrent waves of financial speculation in them.

Historically, many species have been treated as subjects for *koten engei* selection in Japan. Some are not grown now, but others—such as cultivars of *Rohdea japonica*, *Asarum*, and *Selaginella tamariscina*—have enjoyed enduring, if cyclical, interest for nearly 300 years. Some of the plants that will be described in our series are, or have been, part of the cult of *koten engei* and as such have, or have had, acceptable cultivar names. The first group of cultivars treated below—selections of *Ardisia japonica*—are part of the modern and classical *koten engei* tradition.

The Series

This article is part of Brookside Gardens's ongoing effort to reduce the considerable confusion in the nomenclature of cultivated plants from Japan. Our principal sources of information in this effort are the catalogs of nurseries that deal in a wide range of cultivated plants. We have also consulted the very few classic and modern Japanese texts that list and illustrate cultivated plants. Some of the names we publish may have to be changed as we find more sources of information. This long-term, serial effort should yield a reliable catalog of valid cultivar names for a wide range of Japanese cultivated plants.

In the first installment of this series (published in *Arnoldia*, vol. 43, no. 4, pages 3–19, Fall 1983), we described the special collections program in which the plants considered here are acquired, maintained, and evaluated at Brookside Gardens, Wheaton, Maryland, a publicly supported botanical and display garden of the Montgomery County, Maryland, park system. We also described in detail our approach to evaluating the acceptability of existing Japanese names as valid cultivar names, based on our interpretation of the rules and recommendations set forth in the *International Code of Nomenclature for Cultivated Plants.* We wish to establish and preserve in the Western literature legitimate Japanese cultivar names for the plants we are growing and to assign and register a suitable name where none exists that satisfies the *Code* Readers interested in the details of our procedure for judging existing names should consult the previous article.

The inclusion of a plant name in this series does not imply that it is new either here or in Japan, or that we are its first or only introducer. We make no judgment about the garden value of the plants described; we hope that such information will emerge from an evaluation program now in progress under the supervision of Brookside Gardens's curator, Philip Normandy.

We will try to honor requests for more information about these cultivars and will be pleased to receive additional information as well. At present, time and money are not sufficient for the depth of research necessary to answer all questions that might be raised, but we will try to address questions as they arise. We intend to deposit specimens and documentation of published cultivars with the United States National Arboretum in Washington, D. C., as the plants continue to develop. Address correspondence to Carl R. Hahn, Maryland–National Capital Park and Planning Commission, 8787 Georgia Avenue, Silver Spring, MD 20907. **Please note that the Arnold Arboretum cannot supply these plants or information about them.**

Mr. Young June Chang, Seoul National University, Seoul, Korea; Mr. Philip Normandy, Brookside Gardens; and Mrs Gennie Potter, Maryland–National Capital Park and Planning Commission, gave kind and invaluable assistance in preparing the manuscript, for which we sincerely thank them.

The Cultivars

The descriptions are of mature new growth in early summer. The leaves of some cultivars are different at other seasons, particularly during the colder seasons, when pink and red tones appear.

Ardisia japonica (Thunb.) Bl. 'Amanogawa' [Milky Way galaxy] (Yinger Collection No. 805)

Leaves of many shapes and patterns, puckered and often twisted, usually somewhat elongated or bearing large lobes of irregular sizes, 4 to 9 cm by 1 to 5.5 cm, with regularly or sparsely toothed margins. Those leaves without monstrous lobes, green with white or greenish-white central markings, those with lobes, light green with a white reticulate pattern and an irregular, darker-green border 1 to 2 mm wide, the lobes white A vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Beniyuki' [red snow] (Yinger Collection No. 810)

Leaves elongated and irregular, narrowing very acutely at the base, about half of them slightly lobed, the rest prominently and almost regularly lobed (resembling the leaves of *Quercus alba*); 5 to 10 cm by 2 to 4 cm. The slightly lobed ones with very narrow, white margins 1 to 2 mm in width that seldom invade the center of the leaf, the heavily lobed ones with broad, white margins up to 1.5 cm in width Leaf surfaces slightly puckered, with slightly undulate margins. White areas becoming red in winter. A vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

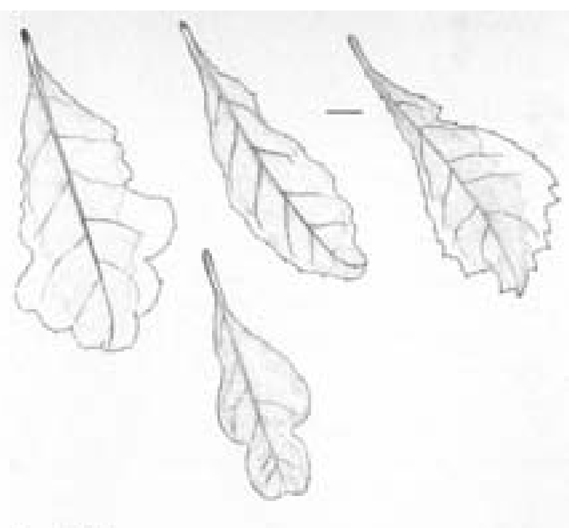
Ardisia japonica (Thunb.) Bl. 'Chiyoda' [a place-name] (Yinger Collection No. 806)

Leaves very irregular in outline, with no teeth on their margins, blades 5 to 11 cm by 1 to 3.5 cm, all bearing thin, white margins 1 to 2 mm in width that rarely invade the centers of the blades Most leaves almost flat, with interveinal spaces sometimes raised or puckered. A vigorous clone.

Ardisia japonica 'Amanogawa' Photographs by Robert Rinker.

Ardisia japonica 'Beniyuki'

'Amanogawa'

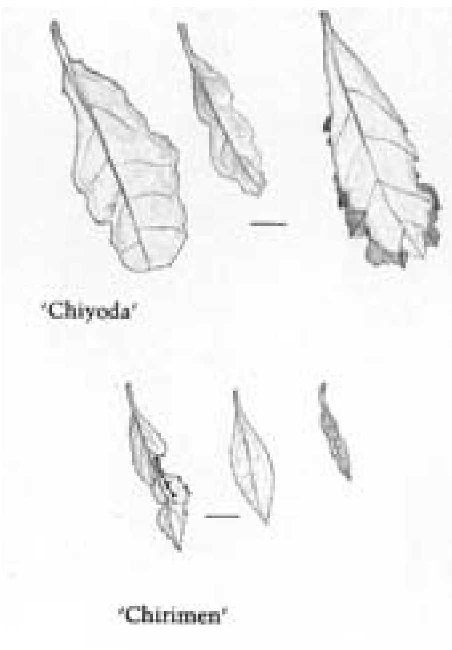


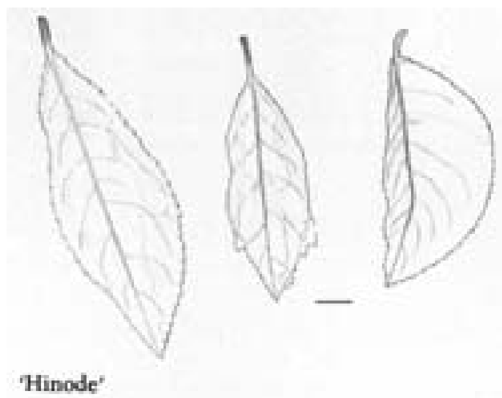
'Beniyuki'

All drawings are by Young June Chang. The scale in each case is one centimeter.

Ardisia japonica 'Chiyoda'

Ardisia japonica 'Hinode'





Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Chirimen' [crepe paper] (Yinger Collection No. 801)

Leaves long and narrow, 3 to 7 cm by 0.5 to 1 5 cm, their margins furnished with fine, regular teeth. All leaves light green with no variegation, with finely puckered surfaces, some leaves bearing as well a row of tubercles, or small, raised, crested growths, on each side of their center veins. A dwarf clone of slow growth

Described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Hinode' [sunrise] (Yinger Collection No. 800)

Leaves large, 6 to 10 cm by 2.5 to 3 5 cm, with regular marginal teeth and occasional small white lobes breaking the regular outline, yellow-green, usually with large, irregular, paler-yellow-green areas in their centers, and usually flat with puckered interveinal spaces. Vigorous and fast-growing, but with short internodes.

Described and illustrated on page 169 of *Koten Engei Shokubutsu* (1977)

Ardisia japonica (Thunb.) Bl. 'Hi-no-Tsukasa' [official day] (Yinger Collection No. 812)

Leaves elongated, 4 to 10 cm by 1.5 to 3.5 cm, all distorted and very acutely narrowed at their bases, some with a few marginal teeth, medium green, many with occasional white, irregular marginal lobes. Leaf surfaces nearly flat, sometimes undulate, scarcely puckered A moderately vigorous clone

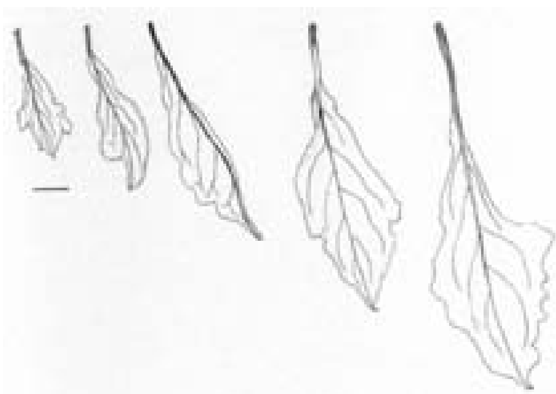
Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975)

Ardisia japonica 'Hi-no-Tsukasa'

Ardisia japonica (Thunb.) Bl. 'Hokan Nishiki' [phoenix crown brocade] (Yinger Collection No. 816)

Leaves usually ovate, usually with blunt or rounded apexes and toothed or sparsely toothed margins, 4 to 7 cm by 2 to 2.5 cm (a very few irregularly lobed), green, with broad, irregular margins 1 to 10 mm wide often invading the leaves to or near their midribs Margins yellow–green, tinged pink Leaf surfaces nearly flat or slightly puckered, often undulate. A moderately vigorous clone

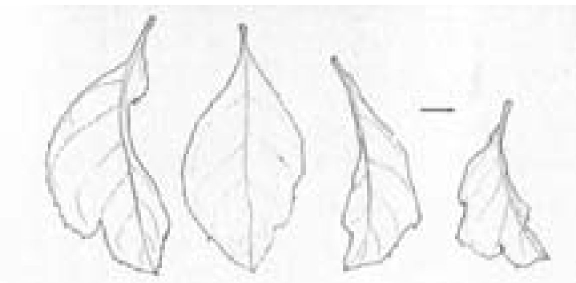
Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975)



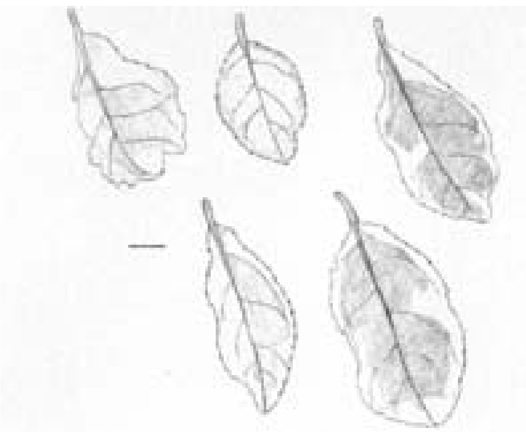
'Hi-no-Tsukasa'

Ardisia japonica 'Hokan Nishiki'

Ardisia japonica 'Hoshiami'



'Hoshiami'



'Hokan Nishiki'

'Ito Fukurin'

Ardisia japonica 'Kimigayo'

Ardisia japonica (Thunb.) Bl. 'Hoshiami' [parched netting] (Yinger Collection No. 813)

Most leaves very distorted, few more or less ovate; most with toothed margins; 3 to 7 cm by 1 to 3 5 cm About 25 percent of the leaves entirely green, the rest bearing fine, white reticulate patterns or irregular streaks of white Most leaves cupped, puckered, or twisted A clone of slow to moderate growth and congested habit

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Ito Fukurin' [thread border] (Yinger Collection No. 811)

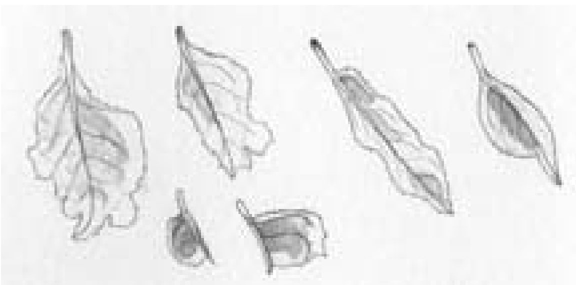
Leaves ovate, mostly regular in outline, 4 to 7 cm by 2.5 to 3 cm, most with regularly toothed margins. All leaves medium green with thin white margins 1 to 2 mm wide, only occasionally slightly invading farther into the centers of the leaves. Leaf surfaces nearly smooth and only slightly puckered. Of moderate to vigorous growth

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Kimigayo' [Japan's national anthem] (Yinger Collection No. 799)

All leaves distorted, of several shapes, most more or less ovate, about 3.5 to 6 cm by 1.5 to 3 cm. Leaf margins irregularly toothed, often with small lobes at various points along the margins. Leaves yellow–green, with darker-green central blotches; marginal lobes white All leaves puckered and twisted, some with prominent, bubble-like swellings near their centers Somewhat dwarf and slow-growing

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975)



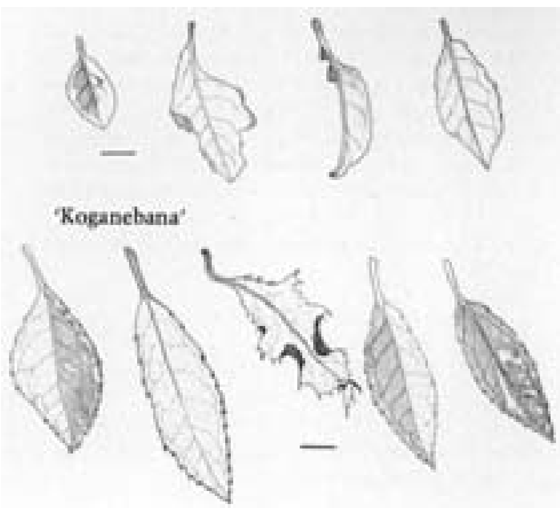
'Kimigayo'

Ardisia japonica (Thunb.) Bl. 'Koganebana' [gold flower] (Yinger Collection No. 817)

Leaves small, ovate to elongate, regular or irregular in outline, 2 5 to 4 cm by 1 to 2 cm, the margins with occasional teeth. Leaves medium green, usually with narrow or broad white margins 1 to 6 mm wide A few leaves almost entirely white. Leaf surfaces nearly flat or puckered A dwarf clone of slow, dense growth

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica 'Koganebana'



Ardisia japonica 'Shirofu Chirimen'

Daphne odora 'Ringmaster'

Daphne odora 'Zuiko Nishiki'

Ardisia japonica (Thunb.) Bl. 'Shirofu Chirimen' [white variegated crepe paper] (Yinger Collection No. 804)

Leaves of regular outline, elongated, with acutely pointed apexes, blades 3 to 5 by 1.5 to 2 cm; margins toothed. Some shoots and leaves all green or all white, the rest with sectoral white markings or flecks of white A few leaves equally divided longitudinally into green and white halves Most leaves flat and scarcely puckered, a few with undulate margins A rather dwarf selection

Illustrated on page 96 and described on page 293 of *Shumi no Koten Shokubutsu* (1975).

Carex phyllocephala T. Koyama 'Sparkler' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 1403)

Leaves, which persist for at least two years, lime green to dark green, with 1- to 4-mm-wide white margins One to four longitudinal streaks of white often within the green portions of the leaves. Sheaths at the bases of the leafstalks purplish. A rare and attractive variant of a rare plant.

Sold by Ishiguro Momiji En (nursery), Nagoya, Japan, as *fuiri tenjiku-suge* (variegated *Carex phyllocephala*).

The following two plants are selections of *Daphne odora*, a Chinese shrub long popular as a garden plant in Japan. Many cultivars have been selected for pot culture as well, especially those with leaves variegated in various patterns, fasciated shoots, or twisted leaves. The classic works *Somoku Kihin Kagami* (1827) and *Somoku Kinyoshu* (1829) list twenty-one variants. The two more-modern cultivars described below are notable for their floral display as well and seem not to be included among the cultivars listed in the classics.

Daphne odora Thunb. 'Ringmaster' [a new cultivar name assigned by Carl R. Hahn] (Yinger Collection No. 1894)

Leaves green with 2- to 4-mm-wide margins of cream or pale yellow. Flowers 2 cm across, with a tube 1 cm long, pure white, appearing relatively late.

A very beautiful selection combining white flowers with clear marginal variegation to produce plants that are unusually striking in flower.

Grown in Japan by Mr Yoshimichi Hirose, Iwakuni City, Yamaguchi, Japan Described, but not named, on page 51 of the 1911 catalog of the Yokohama Nursery Company, Yokohama, Japan.

Daphne odora Thunb. 'Zuiko Nishiki' [fragrant brocade] (Yinger Collection No. 279, No. 1794, and No. 1920)

Leaves green, not variegated. Flowers dark pink (Rhodamine purple or Fuchsia purple in the 1938 Royal Horticultural Society's Colour Chart) or white On young plants, flowers usually all of one color or the other, both colors appearing on the same plant as the plant matures All the flowers of an umbel usually of one color, but some umbels having both pink and white flowers, and a few individual flowers showing sectoral (chimeral) patterns Individual flowers large, 2 to 2.5 cm across, each with a tube 1 cm long. Corolla lobes obtuse or rounded at their tips. Flowers borne in large, rounded umbels of 15 to 25 flowers A very beautiful plant marketed under several names, including *"sakiwake"* and *"shibori,"* both of which are applied to two-colored flowers or inflorescences.

Described and illustrated on page 33 of the Fall 1980 catalog of Kairyo En (nursery) Grown by Kairyo En, Angyo, Japan, and several other major nurseries.

Distylium racemosum Sieb. & Zucc. 'Akebono' [*dawn*] (Yinger Collection No. 269)

Leaf blades 5 to 10 by 2 to 5 cm, mostly about 7 cm by 3 to 3.5 cm, persisting two years. One-year-old leaves creamy white, all on new shoots, some below the apexes of the shoots speckled or veined green Two-year-old leaves dark green with no markings Stems of new shoots creamy white or sometimes dark pink, those of older shoots green. A vigorous plant with obliquely ascending branches. A very distinctive variegated clone, one of several listed in modern and classical Japanese sources.

Described under the name 'Akebono' [dawn] on page 11 of Catalog No. 62 (Fall 1978–Spring 1979) of the Asahi Shokobutsuen (nursery), Okazaki, Aichi Prefecture, Japan.

Distylium racemosum Sieb. & Zucc. 'Guppy' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 274)

Leaves green, not variegated, 3 to 5 cm by 1 to 2 cm, with short (5 to 15 mm) internodes. Typically

Distylium racemosum 'Akebono'

makes 4 to 8 cm of new growth per year A dwarf cultivar making a dense, rounded shrub of congested growth.

Similar to a clone described and illustrated on page 42 of the explanation volume accompanying the facsimile reprint of the classic Somoku Kihin Kagami *(1976) The clone listed, which the text explains is probably not in existence now, is called* "koba hizon" *[small-leaf* Distylium]. *No measurements are given, but the plant pictured has leaves that seem to be proportionally wider than those of the clone we describe here*

Grown and sold by Garden Wako (nursery), Takarazuka, Osaka-fu, Japan.

Houttuynia cordata Thunb. 'Chameleon' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 714 and No. 824)

Leaves dark green with variable broad margins that often invade the centers of the leaves in broad sectoral patterns. Margins creamy white or yellow, often tinged with pink, in sunny locations bright-red and strong-pink shades often dominate Green interiors of the leaves usually streaked or splashed with gray–green, and a green reticulate pattern may appear on the lighter margins. Outlines of leaves less regular than those of the species, the margins often undulate Number of white, showy bracts subtending the inflorescence (normally four) variable in this clone A very showy variegated selection.

A similar cultivar is listed in the classic Somoku Kinyoshu, *illustrated and described on page 73 of the explanation volume accompanying the facsimile reprint (1977) However, that clone appears to have irregularly splashed leaves with no sign of the distinct marginal variegation of 'Chameleon'*

Sold by several nurseries in Japan as *"fuiri dokudami"* [variegated *Houttuynia*] (for example, Garden Wako [nursery], Takarazuka, Osaka-fu, Japan).

Ilex integra Thunb. 'Green Shadow' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 718)

Leaf blades 5 to 9 cm by 1.5 to 3 cm Leaves medium gray–green with irregular creamy-white margins 1 to 5 mm in width that sometimes invade nearly to the midveins Irregular patches of paler gray–green, in broken patterns, also occupying one-third to one-half of the green portions of the leaf blades. The creamy-white areas often suffused with pink on new growth. A vigorous and stable clone.

The classic, Somoku Kinyoshu *(1829), lists six cultivars of* Ilex integra *with variegated or contorted leaves. This selection seems to be different from those listed there*

Grown by Kiraku En (nursery), Mito, Ibaraki, Japan, as *"fuiri mochi-no-ki,"* [variegated *Ilex integra*].

Ophiopogon japonicus (L. *f.*) Ker-Gawl. 'Torafu' [tiger variegation] (Yinger Collection No. 1681)

Leaves to 15 cm long, 3 mm wide, green, with one to four latitudinal bands of pale yellow fading to creamy white. Most bands 1 to 5 cm wide. Some leaves entirely green or, less often, entirely creamy white.

Grown by Kairyo En (nursery), Angyo, Japan.

Pinus parviflora Sieb. & Zucc. 'Fubuki Nishiki' [snowstorm brocade] (Yinger Collection No. 1908)

Needles 2 to 4 cm, mostly about 3 cm, long, not curved; green, those recently produced with a glaucous bloom Most needles banded with creamy white. Of these, the most common pattern a single band, 5 to 10 mm wide, on the upper half of needles. Band sometimes flecked with green so that there seems to be a sucession of smaller bands Tips of needles often creamy white. Habit dense and somewhat congested, with about 4 to 9 cm of new growth each year.

Most similar to P. parviflora *'Janome' (actually, two distinct clones) and 'Ogon' 'Janome' is distinguished by its strongly curved needles and green-tipped needles in both so-named selections 'Ogon' is distinguished by its short, densely tufted needles, which are uniformly yellow except at the base*

Illustrated on the cover of the Fall 1977 catalog of Kairyo En (nursery), Angyo, Japan, and described on the inside cover. Sold by Kairyo En and other nurseries

Cultivar Update

In the Fall 1983 issue of *Arnoldia*, we assigned the name 'Sundance' to a cultivar of *Aucuba japonica* (Yinger Collection No. 267). We have since discovered a validly published name for this clone that is acceptable under the *Code*. Thus, we wish to nullify our name 'Sundance' in favor of the name 'Meigetsu' [the Japanese spring and autumn equinox], which is illustrated and described on page 9 of Catalog 62 (Fall 1978–Spring 1979) of Asahi Shokubutsuen (nursery), Okazaki, Aichi Prefecture, Japan.

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Barry R Yinger is curator of the Asian Collections at the United States National Arboretum Carl R Hahn is chief of horticulture of Maryland–National Capital Park and Planning Commission, Silver Spring, Maryland

Five years of experience yield the formula for success

Replacing the Understory Plantings of Central Park

Geraldine Weinstein

A century after Central Park was created, few vestiges of its original understory of shrubs and trees remained, despite a major replanting that was done in the 1930s. Depleted financial resources, misguided attempts at landscape management, inadequate maintenance, and the impact of millions of visitors were the major culprits. Recognizing the importance of shrubs and understory trees in the Park's design and ecology, the Central Park Conservancy and the New York City Department of Parks and Recreation began to replant the understory in the spring of 1980.

Basing their approach on the Park's history, on growing conditions in the Park, and on the desires of parkgoers, the Park's managers and landscape architects have been focusing on the ability of specific understory plantings to accomplish aesthetic and ecological objectives. They have found that the key steps in successfully reestablishing the understory are analysis of the site, the selection of plants, appropriate maintenance practices, and continual evaluation of each plant's performance.

Construction of Central Park began in 1858, during an era of intense botanical exploration. The idea of bringing plants from abroad greatly appealed to Frederick Law Olmsted and Calvert Vaux, the Park's designers, since an expanded choice of plants would make it easier for them to carry out their design intentions. Combining exotic and native species, they provided a multitude of contrasts in plant texture, color, and form, offering visitors to the Park a continual and fascinating change in scenery. *Leucothoë fontanesiana* (*L. catesbaei*), *Mahonia aquifolium*, and a myriad of *Rhododendron* species brought bold texture and deep color to the landscape, while *Caragana arborescens*, *Cytisus scoparius*, and other fine-textured plants provided a counterpoint.

Fruits of the many species of *Cotoneaster*, *Lonicera*, and *Viburnum* also wove color through the landscape. In autumn, the diversity of color was heightened by the foliage of *Rhus typhina*, *Euonymus alatus*, and *Hydrangea quercifolia* and, in winter, by the twigs of *Kerria japonica*, *Cornus sericea*, and *Vaccinium angustifolium*.

Through the widespread planting of roses, spireas, lilacs, azaleas, and rhododendrons, floral displays became part of the Park's landscape. But in choosing from a wide array of plant species, the Park's designers did not always give horticultural considerations the attention they deserved.

First and foremost, Olmsted and Vaux used plants—especially shrub and understory species—to give specific aesthetic character to a site or to complement such existing features of the landscape as lakes, streams, and meadows. Although Olmsted and Vaux planned the understory with a flawless eye, conditions at a site were not always favorable to the species they planted there. Some of the species probably found the Park's environment as inhospitable in the nineteenth century as they would find it now. Of the plants listed on the 1873 survey of the Park, *Aucuba japonica*, *Kalmia angustifolia*, *Andromeda polifolia*, and *Myrica cerifera* could not have found conditions particularly favorable.

The 1873 survey indicates that the species planted in the Park came from a wide range of habitats. Shrubs familiar in garden settings—*Potentilla* spp., *Buxus* spp., *Hydrangea macro-*

The Fifth Avenue border planting of *Berberis thunbergii* and *Rhodotypos scandens* Photographs by the author.

phylla, Cotoneaster spp., *Hypericum perforatum*—were used, as were shrubs more often seen in their native habitats—*Lindera benzoin, Viburnum dentatum, Clethra alnifolia*, for example.

As much as diversity, scale characterized the shrub and understory plantings. For Olmsted and Vaux, understory planting had to be of considerable scale and depth, allowing the eye to wander, uninterrupted, over large areas of the landscape, evoking a sense of space and dimension. A powerful contrast was to exist between the Park and the surrounding city, where cement and concrete loomed before one's eyes, continually cutting off views of what might lie beyond. Shrub plantings of considerable depth and length would add another dimension to its environment, as well as another texture to the Park's landscape. Installed throughout woodlands, at the edges of meadows, and on the banks of streams and ponds, extensive shrub and understory plantings created environments rich in botanical and ecological diversity. Wildlife found varied sources of food and excellent protective cover. Visitors to the Park saw before themselves the same degree of harmony and contrast among plants that characterizes natural landscapes.

Design and Management Considerations

The objectives of the current replanting echo those of Olmsted and Vaux but have been expanded to meet additional management needs.

Growth habit, foliage texture, and times of flowering and fruiting are still part of the design and plant-selection process. However, management issues pertaining to the Park's appearance as a well maintained and thriving urban green space receive no less emphasis. As in early Park plantings, shrubs and understory trees are currently used to provide soft, undulating edges to wooded areas of the Park. The understory created between canopy trees and the ground surface is particularly important at entrances and along the Park's perimeter, where visitors get their first impression of Central Park as a naturalistic landscape.

Reiterating an important concept of Olmsted and Vaux's, landscape architects at the Conservancy are planning large-scale plantings of shrubs for selected sites along the edges of lawns. Throughout much of the Park, lawns are defined by pavement. The hard visual impact of asphalt paths is offset by lush and vigorous understory plantings, which also define the edges of meadows. Thus the lawns are set off and highlighted as more irregular and undulating spaces than before.

In addition, naturalistic edges of shrubs and understory trees are being planted on the banks of lakes, ponds, and streams in the Park to halt siltation. This process begins with an assessment of the total watershed area to determine whether and, if they will, where understory plantings will minimize erosion of surrounding slopes and adjacent areas. The process ends with an effective waterside planting that will stabilize the banks and shoreline. The waterside planting must have additional merit as a wildlife habitat, providing both food and cover.

Soil erosion in Central Park adversely affects not only its bodies of water. Throughout the Park, the growth and establishment of plants, especially of trees and ground covers, are threatened by the continual loss of topsoil. Erosion undoubtedly became a problem in Central Park soon after the first half million cubic yards of topsoil were brought to the Park during its construction. Other factors related to the erosion problem have been with the Park since its beginning. At any given site, at least one of the following factors is involved: design, soil texture, environmental factors, and use of the Park. Understory planting in Central Park is intended to compensate for the erosion-prone soil, intense use of the Park, difficult-to-manage or -design areas, and harsh microclimate.

Intensity of use in particular is a problem, as the feet of 14,000,000 visitors leave their imprints each year. The problem is most obvious in the dusty and constantly eroding cow paths that crisscross areas in the Park, and on steep slopes, where any major amount of foot traffic results in considerable loss of topsoil. Understory planting is used to manage the circulation patterns of visitors. Such "barrier plantings" protect easily eroded areas, newly restored landscapes, and lawn areas. The species of shrubs chosen are not necessarily thorny, but by their mass and visual impact they effectively deter foot traffic.

In summary, design intentions and management concerns have resulted in specific planting objectives for the restored understory, namely, to control erosion, supply food and cover for wildlife, provide a naturalistic understory in the Park's woodlands, stabilize banks and shorelines, lend spatial definition to landscape sites, and assure the integrity of Central Park as a naturalistic landscape, even at its entrances and on its periphery.

Site Considerations

In any restoration project, if the plant species chosen deal successfully with the existing use and environmental problems, then the design intent will be clearly conveyed; otherwise, it will crumble. After the site has been analyzed, plant material must be chosen with as much knowledge and information as are available to the horticulturist and the landscape architects. Strong emphasis is placed on the use of native species whenever possible, and on integrating broadleaf evergreens into the planting. Existing plant lists can indicate which species are tolerant of shade, salt, or flooding, and which will help prevent erosion. However, existing lists usually do not take into account the many adverse environmental conditions of an urban site.

Central Park is a built landscape. Even its soil, which must support plants, is built. The characteristics of urban soil differ sharply from those of natural soils. Structural and textural inconsistencies in the profile of an urban soil create barriers to the movement of air and water into the soil. In addition, compaction of the surface and subsurface layers of soil decreases the amount of air and water that are available to plants, a common problem in soils that are affected more by people and machines than by natural processes Both periodic flooding and drought can occur within soil layers.

The climate of Central Park, like the climates of other "green islands" in cities, is strongly modified by the areas around it. Winds tunnel between tall buildings, and heat radiates long into the evening, having been trapped in masses of asphalt and concrete during the day.

It is significant, too, how the characteristics of urban soils and microclimates intensify the effects of seasonal changes in temperature. Unlike actual islands, which are protected from climatic extremes by the water around them, urban "islands" have very few ameliorating influences. Temperatures in the soil and air are often extreme, especially in shallow and compacted soils.

Perhaps the most important site consideration is the effect wrought by people. "People-pressure diseases" of urban trees also affect the understory. While most actual islands are inaccessible to large numbers of people, urban islands are created for people. In fact, the intense use of Central Park, despite the damage it does to vegetation, is the Park's greatest attribute. Central Park was created to attract the citizens of New York; it provides them with relief from the city's steel and concrete.

The Border Planting

The restoration along Fifth Avenue between 72nd and 76th Streets was the first attempt to reestablish a border planting at the edge of the Park. The planting was gradually extended, creating a forest edge along the Park's perimeter, adjacent to Fifth Avenue.

This planting lies between two Park entrances. One, the entrance at 72nd Street, a major thoroughfare in the Park, leads to the Mall, Sheep Meadow, and Bethesda Terrace—all of which are major focal points in Central Park. Immediately north of this entrance is the path leading down to the Conservatory Water, which is a model-sailboat pond in spring and summer and an attractive site for ice-skating in winter.

While a proliferation of architectural styles and forms occupies the adjacent city streets, the forest edge just inside the Park is a coherent and free-flowing naturalistic landscape, reflecting harmony along its entire length. From the Park wall, the forest edge slopes either down toward the Conservatory Water or up a short rise toward the 72nd Street entrance. Understory plants weave through and around canopy trees. Unlike the city streets, which are spatially defined by blocks, the border planting conveys the feeling of a contiguous forest.

On sunny days, the lawn around the Conservatory Water is crowded with people. On weekdays, hundreds of people pass through the 72nd Street entrance, on weekends, thousands. During certain special events, hundreds of thousands of people pour into the Park. The spilling over of people from the entrance onto the border planting is a perennial problem, one that affects both the design of the planting and the plants used at the site. The entrance at the other end of the border planting is much smaller in scale—just a gap in the Park wall, and a pathway leading in—and is far less used by visitors. There is a very popular playground just to the north, making large numbers of school children a normal part of the landscape.

In terms of climate, the Park's perimeter along Fifth Avenue is colder by far in winter than all other sites in the Park. The wind coming off the East River increases in force as it whips around and through row upon row of skyscrapers before

Myrica pensylvanica growing on a rocky ledge on The Point.

striking the Park with enormous impact.

Because the perimeter planting faces east, parts of it receive more sunlight than other areas of the Park, particularly in winter. Unfortunately, the winter sun does more harm than good to plants because it can dry them out.

The most striking visual features of the site are the many large and magnificent canopy trees and the extensive steep slope that characterizes the entire planting. In this part of the Park's perimeter the slope extends down from the base of the Park wall, becoming a potentially scenic and dramatic backdrop to the lawn areas below.

Although the trees were for the most part in good condition, the slope was, with few exceptions, bare of understory planting. It was also bare of leaf litter, since the leaves from the canopy trees are swept off the slope by the wind and people onto the lawn areas below. During heavy rainstorms the Park wall adds to the erosion problem: Rain pours down the side of the stone wall and shoots down the slope, leaving rills and gullies behind. As this site is adjacent to the Park wall, we were not surprised to find fill and heavy subsurface layers within the soil profile. To provide a supportive soil environment, truckloads of leaf mold were brought to the site. Where feasible, the leaf mold was rototilled into the soil. Where a Rototiller could not be used, the leaf mold was worked in with grub axes and shovels.

To create a forest edge at the site, understory planting would have to stop erosion effectively. Shrubs and understory trees capable of doing this would be those species able to deal with the adverse effects of wind, heat, sun, and people, as

Cornus racemosa, placed to soften a planting of *Berberis julianae* used to define a path to The Point.

well as with the limitations of deep shade and intense competition from the roots of the many existing mature trees. Over two thousand shrubs and understory trees, consisting of twenty-two species, were used at the site. *Hamamelis virginiana*, *Euonymus alatus*, *Rhodotypos scandens*, and *Viburnum siedboldii* are the "anchors" of this landscape. They have proven themselves in other sites in the Park, and were used to give cohesiveness to the planting and to link this landscape to other sites in the Park. It was also hoped that they would uphold the planting and the design if any of the other plants chosen proved to be mistakes.

Hamamelis virginiana was the principal understory tree used. This species had already indicated its tolerance of severe exposure, drought, and flooding at other sites in the Park. Its wide-spreading habit provides an effective contrast to the many verticals of the major-story trees. Placed at the top of the slope, it breaks the force of the wind and rain and provides a buffer for less adaptable plants on the site. Even from outside the Park, the graceful form and yellow flowers are a welcome contrast to the traffic congestion on the avenue.

Although somewhat stiffer in habit, *Euonymus alatus* 'Compactus', with its dense and compact form, also protects the soil from the pounding of heavy rainfalls. When mass-planted, it provides an equally dense buffer against careless foot traffic. Its density deters visitors from ploughing through the planting. In the autumn, the broad spatial effect of its pink-rose foliage provides additional depth and interest to the border planting.

While both *Viburnum dilatatum* and *Viburnum lantana* were used, *Viburnum sieboldii* has proved more successful. Its lustrous foliage is an especially welcome sight during the hottest part of the summer. It rarely indicates drought or heat stress, and it grows more vigorously than other species of *Viburnum*, with *Viburnum prunifolium* being the only exception.

Rhodotypos scandens is another park favorite, much admired because it tolerates almost anything. With maintenance, it is a very vigorous grower. Its graceful, wide-spreading habit contrasts effectively with the more upright *Euonymus alatus*. At this particular planting site, it flowers for nearly four weeks. The black, bead-like berries are as attractive to wildlife as to people.

Acanthopanax sieboldianus has proved very effective at stopping erosion because it deters foot traffic. It is easily established and is a very vigorous grower, so vigorous, in fact, that it often hinders the growth of less competitive plants growing nearby. Its very-fine-textured foliage lightens up an entire planting. It protects the soil because it virtually covers it with its moundlike and wide-spreading habit.

At the base of the slope, in a wet area, we were successful with a bare-root planting of *Cornus sericea*. While we had often been unsuccessful planting *Cornus* species balled and burlapped, we incurred no losses with the planting at this site.

As all of the above species flourish, they provide protection for rhododendrons and *Kalmia latifolia*. Though not widely used throughout the planting, the contrast between their bold, broadleaf foliage and the lighter texture of the deciduous material magnifies their impact. While it would be nice to use evergreens at the edge of a border planting, so that they could be seen from the street, it doesn't work that way. They are difficult to reestablish, are easily desiccated by the wind and sun, and are intolerant of the heat, urban soils, and disturbances in general. While an environment suitable for rhododendrons, laurels, and azaleas could be provided, site conditions proved totally unsuited for other species selected.

Amelanchier canadensis is a favorite understory tree, but it has not fared well on this site. Heat, surface campaction, and frequent disturbance by people set it back substantially. In Central Park it is slow to establish, even when maintenance is provided, and its stems are easily broken.

Along with *Amelanchier canadensis*, *Clethra alnifolia* and *Ilex verticillata* found the site far too dry for their liking. Even with irrigation and mulching, neither species thrived. Like *Amelanchier*, *Clethra* is particularly difficult to establish. While healthy examples of all three species can be found elsewhere in the Park, the fatality rate has been high, considering the numbers planted during the last two to three years (nearly one thousand *Clethra* plants). *Clethra* and *Amelanchier* are doing well at waterside plantings, even though the soil in which they were planted is not wet. The breezes from the water lower the temperature and provide a degree of air circulation missing from the border planting, where the winter winds are not replaced by any cool summer breezes. In addition, at the waterside sites, both species suffer far less disturbance.

Ilex verticillata was the great mistake in the border planting. This species was totally out of its habitat, and there was no way we could recreate the habitat A planting of this species situated on a shaded slope leading down to an inlet is successful, however. *Ilex verticillata* is the perfect example of shrubs often recommended for wildlife plantings but that cannot benefit the wildlife in Central Park since they rarely survive in the Park's harsh environment.

There have been other planting successes and failures throughout the Park that are worth reporting. Central Park was built on rocky, barren land; therefore, shallow soil is a common problem. *Myrica pensylvanica* and *Elaeagnus umbellata* seem to take this limitation in stride, thriving on rocky, fully exposed sites and yet tolerant of light shade. Both species contribute to the success of the wildlife planting at The Point, a rocky peninsula jutting out into the 72nd Street lake. A planting of *Rosa rugosa* at the tip of the peninsula provides a thicket of cover for wildlife and a great deal of pleasure for birdwatchers and other naturalists. It is extremely vigorous and flowers as profusely as it would in a seaside environment.

At the same site, *Cornus racemosa* has proved successful, tolerating the dryness and exposure of the rocky site far better than *Cornus sericea*. Two other species used at The Point, and which we were hoping to use frequently in the Park, are *Magnolia virginiana* and *Rhus typhina*. Unfortunately, they were never given a chance to survive or to fail: *Magnolia virginiana*, with its attractive foliage and flowers, was repeatedly vandalized; *Rhus typhina* provided sticks and fishing poles until the planting was depleted.

Aronia arbutifolia and *Vaccinium corymbosum* are also used at The Point and other sites to attract wildlife. While not a vigorous grower, *Vaccinium corymbosum* is tolerant of exposed sites and dry periods and can adapt to disturbance by Park users. The site has proved too dry for *Aronia arbutifolia*; nonetheless, we will try the species again where soil conditions are more favorable.

We have had success with *Berberis ×mentorensis*, the mentor barberry, which, when taken care of, is as adaptable as the more weedy *Berberis thunbergii*. While we have often used the mentor barberry to control circulation patterns, we are finding that the shrublike 'Seafoam' and 'Fairy' roses are even more effective in controlling soil erosion by controlling foot traffic. Interplanted on a totally exposed slope in the Park, both the 'Seafoam' and 'Fairy' have grown in a rambling and rampant fashion, forming thick, impenetrable mounds that are covered with flowers for two to three months. The landscape looks far softer and more agreeable to the visitor than it does when barberry is used. The negative connotation of a barrier planting is eclipsed by the aesthetic pleasure the roses provide. The vigorous growth of the roses creates a microclimate where the soil surface is shaded, affording them a cool, moist root run, even in the exposed area. Insect damage has not been a noticeable problem. The floral display is in accord with Olmsted and Vaux's philosophy: they wanted flowers in the Park to be seen, not as individuals but amidst masses of lush foliage and vigorous growth.

In 1983 and in the spring of 1984, we added additional species to Park plantings. Among them were *Fothergilla gardenii*, *Enkianthus campanulatus*, *Calycanthus floridus*, *Rosa nitida*, *Rosa wichuraiana*, *Hydrangea quercifolia*, *Rhus aromatica*, and *Cotinus coggygria*. We also added several species of native azalea: *Rhododendron vaseyi*, *R. schlippenbachii*, *R. bakeri*, *R.* 'Janet Blair', *R. prunifolium*, and *R. nudiflorum*. By 1986 or 1987, they will have shown their tolerance, or lack of it, of conditions in the Park. Some of these species are "fragile," but we hope that if particular species are used with plants that already have proven their vigor, the new species will receive some protection while they are becoming established.

We also realize that many species of plants that are not yet used in Central Park might be successful on "green islands" within all urban environments. While at some locations we can use five to ten of a species, we are more likely to use fifty to five hundred. The availability of particular plant species often limits their use. At specific sites where protection and maintenance are adequate, we plant bare-rooted material. Its use increases the range of species and actually eliminates a characteristic disadvantage of planting in urban soils, which is the problem of interface between the nursery soil of the root ball and the built soil of the urban greenspace. Species that are more "opportunistic" when they are planted with bare rather than balled and burlapped roots will brighten the future of urban park plantings.

Two years after the initial planting, the border planting at the Park's perimeter was achieving its design intent. Wood-chip mulching was still necessary, because leaves continued to be blown off the slope. However, this maintenance task was continually reduced as the understory planting grew and covered the exposed areas on the slope.

While the forest now growing at the edge of Central Park does not block out the harsh urban environment, it is the most effective antidote to it.

Evaluation

We have devised a method of evaluating plants. The evaluation has two objectives:

- To relate plant survival and growth to specific site and environmental characteristics, and
- To determine whether particular plant species are fulfilling the purpose for which they were planted.

To avoid drawing premature conclusions, we have limited our evaluation to plantings that are at least two years old. We have organized our data collection to measure the following four variables:

- The adaptability of given species to existing site characteristics (slope, fertility, drainage, soil depth and texture, exposure, reflected heat, competing vegetation, ground cover, public use),
- Biological condition (resistance to drought, resistance to flooding, pH, salt tolerance, transplantability, percentage of deadwood, growth rate),
- Ornamental value (foliage condition each season, period and persistence of flowers and fruits, growth habit, freedom from serious insects and diseases), and
- Maintenance responsibilities and their frequency (irrigation, pruning, mulching, fertilization, monitoring for pests and diseases, replacement).

A great deal of basic information about the plant materials is collected before any information specific to the site is garnered from field visits. The following data are recorded: planting location and date; height and spread; when planted; native habitat; nursery source, kind of stock (bare root, balled and burlapped, or container); design function; and the plant's historic value to the Park. All data are entered during the winter months. Scheduled on-site visits are made to determine percentage of deadwood (entered mid-July), and growth rate (entered mid-August). Weekly visits are made during the appropriate season to determine the degree and persistence of flowers and fruit, and the condition of leaves and twigs.

Once all observations are computerized, we will be able to retrieve information that will greatly influence our selection of plants. We will know what to expect when a certain species is planted in a specific environment for a well-defined purpose or design function.

Reference

Frederick Law Olmsted Association and Central Park Community Fund *Central Park Plant List and Map Index of 1873* New York The Frederick Law Olmsted Association and the Central Park Community Fund, 1979.

Acknowledgment

The author thanks landscape architects Marianne Cramer and Judith Heintz for invaluable historical background information.

Geraldine Weinstein, director of horticulture for the New York City Department of Parks and Recreation, was director of horticulture for Central Park from 1980 to 1984 She has recently been awarded a prestigious Loeb Fellowship by the Graduate School of Design of Harvard University.

Chemicals That Regulate Plants

John W. Einset

Five key plant hormones have commercially valuable uses in horticulture, and there is promise of more to come

Plants, like other living things, have complex internal mechanisms through which they coordinate their growth and respond effectively to changes in their surroundings. A fundamental concept of botany states that fluctuations in the amounts of a few key chemicals known as plant hormones, or "phytohormones," regulate practically every aspect of plants' functioning. Since the discovery of the first phytohormone nearly fifty years ago, botanists have learned much about these internal regulators, and the knowledge they have gained has been exploited successfully to develop practical uses for phytohormones in horticulture. Without question, research on phytohormones has already paid for itself. Moreover, scientists working on phytohormones believe that the prospects of finding new ways of manipulating plants with these chemicals are especially encouraging.

The Five Kinds of Phytohormones

Five distinct categories of phytohormones are recognized, each of which has characteristic molecular structures and physiological roles in plants: auxin, ethylene, cytokinin, gibberellin, and abscisic acid.

Auxin, the first phytohormone discovered, is probably the best understood of them all. The major form of auxin in plants is the chemical indole-3-acetic acid (IAA), which has been implicated in a variety of phenomena, including plant "architecture," the bending response to light, flower formation, leaf and fruit drop, and fruit maturation.

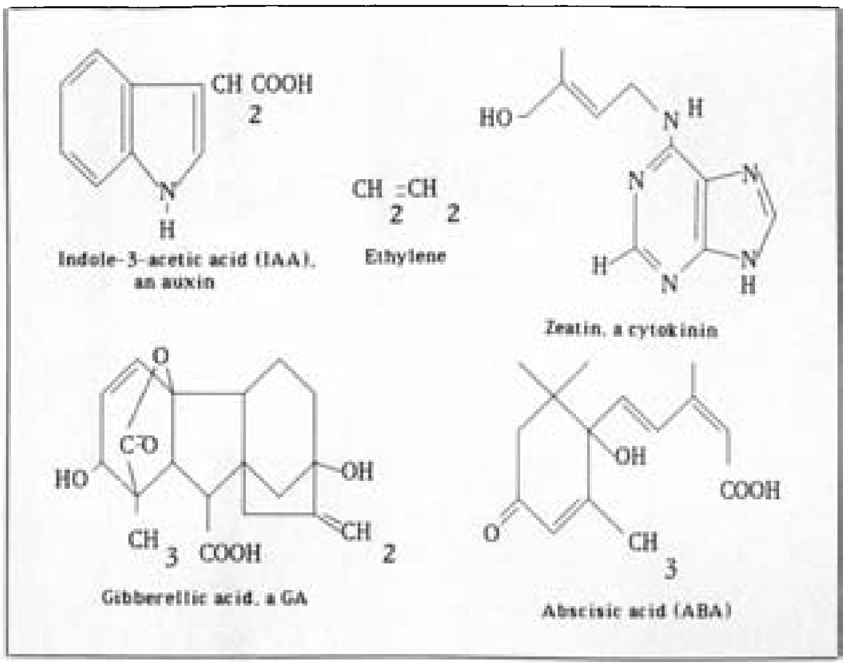
Ethylene, structurally the simplest hormone found in any living thing, regulates fruit drop, flowering, fruit ripening, and the death (senescence) of plant parts. After auxin, ethylene is the most important phytohormone in commercial practice.

The phytohormone cytokinin, on the other hand, currently is of limited practical use, even though tissue culture would be impossible without it. Because of its crucial role in tissue culture, cytokinin undoubtedly will assume increasing importance as advances are made in biotechnology. Cytokinin controls seed germination, plant architecture, the movement of gases between the interior of leaves and the atmosphere, fruit development, senescence, and fruit drop.

Gibberellin (GA), of which over sixty different chemical variants are known, regulates seed germination, stem growth, flowering, and fruit development. Many so-called "dwarf," or stunted, plants are actually defective in their abilities to produce GA.

Abscisic acid (ABA), the last phytohormone to be discovered, is responsible for seed dormancy. It also regulates the growth of roots and the exchange of gases between leaves and the atmosphere. To date, there are no important practical applications for abscisic acid, although the prospects are good that it will become a valuable chemical for increasing the capacity of plants to withstand drought, since it influences the amount of water that plants lose from their leaves.

In spite of all we know about phytohormones, an obvious question comes to mind: "Are there



Representative chemical structures of the five currently known classes of plant hormones Prospects for discovering additional kinds are considered to be especially good

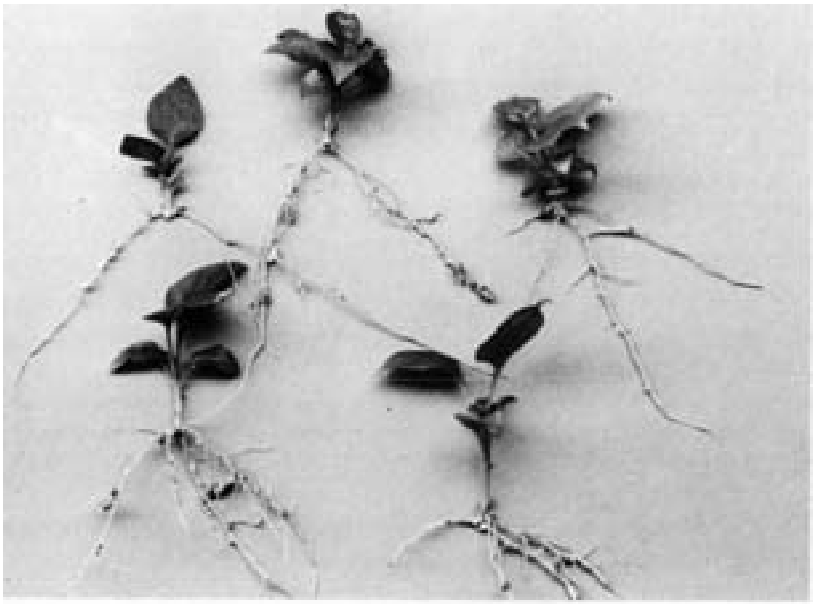
other kinds of phytohormones yet to be discovered?" The answer almost certainly is, "Yes." After all, over fifty different hormones are known among animals; it stands to reason, then, that plants have more than just five different hormone systems. In fact, there is evidence that the actual number of phytohormones is at least twice as large.

Horticultural Applications of Phytohormones

By far the greatest commercial use of phytohormones is as weed killers, that is, as herbicides. A practice begun in the 1930s, the use of excess doses of auxin as herbicidal treatments has become a multimillion-dollar industry. In the United States alone, over fifty million pounds of the synthetic auxin 2,4-dichlorophenoxyacetic acid (2,4-D) are applied to millions of acres of agricultural land, as well as to golf courses, public parks, and lawns. An important aspect of this technology is the selectivity of the herbicidal effect: at the levels of auxin applied, dicotyledonous plants ("dicots"), such as dandelions, are killed, but monocotyledonous plants ("monocots"), such as grasses, are left unharmed.

While the use of phytohormones as herbicides might be considered a drastic measure because it involves excessive concentrations of auxin, most practical methods involve subtle alterations in the levels of hormones *inside* plants. An example is the regulation of seed germination with GA.

When a dry seed of a grain such as corn, barley, or oats is soaked in water, the seed produces enzymes that break down the protein and starch that are stored in the seed into their component "building blocks," which nourish the young seedling during the early stages of its growth. Obviously, the coordination of protein and starch breakdown with embryo growth and seedling development is of crucial importance. This is where



Cuttings of *Syringa* obtained through tissue culture and stimulated to produce roots by applying auxin. Photograph by the author.

GA plays a role. For example, one of the first events associated with water uptake by the seed ("imbibition") is the production of GA in the embryo. The GA produced diffuses from the embryo to a layer of cells immediately beneath the seed coat, where it activates the genes for enzymes that release stored reserve nutrients.

In the production of malt, which is popular as an additive for milk and is used to make beer, barley or oat grains are allowed to germinate only to the stage at which most of the starch in them has been converted to soluble sugar. At this point, development of the seedling is stopped by a heat treatment, and the resulting malt is ground to a powder. Sometimes, the grain is treated with GA during the imbibition period. This practice stimulates the breakdown of starch and ensures uniform malting. Several beers from Australia are produced from GA-treated barley.

One of the earliest applications of auxin in horticulture was to stimulate the formation of roots on cuttings. Nowadays, auxin in either liquid or powder formulations can be purchased at most garden-supply stores; it can be used at home to induce roots to grow on cuttings of most common horticultural plants. Essentially the same procedure is used by nurseries for propagating plants, especially when large numbers of identical individuals are needed.

In the last fifteen years, tissue culture has become increasingly important as a tool for propagating plants. (See "Biotechnology at the Arnold Arboretum" in the Summer 1984 issue of *Arnoldia*.) Known as "micropropagation," the usual method involves "shoot multiplication" in a nutrient medium, followed by the auxin-induced rooting of cuttings. After a shoot tip from a plant has been decontaminated, it is transferred to tissue-culture medium containing enough cytokinin to sustain growth and overcome apical dominance in elongating shoots. The result of this manipulation is the production of several, simultaneously growing shoot axes starting from only one tip, that is, shoot multiplication. Individual shoots are then used for further shoot multiplication in the next tissue-culture passage, or they are used as cuttings and rooted with an auxin treatment Theoretically, it is feasible to produce over a million plants from a single shoot tip through tissue-culture technology in just one year.

New Applications

According to the major scientific hypothesis relating phytohormones to the architecture of plants, shoot growth is a result of interactions between auxin, cytokinin, and GA. Auxin produced by the growing tip inhibits lateral buds in the axils of leaves, a phenomenon known as apical dominance that, in extreme cases, results in an unbranched (or "monopodial") axis Cytokinin, on the other hand, counteracts auxin, so that shoot systems in which cytokinin is produced at a high rate consist of several, simultaneously growing brances, a situation called "sympodial" growth. Branching, or its absence, therefore, is a consequence of the auxin–cytokinin balance. By contrast, the length of internodes (stem elongation) is regulated by GA.

Theoretically, the architecture of cultivated plants could be manipulated by altering the levels of any one of the three critical phytohormones. The common practice of nipping buds on houseplants, for example, effectively removes the source of auxin responsible for apical dominance. The result of this treatment is sympodial growth due to the liberation of lateral buds that the auxin produced in the tips of the stems had prevented from developing. Liberation of the lateral buds causes a bush-like, branched architecture. So-called growth retardants, many of which inhibit the production of GA, shorten the internodes of treated plants, resulting in dwarfed, compact architecture. Two examples of growth retardants are cyclocel and ancymidol.

The use of growth retardants has increased substantially in the last few years. Because they inhibit the elongation of stems, growth retardants reduce the need for expensive tree-trimming operations. As a matter of fact, several utility companies currently use growth retardants as a cost-saving measure along streets with aboveground power lines. Growth retardants are also applied to a major variety of wheat in West Germany that has a tendency to lodge (blow over) in high winds. They are also used on lawns to decrease the need for periodic mowing.

Sometimes, however, it becomes necessary to stimulate the growth of a lawn. Two days before the beginning of a national golf tournament, for example, the grounds crew mistakenly mowed an area designated for high grass (the "rough"). GA was put on the affected area, growth sped up, and the rough was restored just in time for the start of play.

Leaf drop, or abscission, is regulated by the relative concentrations of auxin and ethylene in the abscission zone. Ethylene tends to stimulate the process, while auxin inhibits it. In certain instances, cytokinin, GA, and ABA may also exert some control, although their effects vary widely according to the species of plant involved.

Probably the most important commercial use of phytohormones for defoliation involves cotton production. In normal practice, plants are sprayed a few days before harvest with an abscission stimulator (for example, an ethylene-generating chemical) that causes the leaves to drop but does not affect the cotton bolls, which can be harvested with a mechanical picker without harvesting leaves as well. Obviously, the savings that result from using phytohormones in cotton technology are substantial.

Other practical uses of phytohormone defoliants have been controversial. During the late 1960s in Vietnam, for example, phytohormones were sprayed from U.S. military airplanes to cause the leaves of rain-forest plants to fall off. According to official policy, this was done as a temporary, tactical measure, but the repeated treatments killed most major species of trees in the rain forests. The long-range consequences of this practice, both in terms of human health and the future of the Vietnamese ecosystem, are still being studied.

For years, chemicals have been applied to pineapple plants to stimulate flowering and, thereby, to synchronize fruit development and maturation. The value of this technology is realized in more efficient harvesting of ripe pineapples. When the practice was begun in the 1930s, smoke from fires was utilized. Today, an ethylene-generating compound known as ethephon is sprayed on plants.

Phytohormones also can be used to stimulate flowering in several other economically important plants. Fruit trees such as apple, pear, and peach are treated with chemicals to increase the number of flowers. During the commercial production of seeds for biennials such as carrot, beet, and cabbage, GA is used to cause flowering in the first year. Similarly, GA can shorten the time it takes for conifers to form cones, speeding up breeding programs with these plants.

In some instances, it is advantageous to inhibit flowering An especially dramatic example of this involves sugarcane. Chemicals are routinely utilized to prevent sugarcane from flowering during the time it is accumulating sugar. It is estimated that yield increases averaging 1.3 tons per acre are obtained in Hawaii as a result of this practice. Inhibitors of flower formation also are used to overcome "alternate bearing" in tree crops, the alternation of heavy ("on" years) and low ("off" years) flowering, with corresponding effects of fruit production. In the extreme case of mandarin oranges, alternate bearing causes fluctuations in fruit yield ranging from forty to zero boxes per tree in successive years. GA is used in Spain and Australia to reduce flower formation during "on" years. Similarly, in the United States, apple flowers are thinned during "on" years with an auxin treatment.

Phytohormones also affect cut flowers As soon as a flower is removed from a plant, the natural process of senescence speeds up, in large part through the agency of the phytohormone ethylene. Obviously, if flower senescence is to be delayed or prevented, the logical strategy is to counteract ethylene's effect. Various methods have already been devised for just this purpose, in fact, and some of them may have economic potential in the cut-flower trade. One way of extending the life of cut flowers is to refrigerate them, slowing down the metabolic reactions that result in senescence. A second method involves the treatment of flowers with anti-ethylene compounds Silver ion in the form of a silver nitrate solution, for example, inhibits the action of ethylene. Or, senescence can be retarded with inhibitors that block specific steps in the chemical pathway that leads to the production of ethylene by a plant.

Phytohormones are used extensively to regulate fruits, from their earliest stages of development through harvest, and even during postharvest storage. In fact, the major commercial use of GA in the United States involves seedless table grapes. By treating young grape clusters with GA, one can reduce the number of berries per bunch, but obtain larger and juicier individual fruits. There is no question that the GA-treated product is superior to the untreated one. In this case, phytohormone technology can boast a true success story. (See the inside back cover)

By contrast, phytohormone technology applied to tomatoes yields a definitely inferior product. Nonetheless, tomatoes are routinely harvested in the United States before they are mature, often with mechanical picking devices. The green fruits are then treated with ethylene to simulate ripening. The rationale for using this technology is that savings in the cost of harvesting outweigh the extra value of vine-ripened tomatoes. Moreover, it is argued, added ethylene only accelerates a process—ripening—that normally is under ethylene's control. Unfortunately, this latter assertion is a ridiculous oversimplification of what is involved. After all, who hasn't bought a "red" tomato that actually tasted "green"?

Because of its role in abscission, ethylene can be used effectively when fruits are harvested mechanically. In commercial practice, plants are sprayed with ethephon or some other ethylene-generating chemical a few days before harvest.

This treatment initiates formation of abscission zones that, in turn, loosen the fruits. Harvest then becomes a simple process of agitation—either shaking of the stem or a blast of air, followed by collection of the detached fruits. Ethylene-aided mechanical harvesting is a common procedure for cherries, blueberries, grapes, and oranges.

Sometimes, fruit abscission needs to be prevented. For example, when grapefruits and oranges reach maturity, they naturally drop from the tree as a result of abscission. To prevent this process and its associated economic losses, trees can be sprayed with auxin or with a mixture of auxin and GA when the fruits are quite young. The combination of the two hormones accomplishes two purposes: auxin keeps mature fruits on the tree, GA keeps them fresh.

Once a fruit has been harvested, senescence proceeds rapidly. (Senescence also occurs when flowers are removed.) To prevent this, fruits are usually stored at low temperatures to slow down their metabolism, and they are kept in a controlled atmosphere. Often, the amount of carbon dioxide in the air is artificially increased in storage because carbon dioxide tends to counteract ethylene's stimulatory effect on senescence, through a mechanism called "competitive inhibition."

Promising Areas for Applications Research

Other strategies currently are being used to control plants with phytohormones, but the examples given here illustrate the major strategies in use. Much already has been accomplished, with considerable economic impact, but much more could be done if the appropriate technology were developed.

For instance, it is conceivable that a plant's own defense systems for preventing diseases caused by viruses and microorganisms could be accentuated with chemicals. One class of compounds responsible for disease resistance (phytoalexins) has already been identified, and research currently is under way on phytohormones to stimulate the production of phytoalexins. If this research succeeds, we might be able to improve a plant's response to disease through the use of chemicals.

A second promising area involves so-called "bioregulators," which are chemicals that stimulate plants to make valuable products. For example, ethephon is used commercially to increase the production of rubber by *Hevea*. Another group of bioregulators is now being evaluated for their effects on the production of terpenoids by plants.

Of course, the greatest potential impact of phytohormones involves "biotechnology," the concerted application of different scientific disciplines to plant genetics. While most accounts of biotechnology emphasize the contribution of DNA biochemistry, biotechnology would not be feasible without the use of phytohormones, especially of cytokinin, to produce whole plants with new characteristics starting from single, genetically altered cells. Even today, phytohormones play a crucial role when tissue culture is used for the rapid, clonal propagation of plants that have superior characteristics, and for the production of plants, such as strawberries, that are free of virus and fungal infections.

Tissue culture, in spite of its performance, is still a relatively new technique. The common method for micropropagation takes advantage of the established role of cytokinin as a shoot-growth regulator and of the fact that shoot explants from many species can be grown on a medium consisting of basal nutrients plus cytokinin. During the last few years at the Arnold Arboretum, research has been conducted to determine whether this same method can be applied to woody plants in general. While this research is still under way, it has already made clear that microprogation would be feasible with several groups of woody plants that are not now being exploited. For example, nearly half of the thirty-five families studied to date respond to cytokinin treatments in tissue cultures even though current micropropagation work with woody plants focuses on only two families—the

Rosaceae and the Ericaceae. On the other hand, it is also apparent that this technology will not work for all woody species. Obviously, we do not fully understand shoot growth in several species.

Before cytokinin was known, micropropagation of plants was not possible. Nonetheless, basic research on the internal control of shoot growth led not only to the discovery of cytokinin, but to a new and important practical use for phytohormones. Looking to the future, but reflecting also on fifty years of successful work with chemicals that regulate plants, we can feel almost certain that similar successes will occur. As we learn about phytohormones and discover new kinds, our ability to regulate plants will also increase As so often happens, botany and horticulture will complement each other.

John W Einset, a staff member of the Arnold Arboretum, is associate professor of biology in Harvard University His article on biotechnology at the Arnold Arboretum appeared in the Summer 1984 issue of Arnoldia *With the present article Professor Einset inaugurates a new column for* Arnoldia. *Called "Botany The State of the Art," the column will deal with practical application of botanical research to horticulture*

BOOKS

Garden Design: History, Principles, Elements, Practice, by William Lake Douglas, Susan R. Frey, Norman K. Johnson, Susan Littlefield, and Michael Van Valkenburgh. Derek Fell, principal photographer New York: John Wiley and Sons, 1984. 224 pages. $35.00.

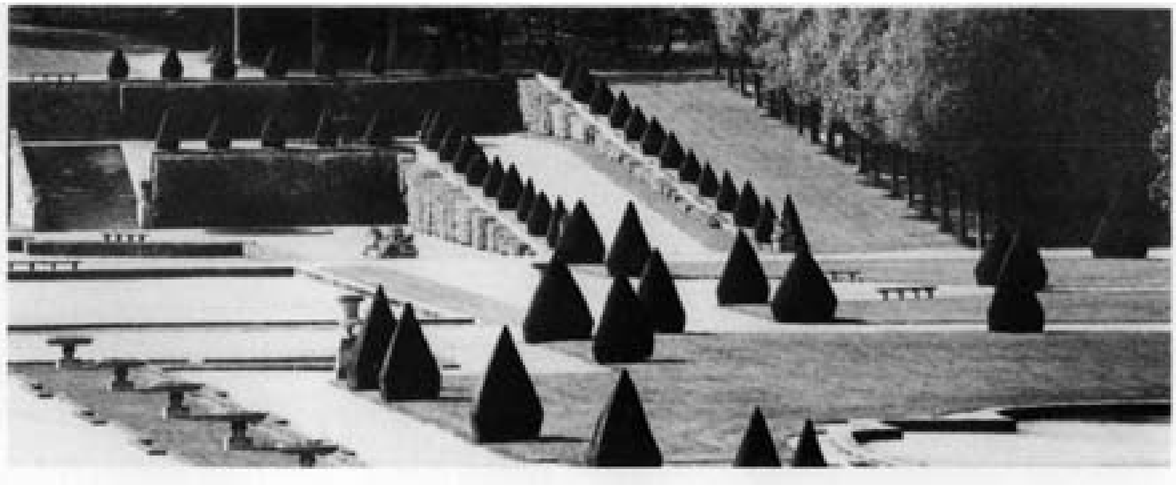
B. JUNE HUTCHINSON

This multiple-author book on garden design is introduced by John Brookes, as well-known landscape designer and garden writer from Britain. Brookes observes that we "dream up a garden to escape the rigors of our society," and, whether or not escapism is the reason people garden, it seems true that gardeners are dreamers. When the earth is frozen and winter snows end the growing season, the serious gardener simply turns to his plant books and catalogs and dreams his visions of the greater glories of the next year. He reads, plans, and anticipates until he can dig in the soil again. *Garden Design* will enrich winter dreaming.

A group of garden designers and writers put this book together in cooperation with the Publication Board of the American Society of Landscape Architects. Hundreds of color photographs, many of them the work of talented garden photographer Derek Fell, illustrate various garden styles ("The Parterre," "The Outdoor Room," "The Country Cottage," "The Oriental Style," and "The Wild Garden") and the varieties of built elements and embellishments that can be used to implement those styles (paving, turf and ground covers, gates and windows, and so on). From its dust jacket to the final photographs, this book is a rich source of ideas.

The first of *Garden Design*'s six chapters is a concise review of garden history. It gives the novice an organized and clearly written overview but will not disappoint the more knowledgeable garden-history reader. The latter will appreciate the author's balanced assessment of landscape gardening. Proper emphasis is given to the enormous impact of nineteenth-century plant collecting on garden design. The author (William Lake Douglas) succeeds in conveying to the reader the vitality and energy of the Victorian who tended his garden during the period when America's

The gardens at Vaux-le-Vicomte, France, considered one of the greatest achievements in the French landscape style It was designed by André le Nôtre in the seventeenth century. Photograph by Christopher Little. Used with the permission of Quarto Marketing, Ltd.



newly emerged middle class was embracing the idea of conscious garden design. Appropriate attention is also given to Andrew Jackson Downing's important role in American landscape design. Downing's widely popular books were the first publications in this country to emphasize garden design based on aesthetic principles and the concept of unity of house and grounds.

The essence of the three major chapters of the book ("Discovering Your Style," "A Sense of Place," and "Elements of the Garden") is simply stated: determine what you want in your garden and adapt it to the space you own by using the appropriate design elements. This is, needless to say, not so easily accomplished, and *Garden Design* will not take the place of professional help, nor will it guide the do-it-yourself gardener through the planning and installation process. However, instructions of creative design ideas accompanied by intelligent and precise captions can help the gardener take the first step toward understanding some general design principles and defining his own personal tastes. This book offers that kind of help in abundance.

Chapter Five, a showcase for the work of fifteen garden designers from the United States and four other countries, is a combination of text and photographs. Both the reader and the designers whose work is dealt with might have been better served if the two pages allotted to each designer had been devoted exclusively to photographs of his work, along with carefully crafted captions telling the reader what the designer's intention was and how he achieved the effects he sought through his choice of design elements. As it is, the two pages are a mixture of biography, direct quotes, and the author's assessment of the designer's work. Photographs allow a reader to see, and judge, for himself.

The last chapter, entitled "Garden Wisdom," is said to be a "necessary reference on all aspects of implementing the garden's plan," but it is much too short to be a useful reference. It does, however, impart some marvelous bits of advice that are essential to successful gardening. Take the first sentence of the last chapter, for instance: "The better part of garden wisdom has to do with patience. You simply cannot make a garden in a hurry" Garden dreamers understand patience. They will also understand and appreciate the rich ideas in *Garden Design.*

B. June Hutchinson is a writer and a landscape designer Her article on the umbrella pine was published in the Winter 1983–84 issue of Arnoldia

Plants that Merit Attention. Volume I—Trees, edited by Janet M. Poor. Portland, Oregon: Timber Press, 1984. 352 pages, 429 color plates. $44.95.

RAY ANGELO

Most illustrated tree manuals are guides to the identification of the trees that grow in a given geographic area. This handsome volume is different. It brings to the fore a number of neglected species, varieties, and hybrids of trees that would be worthy additions to parks and gardens, offering a generous selection of 143 taxa. Most of the taxa it treats originated in eastern Asia (60 taxa), North America (47 taxa), or the Europe–Mediterranean area (17 taxa). This selection reflects the target area for the manual, which is North America. Their visual appeal, seasonal interest, and tolerance of one or more environmental stresses were the bases for including taxa that are not often seen in horticultural landscapes.

This book will be a useful aid in selecting appropriate species and varieties of trees for given sites in yards, gardens, and parks. To consult it is to opt for novelty. The geographic location of a site will immediately eliminate a number of taxa from consideration. One appendix in this volume groups species and varieties according to their cold-hardiness. Only *Larix decidua* is hardy in USDA Zone 2 (northern Quebec, northern Ontario, etc.), for example, while ten species are hardy in Zone 3 (northern Minnesota, northern

Maine, etc). Additional appendixes list the species that do best in sites with special soil-moisture conditions (moist to wet, arid, seacoast) or shade. Still other appendixes list the species that are more or less tolerant of environmental stress and those that are resistant to pests and diseases (although the reader must refer to the text to find out *which* stresses, pests, and diseases).

Once the limitations of a site have been dealt with, the subjective preferences of the reader will narrow the choice further. Appendixes listing species on the basis of flower color, fragrance, conspicuous autumn foliage, and whether they are deciduous, coniferous, or broad-leaved evergreen will assist the reader who seeks a particular quality in the candidate tree.

At this point the reader will want to consult the body of the book, where entries are arranged alphabetically by scientific name. The color photographs are, perhaps, the most striking feature of the book, which as a whole is of a high quality. Albert W. Bussewitz, whose photographic and interpretive work at the Arnold Arboretum is well-known, contributed many excellent photographs. Of particular note for their beauty are his close-ups of *Asimina triloba, Davidia involucrata, Halesia monticola*, and *Sciadopitys verticillata* Although in most instances the three photographs provided for each taxon show its habit and distinctive attractions, the same feature is occasionally illustrated more than once (for example, *Gordonia lasianthus, Ilex* spp., *Oxydendrum arboreum*, and *Tabebuia chrysotricha*). For some taxa there is no close-up one could use to discern their distinguishing features (for example, *Prunus* 'Okame'). The photographs alone may be enough for making a final choice, but, if not, the text is available.

Many botanists, horticulturists, and nurserymen contributed to the text, among them Stephen A. Spongberg and Gary L. Koller of the Arnold Arboretum staff. Since this is not an identification manual, keys to species are not provided or appropriate. Comparisons with closely related species are almost entirely with reference to their landscape value. The text is divided into three categories for each entry: description, culture, and landscape value.

The descriptive material is not intended to separate the included species from related species, which would be done routinely in a taxonomic work, but rather to highlight features of interest and to provide basic information about each taxon: its size, habit, leaf size, fall color, flower color and size, fruit character and size, and bark aspect. An illustrated glossary in the Introduction defines botanical terms, most of which are used in the text. Terms relating to ovary position are not used in the flower descriptions, however, while other terms, such as "rotate," "globose," "glaucescent," and "stomata," are used in the text but not defined.

The section on culture gives more details about soil, light, and moisture requirements and on disease and insect problems that are merely touched on in the appendixes. This section also provides notes on transplanting and propagation that may require elaboration from a nurseryman once a tree has been chosen. For example, the note on transplanting *Sapium sebiferum* is simply, "Easy when young."

If at this point the reader is still weighing evidence before making a decision, the landscape-value paragraph might suffice to tip the balance. This portion of the entry certainly makes the most interesting reading. Noteworthy facts about the species (for example, *Prunus subhirtella* 'Autumnalis'—"One of the earliest Oriental cherries to bloom"), comparison with related species, and practical or historical notes (*Michelia doltsopa*—"A valuable timber tree in the Himalayas"; *Roystonea regia*—"Named for General Roy Stone") make up this section.

As a last resort, one might have to examine a living specimen before making up one's mind. To this end, the entry for each species includes a list of the arboreta, botanical gardens, and notable parks and gardens where one could observe the species. Useful as such a list is, many readers will find it impractical to visit most of the worthy institutions listed. In particular, the list could properly omit foreign arboreta and gardens, such as the Royal Botanic Gardens, Kew, Munchen Botanischer Garten, and Forest Parks–Ibaraki, Japan, which most North Americans could not readily reach.

Assuming that the reader has at last selected a species of tree for the site, the next question is where to obtain it. This book addresses the issue by listing nurseries across the continent (including their addresses and, for most, their telephone numbers) that carry one or more of the included species. Making this list even more valuable is an appendix that lists the species and varieties included and the code letters of each nursery that carries the particular species or variety.

Through this impressive volume, even someone who is not particularly seeking a tree to enhance a yard or a city park will become acquainted with a wide variety of trees that deserve more appreciation than they receive at present. This is the first volume of a series that will include shrubs and herbaceous plants. If the future volumes maintain the standard of quality represented here, they should be well received.

Ray Angelo, curator of the New England Botanical Club's vascular plant collections, is the author of Concord Area Trees *(1976) and* Concord Area Shrubs *(1978).*

The Book of Edible Nuts, by Frederick Rosengarten, Jr. New York: Walker and Company. 412 pages. $35.00.

GEORGE STAPLES

I have eagerly awaited Frederick Rosengarten's *The Book of Edible Nuts,* since I had often referred my students in economic botany to his excellent *Book of Spices.* The wait for Rosengarten's newest book has been worthwhile; like the earlier volume, *The Book of Edible Nuts* will become a standard reference for economic botanists, horticulturists, home economists, and producers of edible nuts. The thoroughly researched and well written text will make it an enjoyable acquisition for anyone eager to learn more about nuts—their botanical origins, historical uses, and current commercial production.

This is not a "how-to-do-it" book on the home cultivation of edible nuts. Given the diverse readership the book will attract, this limitation seems sensible. While the biology of each of the twelve major and thirty lesser-known species is discussed in general terms, there are no specific horticultural instructions in the text. The bibliography includes the titles of agricultural bulletins and other sources of information on growing edible nuts. Interested readers will have to scan the entire bibliography to locate these titles; cross-references from the text to the bibliography would have made this information easier to locate.

But the book offers a wealth of other fascinating information. Beginning with the accepted scientific name and a list of common names in eleven languages, each of the twelve major nuts is discussed with respect to its historical use, botanical status, and current commercial production. Each discussion concludes with selected recipes. The minor nuts are treated in less detail, but afford an appreciation of the diversity of nut crops worldwide and stimulate one's curiosity to learn more about such exotic species as the pili and the jojoba.

I found the descriptions of the historical use of nuts from different cultures and time periods fascinating; the breadth of this treatment alone attests to the amount of research the author put into his work. This section interweaves medicinal, artistic, literary, and archaeological information into a highly readable narrative. The botanical accounts are equally interesting, while the commercial-production figures are current and indicate the economic importance of nuts at the present time.

I confess to having felt some misgivings as I read the recipes offered for the various nuts, however; they presented a sterile uniformity reminiscent of a home economics text. I consulted the recipe acknowledgments and confirmed my suspicions. No family heirlooms mentioned here: all the recipes were contributed by commercial nut-production and marketing organizations. The reader with gastronomic inclinations will miss the homey touch of Polly's Perfect Pecan Pie or the challenge of a new interpretation of Gong Bao Ji (Kung Pao Chicken). I felt that the recipes were the book's weakest point.

The profusion of illustrations is a visual feast that compensates for the blandness of the recipes. Taken from diverse botanical, historical, and artistic sources, the black-and-while photographs correlate closely with every aspect of the text. Inclusion of international postal stamps featuring nut motifs adds an unusual twist, and brings philatelists within the scope of the book's readership. The endpapers are the only colored photos in the book. The inclusion of more colored illustrations would doubtless have increased the book's cost considerably.

Two minor practical shortcomings bear passing mention. Verbal descriptions of the historical place of origin and modern areas of cultivation for each species of nut presuppose that the reader is familiar with geography. Regretfully, many college undergraduates today lack sufficient command of this subject to relate place names to a world map. For those who would use this volume as a reference in teaching economic botany, inclusion of distribution maps would have been a welcome addition. The adventuresome might also wish for a list of mail-order sources of the exotic and lesser-known nuts, so as to order some for consumption at home.

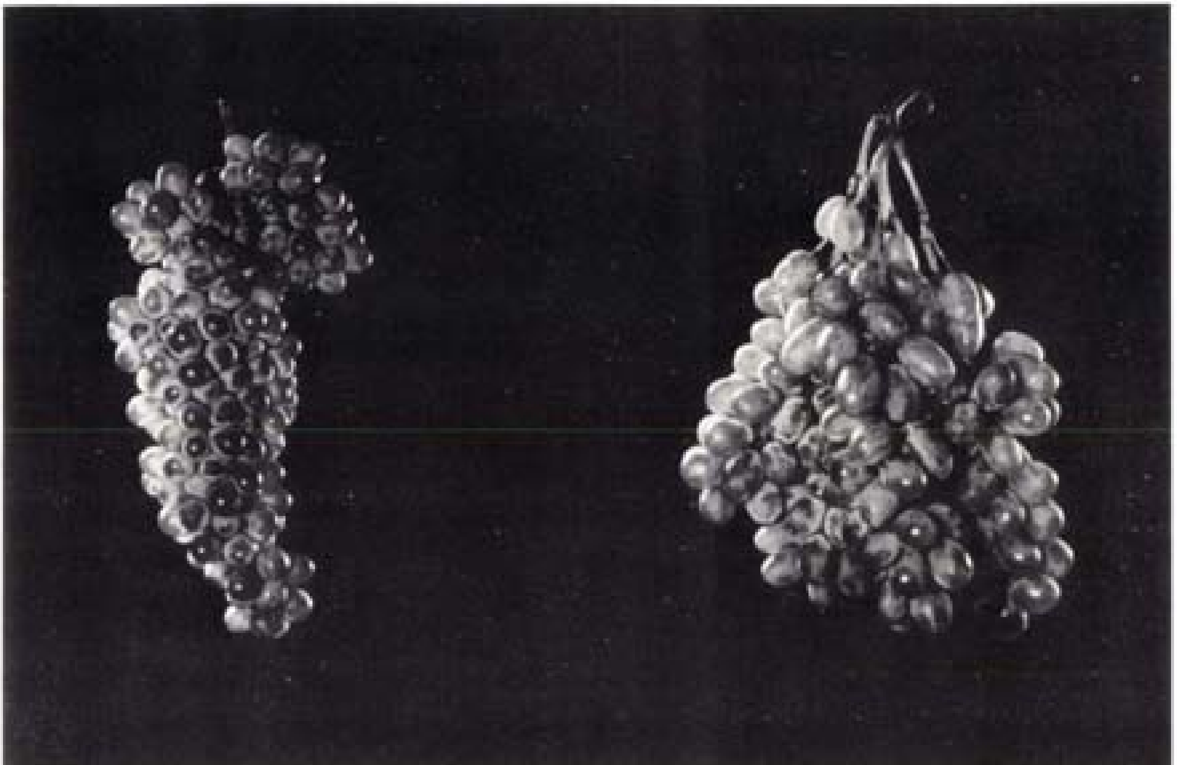
Perhaps these small improvements will appear in future editions of *The Book of Edible Nuts.* Better still, Mr. Rosengarten might keep them in mind for his next book. Whatever his choice of subject, the new work will be worth waiting for.

George Staples is a graduate student in the Department of Organismic and Evolutionary Biology of Harvard University.

Coming in *Arnoldia*

From a watercolor by Alice Tangerini, Smithsonian Institution

The inflorescence and fruits of flowering dogwood (*Cornus florida* L.), top, and of kousa (*Cornus kousa* Hance), bottom. In the fall 1985 issue of *Arnoldia*, Richard H. Eyde will explain why kousa has compound fruits and flowering dogwood does not.



The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanical research. The living collections are maintained as part of the Boston park system. The Arboretum is supported by income from its own endowment and by its members, the Friends of the Arnold Arboretum.

001274G
HALLAM J KOONS
RD 1
BOX 1190
BROOBECKS PA 17329