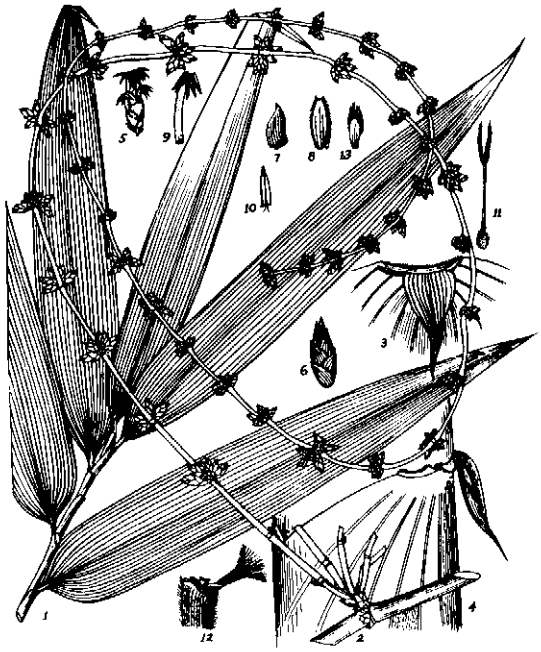


Gigantochloa verticillata: ***(1) Leafy twig. (2) Flowering branch, with tufts of pseudospikelets. (3) Culm sheath tip, dorsal view. (4) Same, lateral view. (5) Pseudospikelet. (6) Spikelet. (7) Lemma. (8) Palea. (9) Androecium. (10) Stamen. (11) Gynoecium. (12) Top of leaf sheath and base of leaf blade.***

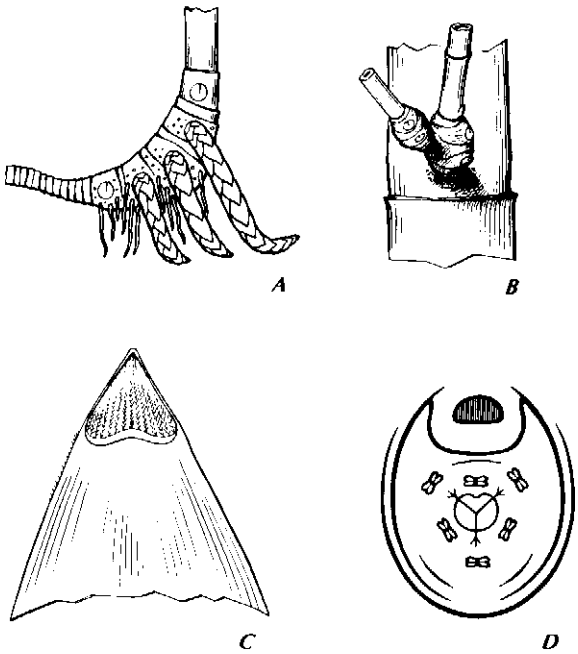
This species is one of seven economically elite bamboos given extended attention by McClure,[185] principally for its ranking among the top six of some one hundred species tested in a survey of pulping properties for paper production of bamboos available in the West. According to its "spectacular showing" in field tests in Guatemala (at Rosario in the Polochic Valley), *G. verticillata* could yield "more than 4 tons of oven-dry cellulose per acre per year from plants spaced at 7 × 7 m."[186] Groves have been established at Coconut Grove, Florida, Lancetilla, Honduras, and at Chocolá and Rosario, Guatemala.[187]

Guadua.

Guadua aculeata: 75–90 feet by 6 inches; *tarro* (Central America). Native from Mexico to Panama, the erect culms nodding somewhat at the tip, culm walls nearly 1 inch thick at the base of clumps that are fairly open, like all *Guadua* species, owing to the long-necked rhizomes. The uninflated nodes are conspicuously ringed beneath by an area of dense feltlike hairs that wear away in time. These stand out sharply on the bright green new culms, providing—along with typically short internodes—a characteristic identification for members of this genus. The culm sheaths are triangular, with tiny or absent auricles and a sheath blade that is small and persistent. The sheaths are quite persistent at basal nodes, deciduous above, thickly covered with hairs that are rich in itches to the touch. Single branches well armed with wicked thorns are usual at basal nodes; branches are typically two at midculm and several above. Heavy construction, fences, water pipes, and water vessels are among its commoner uses. Once abundant locally in a number of Central American countries, this species has been almost completely eliminated in many locations by excessive harvesting for building purposes without replanting.[188]

Guadua amplexifolia: 60 feet by 4 inches; *cauro* (Central America). Native Venezuela to Mexico. Short internodes, semisolid in lower culm. General uses in construction. "The least desirable of the listed species for the purpose, but much used in Nicaragua."[189]

*Guadua *angustifolia:* 90 feet by 6 inches; *guadua.* "Best known and most versatile species of the genus. . . . This bamboo apparently has a relatively high resistance to both rot fungi and wood-eating insects. It has been observed repeatedly that ordinary hardwoods used in conjunction with this bamboo have had to be replaced because of insect damage while the



Guadua angustifolia: ***(A) Rhizome with necks of new rhizome branches that help support the mother culm. (B) Midculm branch complement. (C) Tip of culm sheath, inner (ventral) view. (D) Diagrammatic cross section of a floret.***

bamboo still remains serviceable. The original untreated siding, of boards of this bamboo, in a forty-year-old plantation house at Pichilingue in Department Los Rios, Ecuador, was still in a serviceable condition in 1945, long after the hardwood floors had had to be replaced."[190] For an extended treatment of this species, see Chapter 5.

Guadua capitata: 20 feet.
Native to Brazil, used for crafts.[191]

Guadua inermis: 50 feet by 5 inches; *tarro* (Central America). Native from Mexico through Central America. Thick walled, even completely solid at the base, the wood around the lumen is honeycombed with many small lumina. Broadly triangular culm sheaths with well-developed but very fragile auricles are persistent below, deciduous above. Branches usually single, but as the culm matures extra branches develop from buds basal to primary branch, especially in the upper reaches of the culm. Lower culm node buds usually do not develop, are spineless if developed or bear an occasional short spine. Leaves, coarse in size and texture, partially deciduous in dry season. Uses include house and fence construction.[192]

Guadua latifolia: 26 feet by 3 inches.
Native to Brazil and Venezuela; used in crafts.[193]

Guadua paniculata: 32 feet by 1½ inches.
Native to Brazil; used in crafts.[194]

Guadua superba: 75 feet by 5 inches; *marona* (Brazil). Native to territory of Acre in western Brazil, occurring in large stands along the Purus River, a tributary of the Amazon, with specimen plants in the Botanic Gardens at Rio de Janeiro and Belem. Straight culms with short, 3–5 inches, internodes at base of culm, up to 16 inches or more in midculm. Nodes somewhat inflated with branches at nearly all of them. Culm walls ⅝ inch at base. Its wood was recommended above all bamboos native to the West—with the possible exception of *Guadua angustifolia*—for the manufacture of ski pole shafts when the supply of Tonkin cane *(A. amabilis)* from China was cut off during World War II.[195]

Guadua tagoara: 33 feet by 4 inches.
Native to Brazil; used in crafts.[196]

Guadua tomentosa: 15 feet by 1½ inches.
Native to Peru and Brazil; used in house construction.[197]

Guadua virgata: 26 feet by 2½ inches.
Native to Brazil; used for crafts.[198]

Guadua werbertauneri: 32 feet.
Native to Brazil and Peru; used in construction of houses.[199]

Melocalamus.

Melocalamus compactiflorus: 32–114 feet by 1¼ inches.
Native to Thailand, Burma, India. A climbing species used in crafts.[200]

Melocanna.

**Melocanna baccifera:* 70 feet by 3 inches *(Melocanna bambusoides, Bambusa baccifera).* In eastern Bengal and Burma, this species is one of the most common and useful bamboos, growing in groves extending nearly 700 square miles with estimated annual yields of some 300,000 tons in one area of its distribution. Rhizomes with necks up to 3 feet long form the open clumps that characterize *muli* bamboo, as this species is known in Bengal.

Its erect culms, nodding slightly at the tip, are durable, straight grained, with nonprominent nodes and internodes up to 20 inches at midculm. The lower half or more of the culm is usually without branches; above, the usual complement consists of numerous slender, subequal branches that snap off easily with a blow of a stick.

Easy to propagate from rhizome cuttings that produce vigorous clumps recovering quickly even

Melocanna baccifera: ***(1) Flowering leafy branch with stigmas emerging. (2) Leafless flowering branch with some flowers in anthesis. (3) Culm sheath, outside (dorsal or abaxial) view. (4) Upper part of pseudospikelet (lacking prophyllum). (5) Floret. (6) Lodicule. (7) Stamen. (8) Fruit, much reduced. (9) Fruit in longitudinal section.***

after clear-cutting harvests, muli bamboo yields 6,000–10,500 culms or 24,000–33,000 pounds of air-dry culms per acre per year. Much used for house construction, mats, and basketry, it is a chief source of excellent paper pulp in its native area. In pulping studies of one hundred bamboo species available in the West, *M. baccifera* ranked among the top six. The main material for economical housing in its area of densest growth, flattened-out whole culms of muli are woven into prefabricated walls as large as 10 by 30 feet.

Its flowering cycle has been variously estimated, on the basis of conflicting reports, at thirty-five to sixty years. The fruit produced, thick walled and pear shaped, is the largest of any known bamboo—nearly 3 inches in diameter—and the seed germinates even while still hanging on the branch. This species is one of seven examined at some length by McClure.[201]

"It is said that the fruits of *M. baccifera* in northeast India and Burma are 'readily devoured by cattle, elephants, bison, rhinoceros, deer, pig, and other animals.' Admittedly, *Melocanna* has an unusually large fruit and (a quite exceptional feature in the grasses) it bears viviparous embryos which depend for early nutrition on the swollen starchy fruit wall or pericarp rather than upon the endosperm tissue within."[202]

Language reflects use: Eskimo peoples have twenty-eight words for snow. McClure lists thirteen different local names for this species: *terai* bamboo, *muli, metunga* (Bengali), *tarai* (Assam), *wati* (Cachari), *artem* (Mikir), *turiah* (Naga), *watrai* (Garo), *kayoungwa* (Magh), *kayinwa* (Burmese), *paia, taria, pagutulla.*[203]

Nastus.

Nastus elongatus: 65 feet by 1¼ inches.

Native to Madagascar; used for paper pulp and small crafts.[204]

Ochlandra.

Ochlandra capitata: 33 feet by 1–2 inches.

Native to Madagascar; used for houses, paper pulp, baskets, and musical instruments.[205]

**Ochlandra travancorica:* 6–20 feet by 1–2 inches.

"Elephant grass," as this species is commonly known, occurs in vast stands in the South Travancore and South Tinnevelly mountains (India) from 3,000–5,500 feet. It grows in impenetrable tracts that even elephants cannot enter, extending for many miles, often to the complete exclusion of all other vegetation. The culms are thin walled and straggling, sometimes supported by the dense clump; internodes are grey green and rough, nodes slightly inflated. The immense exuberance of its distribution and the maximum length of the cellulose fibers of the culm tissue—9 mm—(roughly ⅓ of an inch) are the most remarkable properties of the species in relation to possible human use. "Its culms . . . yield, by the sulfate process, a pulp containing 92.66 percent alpha cellulose, with an ash content as low as 0.2 percent, characteristics indicating . . . possibilities for rayon manufacture."[206] A mill equiped to produce 5 tons of rayon and 1¼ tons of transparent paper daily was established in Travancore in the mid 1940s to exploit the huge stands of *O. travancorica* there.

Ochlandra travancorica: ***(1) Leafy flowering branch. (2) Culm sheath. (3) Pseudospikelet. (4) The one-flowered spikelet, with two bracts still attached, and the flower in anthesis. (5, 6) Bracts. (7) Lemma. (8) Palea. (9) Lodicules. (10) Stamen. (11) Gynoecium. (12, 13) Stigmas, much enlarged. (14) Fruit, still surrounded by lemma, palea, and bracts.***

Field studies are needed, according to McClure, "to determine whether *O. travancorica* is a desirable silvicultural subject, in relation to the high- and sustained-yield requirements of a paper mill. The reputedly short flowering cycle and subsequent death of culms may, if true, be a disadvantage to its cultivation as a source of cellulose pulp. However, the plant apparently fruits freely, and there is the possibility that the development of a seedling progeny would be sufficiently rapid to restore the stand to a productive state by the time the dying flowered culms had been harvested—if the stands maintained are of sufficient extent to provide several years' supply from a single progressive-harvesting cycle. Flowered culms of

Dendrocalamus strictus are usable, and give a slightly enhanced cellulose yield of undiminished quality after standing in the field four years."[207] This species was successfully introduced in 1951 by the USDA at the Mayaguez, Puerto Rico, Experiment Station.[208]

Oxytenanthera.

Oxytenanthera abyssinica: 48 feet by 3 inches;

arkai, chommel. Native to Ethiopia, Angola, Gold Coast, Malawi. Used for house construction, farm equipment, basketry, and production of paper pulp.[209]

Oxytenanthera albociliata: 32 feet by 1½ inches.

Native to Thailand, Burma, Laos; used for basketry, farm equipment.[210]

Oxytenanthera nigrociliata: 50 feet by 5 inches;

poday (Andaman), *washut* (Garo), *bolantgi bans* (Orissa), *lengha* (Java). Native to Thailand, Burma, Indonesia, Malaysia, India. General uses for farm equipment and furniture construction.[211]

Pseudostachyum.

Pseudostachyum polymorphum: 50 feet by 1 inch;

filing (Nepal), *purphiok, paphok* (Lepcha), *wachall* (Garo), *bajal, tolli, ral* (Assam), *bawa* (Burmese). Native to India (eastern Himalayas, Assam), Sikkim, and upper Burma. Thin-walled culms with long internodes are used for lath, matting, withes for tying frames of houses, and small crafts.[212]

Schizostachyum.

Schizostachyum hainanense: 100 feet by 1 inch;

tang chuk (Chinese). Native to Hainan Island. Thin-walled culms with long internodes are used for lath, matting, crafts.[213]

Schizostachyum lima: 25–30 feet by 1 inch;

bolo, bagacay. Native to Philippines, Luzon, and Davao. Culms have very long internodes, thin walls. Uses include matting, shingles, and lathing.[214]

**Schizostachyum lumampao:* 60 feet by 3 nches;

lakap (Bosayan), *tamblang* (Bila-an). Native to the Philippines, Luzon. Culms are very straight, thin walled, with some 40 feet to first branch. Used to make boards and shingles.[215] This is an extremely useful species deserving wide distribution in Latin America. Its thin walls permit weaving of the entire culm after opening it out flat and removing nodal tissue. See p. 16, "airplane skins."

Sinarundinaria.

**Sinarundinaria nitida:* 20 feet by ¾ inch

(Arundinaria nitida).

Native to Szechuwan and Kansu Provinces of China, this clumping species is reportedly hardier in England than many of the running, temperate bamboos. In its native region it grows up to 10,000 feet on the northern slopes of mountains. The slender dark purple culms are there used locally in basketry, sieves, fencing, and light construction. Classed by some botanists as an *Arundinaria,* Lawson lavishes on this species his most raptured superlatives: "*A. nitida* is without doubt the most graceful of all the Arundinaria family . . . in some countries known as the 'Queen of the Arundinaria.' The leaves dislike direct sun, and the margins will bend towards midrib, forming a channel, at the first touch of brilliant sunshine . . . As soon as the clouds again cover the sun, the leaves will once more open out to their graceful normal shapes. . . . Grow this dainty bamboo where there is some partial overhead cover . . . The slender purple canes are densely packed into a closely circumscribed clump. Their lower halves are bare, and rise almost vertically, but at the higher levels, the wealth of foamy foliage bends them outwards in a filmy mass. The individual leafed branchlets are so fine that the foliage gives an impression of floating in the air. The thin whiplike new canes sway above the mass of foliage below."[216]

Named *nitida* ("shining" or "lustrous") by Freeman-Mitford, now commonly known as "fountain bamboo," the species was introduced into Russia, thence to England, by seed in the 1880s. Believed by the Chinese to flower once in a century, that rare moment may at present (1984) be returning. Lawson states that no flowering outside China has ever been recorded.

Culms, light to deep purple, are without branches the first year, then four to five per uninflated node, 6 inches apart, in the second season with more branches and twigs growing as the canes mature. The pale purple culm sheaths, hairy and often as long as the internode they cover, are thin textured and persistent. Small leaves, 3½ inches by ½ inch, are paper thin and bristled at the edges—a brilliant green above, matt green below. Delicate in appearance, the leaves weather severe winters with minor leaf scorch. Strongly recommended as an excellent garden or tub plant for northern locations because of its hardiness, the striking beauty of its culm and foliage, and its tendency to stay put where you put it.[217] More on this species under *Thamnocalamus spathaceus,* "umbrella bamboo."

Teinostachyum.

Teinostachyum dullooa: 20–30 feet by 1–3 inches;

dullooa (Assam), *paksalu, pogslo, wadroo, gyawa.* Native to India (Assam) and Vietnam;

thin walled with internodes up to 40 inches long. Used for lath, matting, and crafts.[218]

Thamnocalamus.

Thamnocalamus falconeri: 30 feet by 1¼ inches

(Arundinaria nobilis, Arundinaria falconeri, Bambusa floribunda).

Native to N.E. India, in the Himalayas, introduced in 1847 into England. The pliable, thin-walled canes are much used for fishing rod manufacture and basketry. Distinctive identifying characteristics to note include the tiny, paper-thin leaves, not visibly tessellated, and the nodes, which are stained a purple brown, especially noticeable on older canes. The species grows in a tight clump of stiffly erect canes, surrounded at the edge by culms curving gently outwards, with dense foliage beginning almost at the base on many delicate branches and twigs.

"Noble"—the specific given by Freeman-Mitford, who called this bamboo *Arundinaria nobilis*—describes the tall canes well. Olive green when young, dull yellow when old, the new culms appear from mid to late May on. The culm sheaths, pale crimson fading to a dull purple shade, are frail and deciduous, and truncated at the tip. The nodes, roughly 10 inches apart, are rather prominent, and stained about a half inch on either side with the characteristic brownish-purple ring, more pronounced in sunnier locations. The species is not invasive; it expands slowly in a clump. "Makes an excellent ornamental in shady spots in warmer gardens, and is especially recommended as a tub species for the conservatory."[219]

**Thamnocalamus spathaceus:* 14 feet by ½ inch

(Arundinaria murielae, Arundinaria sparsiflora, Fargesia spathacea, Sinarundinaria murielae).

A hardy, although clumping, Chinese bamboo from the mountains of western Hupeh Province, growing at some 10,000-feet elevation. First collected by European botanists in the late nineteenth century, live specimens arrived in Harvard's Arnold Arboretum in 1910 sent by E. H. ("China") Wilson, who called it the handsomest bamboo he'd ever seen. From Harvard, they were sent to Kew Gardens outside London in 1913 to become the most widespread of the ornamental bamboos in Europe, commonly known as "umbrella bamboo."

The culms are bright green during their first season, maturing gradually to a deeper green and finally a dull yellow. Deciduous pale green to cream color culm sheaths, bristled with fine hairs at the base, fade to straw. Late-shooting culms may keep their sheaths until the following spring. Uninflated nodes, some 6 inches apart, bear three to four branches the first year, which become more numerous as the culm matures. Leaves, 3–4 inches by ½–¾ inch, are light pea green above, duller pale green below. Long

Thamnocalamus spathaceus: *rhizome system and culm tips.*

considered an *Arundinaria,* this species began flowering in Denmark in 1975, revealing its true identity as a *Thamnocalamus.*

In an interesting article detailing the century of botanical confusion that surrounded this popular species, Soderstrom permits the nonbotanist to savor something of the slow drama of taxonomy.[220] The related "fountain bamboo," named *Arundinaria nitida* by Freeman-Mitford in 1895 and reclassified as *Sinarundinaria*—a new genus erected in 1935 by the Japanese botanist Takenoshin Nakai—last flowered in 1886. According to oral tradition among the Chinese of its native region, the species has a flowering cycle of about a hundred years. Soderstrom suggests that when flowers become available for examination, *A. nitida,* the "queen of *Arundinaria*" will reveal itself to be *Thamnocalamus nitidus,* the fifth member of this limited Sino-Himalayan genus to be described since Munro established it in 1868. Both umbrella and fountain bamboo are sympodial, clumping species, unique in their hardiness as well as their acknowledged loveliness. This species is reported by Lawson to grow in the north of Scotland. Both fountain and umbrella bamboo are named for their similar dense clump

formation, in which the thin canes, burdened with foliage, arch out at the edges, trailing branches groundward in a fountainlike manner.[221]

Thamnocalamus spathiflorus: 15 feet by 1 inch *(Arundinaria spathiflora).*

Native to the western Himalayas of India, Nepal, Sikkim, and Bhutan at elevations of 7,000–10,000 feet. First described by Munro in his 1868 monograph on the bamboos as the type species of a new genus that he then established. "He derived the generic name from *thamnos,* meaning 'shrub,' and *calamus,* meaning 'reed,' since the bamboo formed small, brushlike clumps of densely packed culms . . . [This species] occurs in the undergrowth of forests composed of deodar cedar, silver fir, Himalayan spruce and oak . . . *Thamnocalamus* can be characterized as clump forming with relatively narrow culms of low stature. A number of other features distinguish the genus botanically: more-or-less equal branches borne above the node line, rhizomes sympodial, spikelets many flowered and arranged in racemes enveloped in spathelike structures, and flowers with three stamens and three feathery stigmas."[222]

Introduced into England in 1886, this species is delicate in appearance and not terribly hardy in fact: to be grown in areas sheltered from cold winds. Like its near relative, the fountain bamboo *(Sinarundinaria nitida,* whose imminent flowering will probably reveal it to belong to the genus *Thamnocalamus),* its leaves curl in full sun, open again when shaded. "At one time in India this bamboo supplied the bulk of the raw material used in the manufacture of walking sticks, umbrella handles, pipe stems, and numerous other articles."[223]

Its erect culms, bright to pale green distinguished by a shade of purple pink, inclined to zigzag, are marked with a blue-white bloom the first season. Sheaths are deciduous, hairy at the base, some 7 inches long and quite glossy on the inner surface. Inflated nodes, marked by a white ring on their lower portion, brown above, bear two to three branches colored a pale pink purple. Leaves, paper thin and fringed with tiny bristles, are finely tessellated, up to 6 inches by ½ inch, pale green above, and a flat grey green below. Forms tight clumps; "extremely handsome and elegant . . . an excellent specimen plant for a sheltered spot and a good tub plant."[224]

Thyrsostachys.

Thyrsostachys oliverii: 50–80 feet by 2–2½ inches;

thanawa (Burmese), *maitong* (Kachin). Native to India and upper Burma to 2,000 feet. Culms "greatly in request" (Gamble) for general construction purposes. Also used for paper pulp and farm equipment.[225]

Thyrsostachys siamensis: 25–40 feet by 1½–3 inches;

kyaung-wa. Native to Thailand and Burma. Close clumped, unbranched for 15–20 feet, short, 8 inches, regular internodes on the culms supporting thick, feathery foliage. "One of the two most beautiful Burma bamboos, and by far the finest for planting at lower elevations. It is cultivated from end to end of the country, found almost always near Buddhist monasteries. The culms are much used for umbrella handles and make ideal vaulting poles."[226]

PSEUDO BAMBOOS

A number of plants, although not classified by botanists as bamboos, resemble them in appearance, serve similar uses, and are considered bamboo by the people who coinhabit their terrain.

**Arundo donax:* 20 feet by 1 inch.

One of the most widespread of the pseudobamboos is *Arundo donax.* Native to Europe, introduced by the Spanish in the New World in the sixteenth century, *carrizo* or *caña de Castilla*—as the plant is called in many areas—grows as far north as Texas and is broadly used throughout the American tropics. The pale green internodes are shiny and thin walled but durable. Uninflated nodes usually bear a single branch of sparse pale green leaves, leathery and broad. Frayed portions of the culm sheath remain on cured culms which mellow to a rich yellow brown, darkening with the years.

Still sound after over a century in walls of *bajareque* construction (see Chapter 9, pp. 259–260), carrizo can also be seen in ceilings forty to fifty years old, outlasting some of the wooden rafters with which it is alternated to support the tiles. Widely used for basketry and mats, occasionally as spools in textile industries, carrizo also forms the shell for skyrockets *(cohetes),* an integral part of any Latino fiesta. *Rondadores* (panpipes) and simple shepherd's flutes are other ancient uses of *Arundo donax*—which also provides reeds for saxophones. The erect or sometimes slightly curved culms of "Spanish cane" are cultivated as a garden ornamental as well.[227]

**Gynerium sagittatum:* 25 feet by 1¼ inches.

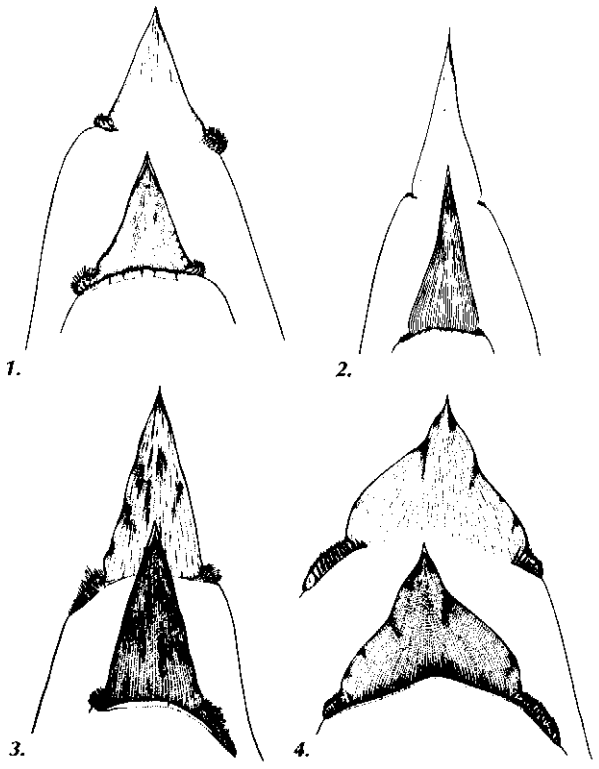
Grows usually at low elevations in tropical America. The plant is covered with persistent sheaths. Beneath these, the culm is sticky and pale green to cream colored when fresh, the internodes filled with pith that shrivels when dry. From the uninflated nodes at midculm the single branches, growing nearly parallel to the culm, bear long narrow leaves that cluster also at the culm's tip. From a distance, the plant resembles sugarcane. Its uses include basketry and construction of houses, in which it serves for partitions, horizontal lathing in the framework of

bajareque walls, and roof "sheathing," which supports the tiles and is supported by rafters. The name of the plant varies from country to country: *caña arava* in Cuba, *caña blanca* in Panama, *caña amarga* in Venezuela, *vara de tusa* in El Salvador.[228]

TAXONOMY

With some seventy-six genera and twelve to fifteen hundred species of bamboo worldwide, each possessing quite different tastes in climate and soil, quite distinct physical properties making different species suited to different tasks, a precise way of determining their classification is obviously imperative. Taxonomy—from the Greek *taktos,* meaning to order or arrange—the science of this classification of plants and animals according to biologically related groups was established in the West by Linnaeus (1707–1778). The problem with bamboos is that the flowering portions necessary for precise identification are not usually available. When bamboo flowers, vegetative production creeps or ceases so leaves and culm sheaths are generally not present. McClure's solution to this botanical impasse was to establish a living garden.

> Familiarity with the living plants is an essential preparation for sound taxonomic work on this group. To achieve this, one must be able to return again and again to the same plants to make notes, take specimens at different stages of development, assemble a complete array of structures essential to identification. This conviction led me to bring together living plants at Lignan University, and to date nearly six hundred introductions have been made. Every introduction is given a distinctive number, plants are tagged, their position in the garden plotted. A record is kept of the source of each plant, date of introduction, vernacular names, uses, and other pertinent observations. Herbarium specimens are made of all available structures, and a record kept. Usually neither culm sheaths nor flowers are available at first. As these structures appear, they are collected and recorded. As the picture of the plant becomes more complete, its identity becomes clearer. The identity between different numbers becomes apparent, and, finally, I have not only an adequate idea of the range of variation of each species, but I know its geographical distribution as well.[229]



***Bambusa* midculm sheaths, the outer (dorsal) view above, the inner (ventral) view below (× ⅕).**
***(1)* B. tuldoides. *(2)* B. textilis. *(3)* B. pervariabilis. *(4)* B. tulda.**

Collecting specimens for identification.

For those who wish to dig into the matter up to their muddy elbows, collecting bamboo specimens becomes important at some step along the bamboo path. For the less active reader, also, curious what a botanist must go through in the field, we include the following suggestions. They were prepared by McClure for the Smithsonian Institution, which has the largest collection of dried bamboo specimens in the United States and one of the largest in the world.

Among the twelve to fifteen hundred species of bamboo, many that may look alike have vastly differing properties. The importance of precise species identification is therefore obvious; this is the procedure for obtaining it when confronted with an unknown bamboo in the field.

It is important to collect all bamboos, in flower or not. A properly selected, labeled, and preserved series of the vegetative structures listed below will be entirely adequate to identify a given bamboo. Reproductive structures are traditionally required for identifying bamboos and many other plants, but vegetative structures have proven to be a practical —and necessary—basis for field identification of bamboo owing to the infrequent flowering of many species.

Never mix material from two distinct plants under the same number, assuming they represent the same bamboo. Two or more different bamboos may grow so close together they appear as one plant. Exacting care is needed, as mixtures cause much confusion.

Make specimens for permanent preservation. Fragmentary specimens collected hastily, "just for identification," frequently turn out to represent new species or new records. Such specimens, often too fragmentary to be identified with confidence but too intriguing to discard, may be more a hinder than a help. So make specimens of each bamboo as complete as possible. Represent omitted or fragmented structures by sketches or photos and notes illustrating them whole. Seedlings and small plants may be collected entire. For all plants, the following structures are essential:

CULM SHEATHS. At least two complete and in good condition, preferably from midculm nodes of mature-sized culm. Mark with node number (counting from base) and collector number. Press flat. If too large, cut or fold to 10 by 15 inches or less. Keep all parts. If sheath will not spread without breaking, do not press. Let it roll up and tie paper over tip to protect fragile parts. Persistent sheaths may be left attached to culm section of sheath length and dried. Young shoots slender enough to dry readily by artificial heat should be sent in whole. The more complete the series of culm sheaths, the more reliable the identification. Represent the whole series as fully as circumstances permit.

LEAFY TWIGS. Include big and little leaves, young and old, healthy and diseased (if any). *Press promptly* before they curl in driers thick and soft enough to prevent crinkling. At first change of driers, arrange leaves so that some show upper surface, some lower.

BRANCH COMPLEMENT. At least one typical example from middle of series on culm of mature size with at least 12 inches of culm itself. Cut branches 2 inches from base. Mark node and collector number on culm. Split and discard culm half opposite branch if space is limited. Additional specimens from lower and upper culm are desirable but not necessary.

CULM NODES AND INTERNODES. Best represented by segment of mature culm including nodes four and five above ground level and the internode between, marked with node number and collector number. Cut any branches back to 2 inches. Segment may be split to save space or speed drying.

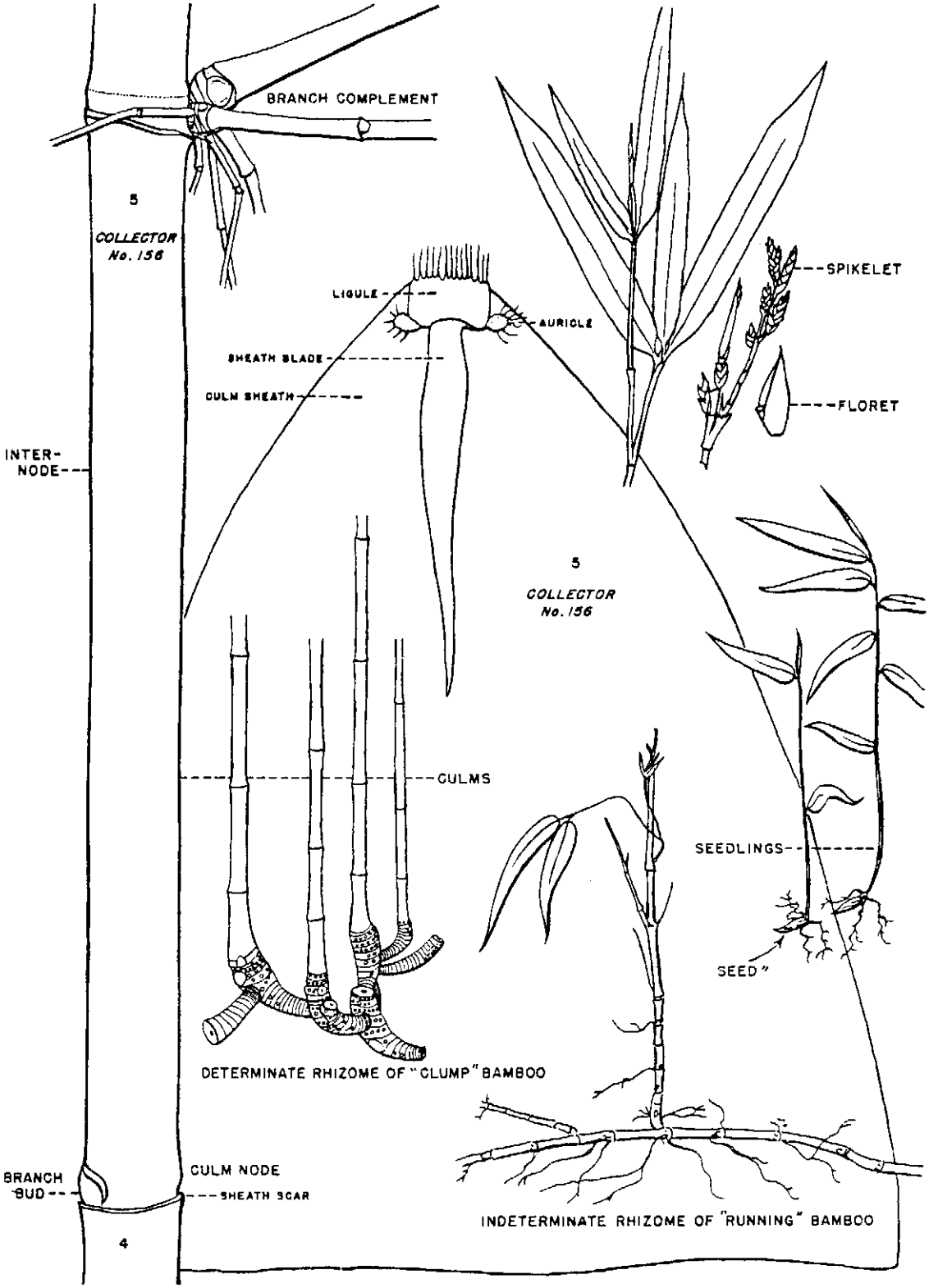
RHIZOME. At least one complete example; if space permits, two or more rhizomes attached together to show typical branching habit. Wash and trim roots. Mark or tag with collector number. A sketch or photo, showing proportion and branching habit, will serve in place of actual specimen if facilities are limited.

FLOWERING BRANCHES. If present, collect longest possible series to show range of variation in habit, leafiness, stages of development, and so forth. Seek fruits and put some in a small folded paper to call attention to them and prevent their loss. Mature fruits usually fall very promptly. *Distribute specimens thinly between thick driers; change often to dry promptly* and prevent breaking up of spikelets. Unless absolutely necessary to save paper, do not pile dried specimens together, but keep in original folders to avoid serious damage to spikelets. Put single example of long, fragile spikelets in separate envelope of folded paper to ensure floret count.

SEEDLINGS. Special search should be made under and near flowering bamboos. Seedlings should be given a separate collector number from that of the supposed parent plant, but cross-reference should be made in notes, setting forth evidence of their supposed relationship. The "seed" still attached to very small seedlings is sufficient for identification if kept intact.

HANDLING BULKY SPECIMENS. Node and internode, branch complement, rhizome, and culm sheaths that cannot be pressed flat—especially specimens that come from large plants—should always be marked properly with node number and collector number on clear surface, durable cloth tag, or tough paper. Do not put bulky specimens in press with leafy or flowering twigs. Dry separately and promptly in sun or over fire. Keep in open air as much as possible; don't wrap or store in closed container until thoroughly dry.

MINIMAL NOTES. These should include: clump and culm habit, maximum height and diameter of culms (at base), length and diameter of fifth internode, length and number above ground of longest internode. (Make measurements on largest available



Collecting specimens.

specimen; estimated measurements should be designated as such.) Location should be described or sketched in relation to nearest inhabited place and/or point shown on available map so that it can be found again. Habitat, local names (dialect), local uses, date collected, collector's field number, and reference to photos, sketches, and so on, if added, are kept in a separate book.

PHOTOGRAPHS. These are useful to show habit and proportions of typical clump and the following features, particularly if time is insufficient for making specimens of them: branch complement, culm node and internode, and the rhizome habit and branching. Habitat pictures are useful if the names of the associated plants are recorded or if ecological features are clearly shown. Be sure to correlate photographic numbers with collector numbers at the time the picture is taken.

SKETCHES. The simplest diagrammatic sketch may be used to represent structures called for above but which, for whatever good reason, must be omitted from the specimen.[230]

PRIMARY GENERA OF BAMBOO

The name after the genus is that of the botanist who established it.

1. *Apoclada,* McClure. Some four species, native to Brazil.
2. *Arthrostylidium,* Ruprecht. Around thirty-five species, all native to tropical America; generally not important economically.
3. *Arundinaria,* Michaux. Over one hundred species, mainly southeast Asia and adjacent islands, Japan to Madagascar. In Africa, two possible species; two from the United States, including the genus "type," *A. gigantea.* Greatest concentration in Japan.
4. *Aulonemia,* Goudot. Some twenty-four species from Brazil to Mexico.
5. *Bambusa,* Retzius. Some eighty-five species, all native to Old World tropics, southeast Asia principal center of distribution. Closely related to *Dendrocalamus* and *Guadua.*
6. *Cephalostachyum,* Munro. Three species in India and Burma area.
7. *Chimonobambusa,* Makino. Some five species native to China and Japan. A hardy genus named for its rare habit of shooting in late fall or winter (Greek *cheimōn,* meaning "winter"), famous for "square-stem bamboo," *Ch. quadrangularis.*
8. *Chusquea,* Kunth. Some ninety species, all New World, native to mainland and islands, Mexico to Argentina and Chile. Grows to 12,000 feet, probably widest altitude range of any bamboo genus. Slender, pithy, sometimes solid culms have a constellation of branch buds in place of one bud characteristic of all other genera.
9. *Colanthelia,* McClure and E. W. Smith. Some seven species in Brazil.
10. *Dendrocalamus,* Nees. Some thirty species, all large tropical plants from southeast Asia, mainland and islands. Many locally important for construction and crafts. *D. strictus* is the world's most studied and most drought-resistant species, forming—with *Bambusa arundinacea*—the basis of India's bamboo paper production.
11. *Dinochloa,* Buse. Some four species form this small southeast Asia genus of bamboos equiped to climb other plants. *D. andamanica* is the longest world bamboo, with a culm 100 yards long.
12. *Elytrostachys,* McClure. Two species with distribution centered in Colombia and Venezuela. Likes riverbanks from 200 to 1,500 m in elevation (650 feet–5,000 feet).
13. *Gigantochloa,* Munro. Some thirty large tropical species from southeast Asia, mainland and islands, Burma, Indochina, to Malay Peninsula and Philippines. Many important where plentiful for building and daily use. Java species were introduced there.
14. *Guadua,* Kunth. Some thirty species, all native to Central and South America except *G. philippinensis. G. angustifolia* is probably the world's most durable bamboo.
15. *Melocalamus,* Bentham. Monotypic, that is, a genus with one species, *M. compactiflorus* is found from east Bangladesh to northwest Thailand. Related to *Dinochloa.* Fruits germinate while still on parent plant. Used in basketry.
16. *Melocanna,* Trinius. Some three species include "type" *M. baccifera,* occurring in vast (700 square miles) natural groves in Burma and India. Much used for building, woven ware, and paper pulp.
17. *Merostachys,* Sprengel. Over twenty species, mainly from Brazil, with one species each in Paraguay, Peru, Belize, and Guatemala. Internodes up to 36 inches in one Brazilian species (*M. argyronema,* 10–12 m by 5 cm) used for flutes, resonance tubes beneath marimba keys, and basketry.
18. *Myriocladus,* Swallen. Twenty species in

Venezuela between 1,025–2,500 m (3,400–8,350 feet).

19. *Neurolepis,* Meisner. Some nine species are found between 2,900–4,500 m (9,650–15,000 feet), in Colombia, Venezuela, Ecuador, Peru, and Trinidad. *N. elata,* from the Andes, is distinguished by leaves 5 m long by 0.5 m wide (16½ feet by 20 inches)—the largest known among bamboos.
20. *Ochlandra,* Thwaites. Some seven species in India, Sri Lanka, Madagascar, and southern India. *O. travancorica* (q.v.), "elephant grass," is the most important economically, for paper pulp.
21. *Oxytenanthera,* Munro. Some five species in Africa and Asia, from Angola to Java. *O. abyssinica* most used in Africa; *O. nigrociliata,* in Indonesia.
22. *Phyllostachys,* Siebold and Zuccarini. Some forty species, mostly native to central and southeast China, a few in areas to immediate south. Most thrive in moist, warm-temperate climate.
23. *Pleioblastus,* Nakai. Some twenty-six species, mainly native to Japan.
24. *Rhipidocladum,* McClure. Some eleven species found from Mexico to Bolivia and Brazil.
25. *Sasa,* Makino and Shibata. Some thirty species native to Japan and mainland of north Asia. *S. kurilensis* (from the Kuril Islands northeast from Japan) is the most northern bamboo, the only species native to Russia.
26. *Schizostachyum,* Nees. Some forty species, from tropical and subtropical south China, through Southeast Asia (mainland and islands including Hawaii) to Madagascar. Thin walls in all species, and "by the siliceous, whetstone-like surface you can tell a *Schizostachyum* in the dark."[231]
27. *Thamnocalamus,* Munro. Some four species of this Sino-Himalayan genus include hardy though clumping *Th. spathaceus,* "umbrella bamboo," most widespread European ornamental. West China through Nepal to India.
28. *Thrysostachys,* Gamble. Two species, from India, Thailand, and Burma.
29. *Yushania,* Keng. Two species, from Mexico to Honduras. Known locally as *otate* in many places and much used. This genus is also placed by Lessard (1980) in Taiwan and the Philippines.

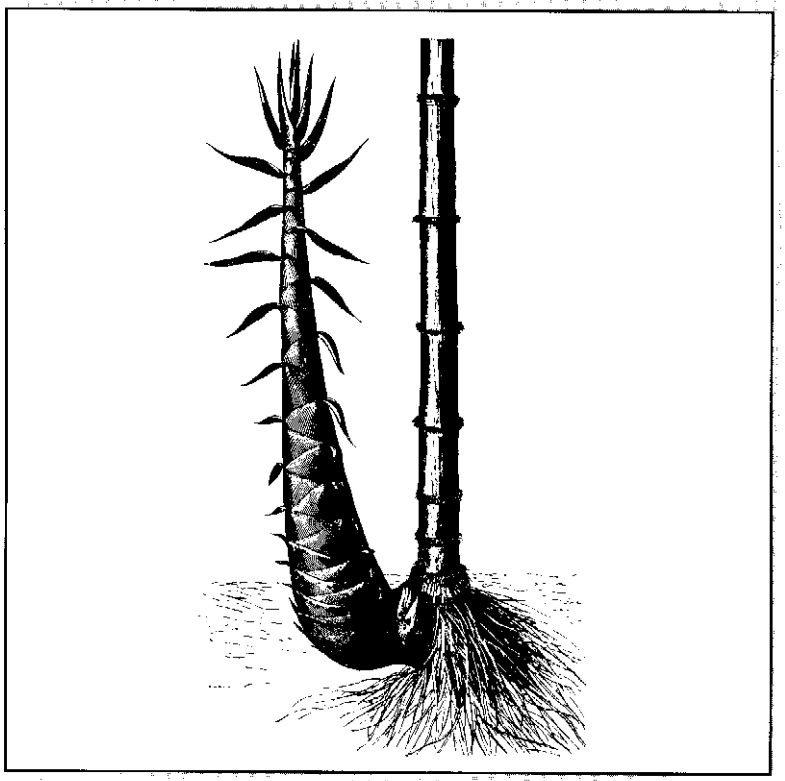
This list of twenty-nine genera represents less than half those known—roughly seventy-six—but includes the main genera of economic importance.[232]

CHAPTER 7.

1. Freeman-Mitford 1896:186.
2. Freeman-Mitford 1899:271–2.
3. Lawson 19.
4. McClure 1953:32. Lin 1972:1.
5. McClure 1931 and 1966:150–7 offers extensive descriptions of culture, harvest, curing, and use of *A. amabilis.* Photos and text of *National Geographic* October 1980 bamboo cover article also focus on this species.
6. Jackson 1949.
7. Lawson 67.
8. Ibid.: 74–5.
9. Ibid.: 75–6.
10. Ibid.: 76–7.
11. McClure 1953:32. Lin 1972:1
12. McClure 1953:32.
13. Ibid. Lin 1972:2.
14. Young 1945a:194.
15. Lawson 85.
16. Young 1945a:194. Young 1961:32. Lawson 83–5.
17. Lawson 85.
18. Ibid.: 85–6.
19. *Southeast Forest Experiment Station Research News,* No 5, May 1949.
20. Quoted in West 1935.
21. West 1935:254.
22. Young 1945a:196.
23. Lawson 111. See also Hughes 1951.
24. McClure 1954c:19–20.
25. McClure 1963b:134–6.
26. Young 1945a:178.
27. Lawson 87–8. Young 1945a:178.
28. McClure 1953:32. Lin 1972:2.
29. Satow 49–50. Fuji 1963:15. *For* Han Shan, see *Cold Mountain,* tr. Burton Watson, Columbia U.P. 1970. Gary Snyder's translations of Han Shan have appeared in a number of anthologies after publication in *Riprap and Cold Mountain* (1957?).
30. Satow 78–80. Fuji 1963:35.
31. Lawson 89–90.
32. Ibid.: 90–1.
33. McClure 1953:32. Lin 1972:2.
34. Ibid.: 33. Ibid: 2.
35. Ibid. Ibid.: 3.
36. Lawson 107–9. Young 1961:19.
37. McClure 1954c:19.
38. Young 1961:19.
39. Ueda 1960:118–9.
40. Lawson 113.
41. Ibid.: 112–4.
42. Ibid.: 114.

43. Ibid.: 114–5.
44. Young 1945a:179; 1961:20.
45. McClure 1953:33. Lin 1972:3.
46. Lawson 96.
47. Ibid.: 94–6.
48. Ibid.: 147–8.
49. Freeman-Mitford 1899:276–7.
50. McClure 1957a:2.
51. Ibid.: 12–3.
52. Ibid.: 13–5. Glen 1954.
53. McClure 1957a:15–8. Young 1961:20–1.
54. Ibid.: 18–20. Ibid.: 21.
55. McClure 1966.
56. McClure 1944.
57. Lawson 120.
58. Young 1961:22–3. McClure 1957a:24. Lawson 120.
59. McClure 1957a:20–5 and Young 1961:22–3 describe *P. bambusoides* and variants.
60. McClure 1957a:25.
61. Ibid.: 25–7.
62. Ibid.: 27–9. Glen 1954.
63. McClure 1957a:29–30.
64. Young 1961:23–4.
65. McClure 1957a:32–4. Glen 1954.
66. Lawson 122–3. McClure 1957a:34–6. Young 1961:24.
67. McClure 1957a:36–8.
68. Ibid.: 38–9.
69. Ibid.: 39–42. Young 1961:24.
70. McClure 1957a:42–5.
71. Freeman-Mitford 1896.
72. McClure 1957a:45–6.
73. Young 1961:25.
74. McClure 1957a:46–7.
75. Freeman-Mitford 1896:151.
76. McClure 1957a:47–8.
77. Young 1961:25–6.
78. Ibid.: 26. McClure 1957a:48–9.
79. McClure 1957a:49–50. Glen 1954.
80. Lessard 1980:48,57.
81. Young 1961:27.
82. Satow 35.
83. Young 1961:27. McClure 1957a:52.
84. McClure 1957a:51–3.
85. Freeman-Mitford 1899.
86. Glen 1954.
87. Glen 1954. McClure 1957a:53–6.
88. Sturkie 1968.
89. McClure 1957a:56–60.
90. Ibid.: 61–2.
91. Lawson 139.
92. Young 1961:28.
93. McClure 1957a:62–5. Young 1961:28–9.
94. McClure 1957a:65–7.
95. Fuji 1963:15.
96. Young 1961:29.
97. Lawson 92.
98. Young 1945a:190; 1961:29–30.
99. Satow 43–5.
100. Lawson 79–80. Young 1961:30.
101. Lessard 56.
102. Young 1961:30–1.
103. Lawson 141–3. Young 1945a:185–7; 1961:30–1.
104. Lawson 103–4. Young 1945a:178.
105. Lawson 105.
106. Lawson 104–6. Young 1945a:180.
107. Lawson 144.
108. Ibid.: 143–4. Young 1946d:36.
109. Young 1946d:36.
110. Soderstrom 1979a:161.
111. Young 1961:20; 1945a:180.
112. Lawson 145.
113. Young 1945a:182; 1961:31.
114. Lawson 147.
115. Young 1961:33.
116. Lawson 151–2. Young 1961:32–3.
117. Huberman 1959:40.
118. Munro 1868:4.
119. McClure 1953:33.
120. Young 1961: 37. See also McClure 1954c:20.
121. McClure 1953:33. Lin 1972:5.
122. Young 1961:37–8; Lin 1972:4.
123. McClure 1953:33. Lin 1972:4.
124. Lin 1972:4–5.
125. McClure 1958b:No. 3, p. 40.
126. Lin 1972:5.
127. Ibid.
128. McClure 1948c: exhibit 12.
129. McClure 1944:48; 1954c:21–3. Young 1961:38–42.
130. McClure 1953:33.
131. McClure 1944:45.
132. McClure 1958b:No. 3, p. 41.
133. McClure 1953:34. Lin 1972:6.
134. Young 1961:42. Lin 1972:6.
135. Lin 1972:7.
136. Ibid.:6
137. Young 1961:43.
138. Dickason 1966:7.
139. Gamble 1896:37.
140. McClure 1944:49. Young 1961:43.
141. Lin 1972:7.

142. Young 1961:44.
143. White 1945:846.
144. Lee 1944:129. See also, Young 1961:44–5. McClure 1944:51; 1958b:No. 3, p. 42.
145. McClure 1944:55. See also McClure 1948c: exhibit 10; 1958b:No. 4, p. 53. White 1946a. Young 1961:45.
146. McClure 1948c: exhibit 14; 1958b:No. 4, p. 53. Young 1961:46.
147. Plank 1950. See Chapter 8, p. 219.
148. McClure, unpublished *Guadua* text, from Grass Library, Smithsonian Institution.
149. White 1945:843–4.
150. McClure 1954c:23. The Jinotepe bamboo cannery mentioned by McClure apparently no longer exists (1983).
151. McClure 1953:34.
152. Lin 1972:8. Simmonds 1963:334.
153. Lin 1972:8.
154. Watt, George: *Commercial Products of India,* London, 1908. McClure 1944:62.
155. Lin 1972:9.
156. Lawson 148–51.
157. Lin 1972:10.
158. Ibid.
159. Ibid.
160. Ibid.
161. Young 1961:47.
162. McClure 1953:35. Lin 1972:11.
163. Ibid.
164. McClure 1953:35.
165. Ibid. Lin 1972:11.
166. Lin 1972:12.
167. Watt, George: *Commercial Products of India,* London, 1908. McClure 1944:62.
168. McClure 1953:35.
169. Ibid. Lin 1972:12.
170. Ibid.
171. McClure 1953:35–6.
172. McClure 1966:169.
173. Deogun 1937:79.
174. Huberman 1959:40.
175. McClure 1966:171.
176. Ibid. Young 1961:48.
177. Lin 1972:13.
178. Dutch patent No. 53,471. 1942.
179. McClure 1955:140–1; 1958b:4,53–4.
180. McClure 1953:36. Lin 1972:13.
181. Lin 1972:13–4.
182. McClure 1953:36. Lin 1972:14.
183. Lin 1972:14.
184. Ibid.
185. McClure 1966:172–9.
186. Ibid.:176.
187. McClure 1955:142–3; 1958b:4,54.
188. McClure 1948c: exhibit 1.
189. McClure 1953:36.
190. Ibid.; 1966:179–87. Hidalgo 1974, 1978. Castro 1966. Lodoño 1970.
191. Lin 1972:15.
192. McClure 1948c:exhibit 2. Lin 1972:15.
193. Lin 1972:15.
194. Ibid.
195. McClure 1944:75.
196. Lin 1972:16.
197. Ibid.
198. Ibid.
199. Ibid.
200. Ibid.
201. McClure 1966:187–97. Chap. 4, "Selected Species," pp. 147–201, is the easiest part of McClure's masterwork for nonbotanists to enter.
202. Simmonds 1963:336. See also McClure 1958b:4,55.
203. McClure 1953:37.
204. Lin 1972:17.
205. Ibid.
206. McClure 1966:197.
207. Ibid. Deogun 1937:115.
208. McClure 1966:197–201; 1958b:4,55. Gamble 1896:121–8.
209. Lin 1972:17. McClure 1953:37.
210. Lin 1972:17.
211. Ibid.:17–8. McClure 1953:37.
212. Lin 1972:22. McClure 1953:38.
213. Ibid.
214. Ibid.
215. Ibid.
216. Lawson 1968:100–2.
217. Ibid.:100–3. Young 1961:49.
218. Lin 1972:24. McClure 1953:38.
219. Lawson 1968:81–3.
220. Soderstrom 1979b:22–7.
221. Lawson 1968:96–8.
222. Soderstrom 1979b:27.
223. Lawson 1968:110.
224. Ibid.:110–1. Soderstrom 1979b:27.
225. Lin 1972:24. McClure 1953:38.
226. Dickason 1966:4,7.
227. McClure 1948c: exhibit 17.
228. Ibid.: exhibit 8.
229. McClure 1952b.
230. McClure 1945a.
231. McClure 1952b.
232. Hidalgo 1974:6–21. McClure 1955, 1973.



8. CULTIVATION, HARVEST, CURING

"Every farm in the South should be supplied with a small forest of these valuable plants, in the same manner as it is now supplied with a wood lot. . . . I have growing in my experimental gardens in Louisiana sixty-four varieties entirely hardy, unhurt by frequent temperatures of 15 degrees F."

—E. A. McIlhenny

DIXIE BAMBOO

"It is impossible for the people of the United States, who have lived among the lush forests that covered North America, and which still cover much of our land, to look forward to the time, a few hundred years hence, when our land will be as bare of forests as China is today, and for that reason, and that reason alone, we cannot visualize the value of the rapid-growing and maturing bamboo capable of producing many times the tonnage of usable wood, many times as rapidly as anything else we know of that will grow from the ground, and with but little care after planting. When bamboo becomes established here, it will be as indispensable to our existence as it is now to the Chinese.

"The U.S. imports millions of dollars worth of bamboo yearly that should be grown at home. Now is the time for our state agricultural departments to see that plantings of bamboo are made wherever they will thrive so that the people of the southern states may be ready for the time which surely will come when our forests are no more, and we will be obliged to rely on the quick-growing timber bamboo to supply the wood for all necessities, from the making of paper to the making of houses, and the furniture for the houses."

McIlhenny was writing this in the mid 1940s. China is no longer bare of woods. Tree cover has doubled according to FAO estimates, and Saint Barbe Baker says it has increased from 7 to 27 percent of China's land area. Deforestation is *not* inevitable, as McIlhenny apparently presumed forty years ago. This is a momentous shift. For the first time in the cultural existence of our race, a significant part of it is proving we *can* regreen the globe. Tree planting has become a kind of permanent national picnic in China. Sometimes such basic sanity is contagious. It could happen in many places now that we know it can happen. After the first runner broke the four-minute mile, suddenly many more found their legs could do it, too.

Fortunately, affection for forests is not something we need to "awaken" in people. It is inherent to our eye, nose, and lung. All we have to do is stop

Bamboo energy is boldly expressed in the phallic power of a newly shooting culm.* (Gigantochloa *is the genus shown.)

Dixie, or Dixieland:
the southern states; probably from *dix*, dixie, a $10 note, widely current in Louisiana before the Civil War, with a large French *dix* (ten) in the center of the reverse. (Webster's New Collegiate Dictionary.)

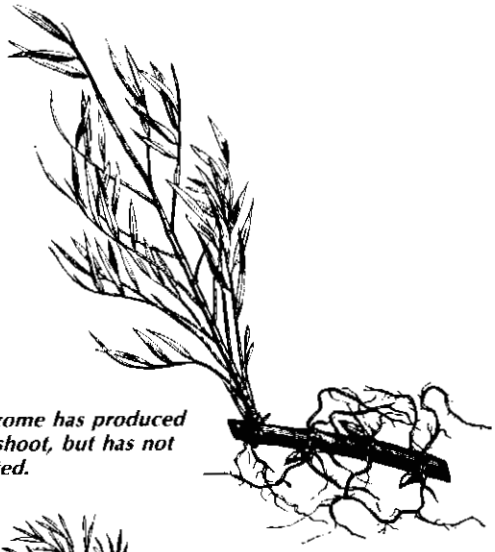
stifling it, foster a love of leaves early in our homes, gardens, schools, and rituals. Then, perhaps, bamboo will be the cheerful friend of our forests, instead of the replacement that McIlhenny imagined. Broad cultivation and use of bamboo's versatile fiber can help us lean more lightly on the woods and thus encourage trees to come back to live with us again.

BASIC GARDEN GUIDELINES

Propagation.
Hardy *monopodial* bamboo is generally progagated from young rhizomes with or without an attached culm. The rhizome should be yellowish, 15–40 inches long, with at least ten good buds. Cut with a saw to avoid shock, and plant 1 foot deep. The attached culm should be young, of the same or preceding year. It is trimmed to about 5 feet, the lower branches left—or culm can be cut off to within 1 foot of ground level. A rhizome alone, some 20 inches long with ten to fifteen nodes and plenty of roots, can also be used. The soil should be washed off and the rhizome wrapped in damp moss or burlap and plastic if it is to be sent any distance. By this method, up to one hundred suitable rhizomes may weigh as little as 3 pounds so it is shipment efficient. Rhizomes without culms are preferably planted 8 inches deep in a nursery and transplanted the following spring when new shoots appear.

For *sympodial* species, a healthy culm is selected with its rhizome and similarly planted at the beginning of the rainy season in early spring. Divisions of clumping bamboos are obtained by cutting culms just above the second or third node. As many as three culm stumps may be included in a single division, which may weigh up to 30 pounds, or more, depending on the species. In an eight-hour day, a laborer may perhaps prepare only three such divisions, whose weight and bulk greatly increase transportation costs. The growth of the parent clump is also retarded by the division, and the amount of propagating material per clump is quite limited.

A monopodial rhizome* (Phyllostachys viridi-glaucescens) *prepared to plant.



The rhizome has produced a leafy shoot, but has not yet rooted.

Propagation of* P. viridi-glaucescens *with rhizome and attached culm.

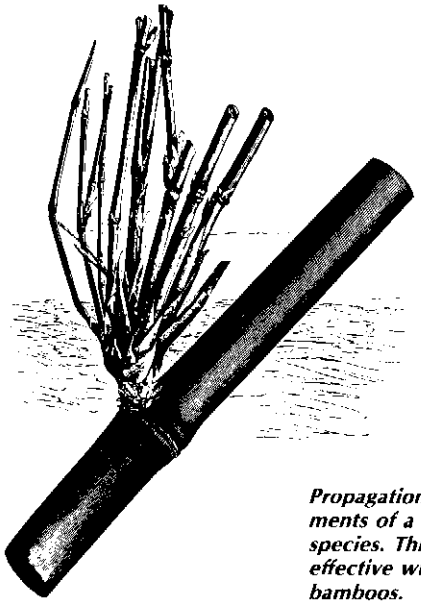
Whole-culm plantings are also practiced with tropical bamboos as is propagation by culm segments: a length of two-to-three-year-old culm, 20–40 inches long without branches, horizontally planted 1 foot deep will also root easily in many sympodial species. This method, however, is rarely productive with monopodial bamboo.

Transplanting by whatever method should be done as quickly as possible to prevent the culm and rhizome from drying out, and newly planted bamboo should be watered at least weekly.

> Unlike many woody plants, especially deciduous species in a dormant state, uprooted bamboo plants or cuttings dry up easily if exposed for any length of time to sun or wind. Disregard of this fact is probably responsible for more failures or partial failures in bamboo plantings than all other causes combined.[1]

SOIL AND SITE. Bamboo likes moderate water in a soil that is fertile, well drained, and mixed with gravel. It grows well on slopes where rhizomes and dense leaf fall both help retard erosion. Strong sun should be avoided, except for black bamboo which darkens well in direct sunlight. Sites facing west into a harsh afternoon heat are not ideal. In warm or mild climates, locations facing north are preferred; in colder regions, the south.

CUTTING. For the first three years of a new grove, all shoots should be allowed to grow. Thereafter, young bamboo should not be cut, but five-to-six-year-old culms should be removed each autumn to reduce insect damage and make room for new sprouts. Cutting thin culms at two years and leaving larger culms uncut favors the rhizomes producing sturdier culms and tends to increase the average culm diameter in the grove. Thinning is important. Greater density can mean fewer new culms each year and less harvest weight. One grove, reduced from 1,200 to 900 and then 750 culms, steadily increased the number of new culms produced annually from 165 to 179 to 218. The harvest weight rose from 1,650 to 1,920, to 2,180 pounds.



Propagation by culm segments of a* Gigantochloa *species. This method is ineffective with temperate bamboos.

Gigantochloa ***species two years after propagation. Culm segments propagate most readily in species with branches swollen at the base. These repeat the anatomy of the bulbous sympodial rhizome at the base of the culm, and assume its functions when planted.***

OVERTHINNING. Overthinning can result in excessive sunlight, which yellows the culms and dries the ground. Enough culms should be left to provide good shade for the grove itself even in broad daylight. Harvest three-year culms, which implies keeping track of their age: a thin wire can be loosely placed each fall around the base of new culms. A code of twists in the wire serves to indicate the year of growth.

"Too much beauty can get out of hand."

Listen, bamboo, chief mischief of my yard, thou shalt not chew the concrete of my neighbor's drive. Feel these sheets of corrugated metal, two dozen inches deep? There ends your bed, my lovely. So by all means stay green, tall, and beautiful, but *stay put.*

The average American homeowner wants to construct a brief Eden in his yard for green relief from commuting to the job. He doesn't want to come home from battling his boss to battle his bamboo. Ruth McClure, brisk widow of F. A. McClure, is insistent in her warnings: "I'm afraid I'm not much use to you. I just keep warning people that bamboo's sneaky. My husband knew a man who *died* trying to get it out of his yard. Sure, it's beautiful, but too much beauty can get out of hand. So my husband always warned anyone he gave bamboo to: *it has to be contained* if you don't want it everywhere."

McClure issued his warning in print as well: "*Sinobambusa tootsik,* a Chinese bamboo once highly prized as a garden ornamental in Honolulu, has come to be regarded as a dangerous weed there because it escaped from cultivation and now dominates many acres of once pure native vegetation."[2]

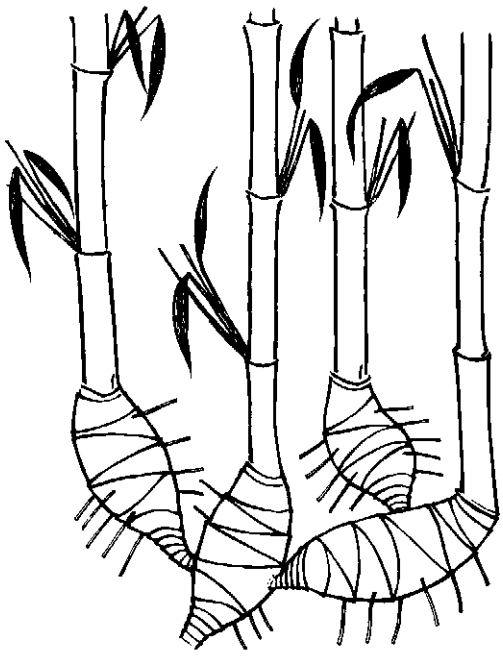
FERTILIZING. Compost or, less recommended, commercial fertilizer, increases grove vitality enormously. The number of culms and harvest weight can be doubled, with culms both taller and greater in diameter. Ten parts nitrogen, six parts silicate, five parts each of potassium and phosphate are applied about a month before spring shoots appear and again before the onset of rhizome growth, which immediately follows completion of culms. For 1 acre, apply 80 pounds of nitrogen to 48 of silicate, 40 of potassium and 40 of phosphate. Bamboo leaves, roughly equivalent in weight to the annual harvest in some species, are left in the grove. A dense leaf fall of up to 4 inches annually provides fertilizer and excellent mulch. They are 6 percent silicate, and their decomposition increases the availability of this toughening component of bamboo. Theoretically, older groves should produce harder culm wood. (Fertilizing bamboo is not recommended where durability, not quantity, is sought: see below, Soil and site, pp. 215–216.)

CONTROL. If bamboo is to be confined to a limited area, rhizome growth in some monopodial species must be controlled. Galvanized metal sheets or 1–2 inch concrete slabs are sunk 20–24 inches deep, with about 2 inches above ground. Concrete made with peat moss replacing some or all of the sand provides a barrier porous enough to allow groundwater to pass. Pebbled paths around the grove will harden the soil, reduce the shoots, and also reduce rhizome development. Sprouts that emerge where unwanted should be eaten or kicked over while still young and brittle. Make sure you *need* to control your specific species before you go to the trouble and expense of confining it. See p. 215 for more on the bamboo invasion. Also, "Eat your lawn," p. 278, for direct action.[3] Basically, bamboo becomes a problem only if you choose the wrong species, and don't *use* it. If you can't use your harvest, call the crafts teacher at your local school and offer a copy of this book and free harvest in exchange for taking your bamboo abundance off your hands.

TRANSPORT

Selecting and shipping bamboo starts.

Go to the grove prepared with digging and pruning tools and enough waterproof material to wrap plants and keep them moist at all times. Find an area in the grove where small, strong, disease-free plants seem most plentiful. Make exploratory digs to get a clear picture of underground organization of rhizomes. At the young edge of a clump, choose three to four adjacent culms. One or more of them should be at least one year old with branches or visible buds at nodes below a height of 18 inches.



A group of sympodial rhizomes prepared for shipping and planting. Two or more connected rhizomes, two or more nodes of a culm segment, will survive more readily than a single propagule.

Dig out a part of the clump large enough to include a ring of culms beyond the selected portion, and remove the soil to expose where the rhizomes join. Cut the part wanted from the rest in such a way that all the culms of your propagule remain joined by their rhizomes. Prune culms to roughly 18 inches and branches to 4–5 inches. Don't cut branches close to culm. Remove most of remaining foliage, and prune roots to about 3 inches. Cover propagules with moist litter as soon as work on each is complete. To assure that at least one will survive, prepare, if possible, at least four propagules. Wrap them in waterproof material with moist litter (sphagnum if possible) for transport to base where packing for shipment is done.

Packing for shipment.
Prepare a batter of rock-free clay, about 1½ gallons, the consistency of mayonnaise or thick gravy. Wash off soil from propagules and dunk the rooted base of each into batter until roots and rhizomes are completely coated. Pack in moist (not wet) sphagnum, an equal number of bases at each end of the pile, then wrap in waterproof plastic or heavy wax paper. Wrap finally, and firmly, in heavy manila paper and tie well. Ship by air express or other rapid means.[4]

Receiving bare-root bamboo.
"Keep packages in a cool place and unpack in shade, protected from any wind. Don't try to remove all the packing material as this may damage young roots. Set plants in moist sphagnum or similar material in a windless, shady place until ready to plant. It is best to prepare ground before shipment arrives. A nursery is most convenient, efficient, and effective. Plants can be observed frequently and needed attention promptly given, till well established; they will be planted in permanent locations at the onset of the next rainy season.

"Set plants in rows 5 feet apart, 1 yard between plants. This is the minimal distance, good for no more than one year. Rows follow land contour to provide natural drainage. Avoid poor drainage, which bamboos abhor—except for some *Guadua* species. Water should be handy for irrigation or at least sprinkling during droughts until plants have dug in well.

"Dig holes of ample size. Spread roots out thoroughly while adding well-sifted soil. Tamp the soil firmly while adding it *before adding any water.* Then water generously, adding a thick mulch of loose organic matter. Plants set out in dry season require temporary shade—and windbreak for any strong, dry winds. Sketch a map of species position immediately in case plant markers get lost or confused. Keep weeds down, especially climbers."[5]

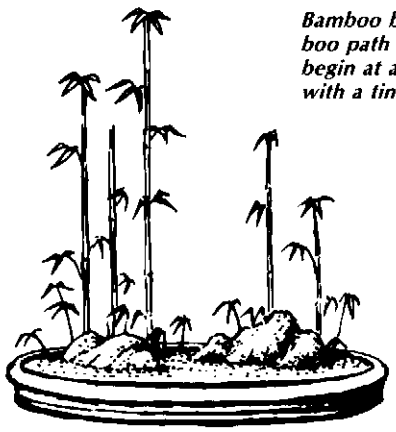
EXPANDING GROVE

Bamboo bonsai.
Chinese ornamental gardening developed largely as miniature idealizations of natural scenery. Travel was difficult, space limited, plants much loved by the Chinese people—so nearly every home had a tiny garden whose aesthetic traditions were extended, in time, to dish-gardening, *p'oon tsui,* or *bon-sai* in Japanese, the more familiar name for this type of microgarden in the West. Plants used are either naturally miniature or capable of thriving indoors while being subjected to the severe dwarfing techniques evolved in bonsai practice over the years.

Usually, bamboos coming from extreme north or south latitudes are natural dwarves. *Sasas* from northern Japan are the most common known in Western gardens. But all species can be shrunk in stature by reduced water and nutrients, small containers that confine roots, and the practice of removing culm sheaths from growing culms, which stops growth of the internode above it.[6] (See description, Chapter 6, "Seedling," pp. 151–152.)

Sympodial bamboos are used in pot culture by cutting them off to a short stump just before new growth would normally begin from the rhizomes. The new shoots are quite small compared to the ordinary size of the plant.

Monopodial bamboos are potted by digging a rhizome a foot or so long and planting it upright or at a slight angle with 3–4 inches in the soil. Buds underground produce short shoots, while those above send out branches and leaves from the rhi-



Bamboo bonsai. The bamboo path is endless. It can begin at a tiny window with a tiny grove.

zome, which turns green in response to light, thus resembling a tiny culm with short internodes.[7]

Some favorites for potted plants or small gardens include those with swollen internodes, like *Bambusa ventricosa* or *Phyllostachys aurea,* the square-stemmed *Chimonobambusa quadrangularis,* or the green-striped yellow culms of horticultural forms of *Bambusa vulgaris,* and *P. bambusoides.* White powdery bamboo *(Lingnania chungii)* is a popular species long honored in Chinese art and poetry, introduced in the West, but little known or distributed as yet.

Pseudosasa japonica is an indoor favorite for which propagating material is widely available. *B. glaucescens,* also, in its horticultural form of Chinese goddess bamboo, "does well as a potted plant, and will stand more shade than most bamboos. Chinese gardeners use it a great deal in their miniature gardens, where it assumes, under skillful treatment, a stature of a few inches, with all parts in proportion."[8] Extended advice on bamboo bonsai techniques is provided by Austin in the broadly available *Bamboo.* The text is by the eminent Japanese bamboo master Koichiro Ueda and is painstakingly detailed about some of the refinements of the art:

> When the shoots in the nursery have grown to about 4 inches in height, their sheaths should be peeled off. This is done by inserting scissors between the sheath and the culm starting from the lowest node—and gently cutting the sheaths from the top down to the node into thin strips, which are then removed carefully and without damaging the culm. The sheaths and the strips must not be torn off by hand as this has a serious effect on the culm. After removal of the first sheath, several hours should be allowed before starting on the second, and so on. The treatment should also be followed through the evening, since bamboo continues its growth by night. Once the stripping operation has been completed, the bamboo bonsai should be given a little oil cake, or other compound fertilizer, in spring and in early summer to improve its color. The tender shoots without sheaths should initially be protected from the sun and must be watered if they get dry. Finally, they should be transplanted into the bonsai pot in the autumn after the new shoots have completed their growth. The rhizomes are cut to fit into the pot and a mixture of large and small stems planted to simulate the variety of a bamboo grove.[9]

Potted bamboo. Mini-Eden: the courtyard garden.

Large containers of potted bamboo are gallons of dirt beyond windowsill bonsai efforts at deliberate miniature but still represent considerably less effort and space than a grove. The Chinese and Japanese are both famous for moving their gardens where they go (see Morse 1886, Keswick 1978), and potted bamboo is the obvious option of modern, mobile, urban populations in the West. *Small* is no obstacle for the Chinese or Japanese gardener, long accustomed to population densities that people in other areas of the world are now only approaching. The infinite variety of oriental adaptations to density, their Tao of Crowd, is one main aspect of their culture that makes it seem so apropos in the now denser West.

Inspiration for bamboo use in a cramped place is lavishly presented by *The Japanese Courtyard Garden. Landscapes for Small Spaces* by Shigemori (1981). But offering a model for the population at large—to which we speak—is not an objective of Shigemori's book, whose price—$150—suggests its intended audience.

Chic critique.

Bank Zen, marble downtown Tokyo corporate garden architecture, is the book's unfortunate main focus. The spare effects, the bamboo chic it makes breathlessly available—on the page but not to the people—is actually at considerable variance from the attitudes of its design grandfather. The mini-Zen "grass hut tea," the humble shack of Rikyu and surrounding garden, which is the cultural bone of Shigemori's flawlessly beautiful places, was deliberately *a norm for all.* It demanded a certain attitude, not extravagant resources. Nevertheless, Shigemori is a source for striking and suggestive photographs. Look for it in your local arboretum, along with Austin (1970) *Bamboo,* and *The World of Bamboo* by Shinji Takama (1983), the latest and by far the most inspiring of these books.

All of these are full of beautiful photographs, and all suggest that bamboo is still basically the coffee-table preserve of the few. There is an irony —and a publishing gap—in a major global resource being limited to a handful of initiates, and of books focusing, again and again, more on the cosmetic possibilities of the plant for the landscapes of the overrich than on its useful beauties for everyone. Shigemori's book misses the more globally relevant mark of a book on small gardens for the nonelite. Takama's obvious reverence for bamboo puts his book in a class definitely apart, and classless, transclass in appeal.

For more on the central position of bamboo in oriental gardening, see Schaarschmidt-Richter

(1979) *Japanese Gardens;* Engel (1959) *Japanese Gardens for Today;* Sirén (1949) *Gardens of China;* Keswick (1978) *The Chinese Garden;* Davidson (1983) *The Art of Zen Gardens.* Bamboo was also a standard component of the small teahouse garden and path (see p. 91 and p. 110). The current interest in the teahouse and adjacent garden seems attested by a number of recent books we can only acknowledge in part and in passing: Hammitzsch (1980) *Zen in the Art of the Tea Ceremony;* Sen (1979) *Chado: The Japanese Way of Tea.*

Hedges.

> A hedge between
> keeps friendship green.
> —Mother Goose

Hardy bamboos tested for hedges at Savannah, Georgia, USDA groves include *Pseudosasa japonica, Arundinaria fastuosa* (narahira bamboo), and three species of *Phyllostachys: P. meyeri, P. nigra,* and *P. purpurata. P. aurea* and *P. aureosulcata* were also recommended. All these species branch close to the ground in plants of moderate height, producing a close hedge.

Into a trench 18 inches deep and 36 inches or more wide, excavated and filled with fertile soil high in humus content or well-rotted manure, transplant cuttings of rhizomes formed the previous year. These are distinguished from older rhizomes by the presence of sheaths or bud scales. Rhizomes with at least six to eight good buds are planted vertically in two to three rows on each side of trench with cuttings 6 inches apart. Vertical planting encourages quick culm growth and retards rhizome development. Horizontal planting in rows parallel to trench sides will yield greater rhizome development along trench axis. Plant bamboo with stems cut back to about 1–2 feet, covered with 5-6 inches of loose soil to the same height as the natural soil line on the culm, with attached rhizomes as parallel as possible to trench sides. Mulch with leaves, peat moss, or organic litter to help keep soil moist and loose. Plants that die should be replaced.

Plants or rhizome cuttings can also be established in a nursery for a few years, 3 feet apart in rows 5 feet apart. When these are transplanted to the desired site, move them with a ball of earth 18 inches square, 8–10 inches deep, with all their rhizomes carefully preserved and placed parallel to the trench. When desired hedge height is reached, prune its top and sides with slanting rather than right angle cuts, 1–2 inches above nodes of culms and branches. Always prune *after* new shoots have reached full height, extended branches, and opened leaves.

Hedge of living culms lashed to split bamboos of a larger grove.

A hedge can be kept trimmer along the sides by stretching a strand of #12-gauge galvanized wire slightly above mid height on each side on posts close enough to maintain tension with cross wires running between them to keep hedge the desired width. Periodic use of organic or commercial fertilizers rich in nitrogen will assure dense and deep green foliage.[10]

Windbreak design: the harvested hedge.

"In 1956 a hedge of *Pseudosasa japonica,* a hundred yards long, was planted at Rosewarne Experimental Horticultural Station in Cornwall (England) and is now an effective barrier against the Cornish gales. Four years after planting, many individual canes stood 8 or 9 feet high. In another trial, four hundred species of hedging plants were carefully compared and assessed for possible agricultural use

as shelter hedges, and *Pseudosasa japonica* was one of the eight finally selected as most suitable.

"Wind velocities are reduced by a solid barrier for as far as thirty times the height of the obstruction, but the degree of protection needed for ordinary garden purposes probably does not extend farther than ¼ to ⅓ this distance. It has been found that a hedge presents a more satisfactory barrier than close fencing, stone, or brickwork, and so on. A solid wall, ironically, gives rise to air turbulence on the leeward side, and the swish and eddies of the disturbed air do more damage than would have been done had the wall never been erected. Experimentally it is shown that the most satisfactory barrier is one with a 50–60 percent degree of permeability. A bamboo hedge meets these requirements."[11] Lawson also notes that, unlike brick walls or other inorganic barriers, a bamboo hedge also complements any garden by providing materials for stakes, arbors, trellis work, fences, tool sheds, and so forth from harvested culms.

BAMBOO FARM MANAGEMENT

Silvicultural summary.

Bamboo silviculture, or the scientific management of bamboo plantations, has been most developed in India, which probably has the world's largest reserves of bamboo. About one seventh of India's forest resources, some 25 million acres, are bamboo groves. The Forestry Research Institute at Dehra Dun has since 1878 been the principal world center for bamboo research.

A few rules of the big groves: "A rich, well-drained soil is desirable. The two other most important factors governing bamboo growth are temperature and moisture."[12] To establish a large grove of monopodial bamboo, rhizomes set out are 8–10 feet apart, requiring around 550 or so rhizomes per acre. Until the grove is well established, hand weeding will be necessary since even shallow cultivation would destroy the rhizome growth immediately below. Fertilize with up to 7,000 pounds of manure per acre.

Immature culms should be cut only if attacked by insects. Old or injured culms should be removed first. Remember that cutting around the edge of a sympodial grove decreases its growth. If practiced regularly, the rhizomes surrounding a grove die, forming a barrier and driving the remaining rhizomes back into the already overdense center of the grove.

Cuts, 6–12 inches above ground, are made

Bamboos in snow, by Kuo Pu (1280–1335). Culms can be flattened or snapped by severe snows, and commercial groves are often pruned at the top to prevent snow damage.

level with the node so no rainwater collects to rot first the culm, then the rhizome below. Culms cut higher not only waste the broadest section of the culm but make future work more difficult through increased congestion: branches often grow from nodes of these tall stumps, blocking movement more. Culms in flower should be cut after the fruit falls, not before. Culms which are badly formed, dead, sick, or useless in any way should be removed at each harvest. Cleanliness in a grove both reduces insect infection and clears way for new growth.

Environmental impact: bamboo invasion.
To play the devil's advocate, we collected published warnings on bamboo invasiveness from other lands. They weren't many. In northern Japan, *Sasa* species, one sixth of the forest biomass in Hokkaido, prevent erosion but disturb tree regeneration and hinder summer work of foresters. Use for flakeboard is feasible but harvest presents economic problems.

In Malaysia: "Forest departments regard bamboo as weeds interfering with timber growth and regeneration. Control options are available: starve clumps over a period of years by kicking over young culms in growing season or eliminate with various chemical sprays. Medway (1970), a zoologist, considered bamboos a nuisance for reducing species diversity of forests by suppressing other plants, reducing fauna to narrow selection of bamboo-loving species.

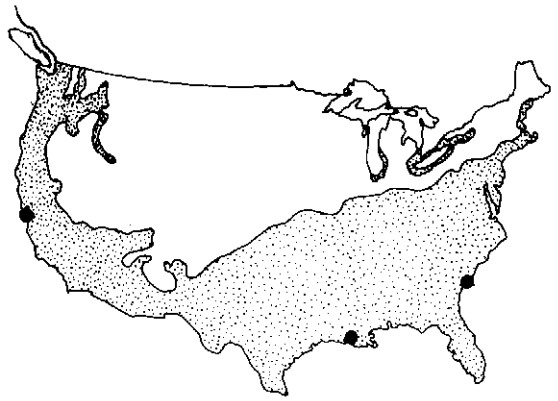
"In cleared or logged forests, such as in Sabah (northeast Malaysia), *Dinochloa* species [a climbing bamboo] can become a very serious weed problem, preventing regeneration of commercial timber." (Quotes from Lessard 1980: 56, 95, 129.)

Selective introduction: control by use.
Of the more than twelve hundred bamboo species, the more vigorously spreading varieties turn weed or wonder depending on *use*. Many useful bamboos are extinct or much reduced in former habitats: Human interest is an overly effective control. We recommend, obviously, an integrated approach to cultivation: Choose species whose use to people takes care of the question of harvest and control. If you choose a useful, unrampant bamboo and cultivate it well to grow culms of maximal size and encourage maximal vigor of rhizomes, you can, with little effort, distribute plants and cured culms locally. (See pp. 210, 248 on school use of bamboo in relation to these questions.)

Soil and site.
"A favorite site for a bamboo grove is the base of some range of hills or a broad valley where some mountain stream has brought down and deposited a mass of alluvium. These situations have the double advantage of suitable soil and shelter from strong winds. Wind shelter, all growers agree, is important: The young shoot thrashed about by winds with branches of older culms injures its growing tip, stopping growth and producing an imperfect culm. Windbreaks of conifers sometimes protect groves in an exposed position.

"*Soil quality* materially influences texture of bamboo. In Japan, a particular mountainside reputedly produces the hardest, flintiest bamboo in the country. The culms grown at Togeppo are cut up into the cylindrical ash boxes, or *haifuki,* upon the edge of which the smokers strike their metal-trimmed pipes in order to knock out the ashes. After years of use the edge of Togeppo ash boxes remain smooth while that made from a stem grown in the lowlands is splintered to pieces."[13]

"Relatively poor soils and dry sites are commonly used in preference to fertile ones among bamboo growers in China where strength and hardness of wood is more important than large size of individual culms or total annual yield per unit area. Culms of *Bambusa textilis* grown under this regime



Bamboo cultivation extends north of Vancouver, B. C., on the Pacific Coast. Stars indicate suggested regional experimental centers for distribution of plants and training of workers. Savannah, Georgia, and Avery Island, Louisiana, are natural sites for eastern and central regions. The San Francisco Bay Area provides a climate friendly to both tropical and temperate species, and a large oriental population with deep affection for the plant. Early plans for extensive bamboo groves in Golden Gate Park are beginning to be realized. The arboretum and research library there provide an ideal base for an urban bamboo information center on the West Coast.

give years of service as bean and cucumber stakes in the Canton delta."[14]

"Canal embankments, pond borders, and riverbanks are suitable locations, especially in dry regions. Large clumps grow along canals in Egypt. Algiers has many varieties growing in her trial gardens watered only by irrigations. There are in California, Oregon, Texas, and throughout the Gulf and Southern states thousands of suitable locations. The banks of small streams, the deltas of rivers, low, irrigated islands, like those in the San Joaquin and Sacramento rivers, would produce big forests of these valuable plants, while the banks of irrigation canals, wherever such occur in mild climates, could be made beautiful by them."[15] Especially in areas with long dry spells, locate plantings along ponds, streams, and near springs, just before rains start. (If propagating material is available, try drought-resistant species such as *Bambusa ventricosa* or *Dendrocalamus strictus.*)

Nursery.
Anyone planting a large area with bamboo will consider whether to plant at once in the field or in a nursery first. A nursery recommends itself for several reasons. You can establish the same optimum conditions of soil preparation and care, watering, watching, weeding—whatever seems required. Cost is diminished, efficiency increased. Dead plants are more quickly noted, more easily replaced. More time is available to choose and prepare a permanent site.

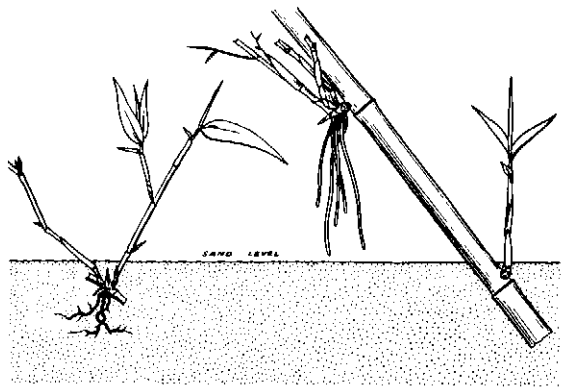
Planting distances depend on time plants will remain in the nursery and also vary with the species. Leave 1½ to 5 feet between rows, 1 to 3 feet between plants, depending on species and size of propagule. As little as ½ to 1 inch of soil can cover rhizomes if mulch covers the soil: well-weathered sawdust, wood chips, cocopeat (meal from coconut husks) are some alternatives; others depend on your surroundings.[16]

Slope or level?
In general, sympodial bamboos thrive better on land not too steep; monopodial bamboos seem to develop best on steeper slopes. Sympodial rhizomes tend to arise from progressively higher levels as the clump develops and soil is gradually carried away by erosion. The rhizomes of monopodials, on the other hand, seem able to burrow as deeply as circumstances require. If land with a steep gradient must be planted to sympodial bamboos, it should be terraced, if possible.[17] Even on level land, sympodial bamboos thrive best when some fresh earth is thrown over the rhizomes each year. In the culture of this type of bamboo for shoots in southeastern China *(S. beecheyanus* and *S. latiflorus),* the earth is pulled away from the base of each clump every year in December or January and the deadwood of old rhizomes removed. Earth is then heaped afresh and systematic application of fertilizer, usually diluted urine, is begun. In addition to protecting the rhizomes and roots from undue exposure and drying, these heaps of earth protect young shoots from light until large enough to be harvested.

Monopodial bamboos are grown on both level lands and hillsides. Aside from fertility, which is usually higher in level land, hill land seems preferred in part, perhaps, because bamboos loath poor drainage. Maybe, also, the slope stimulates rhizome use of greater vertical range of soil, evident in hillside cultures. This postpones the competition between rhizomes common on level land.[18]

Field planting distances.
Sympodial (tropical clumping) bamboos are planted at distances that vary with species, climate, and soil. The rough rule of thumb in the accompanying table for equidistant triangular plantings of five common species was developed at the USDA Federal Experiment Station in Mayaguez, Puerto Rico, a major site of Western experiments with tropical bamboos.[19]

Monopodial bamboos: Large species of temperate, running bamboos are most happy in an area at least as long and broad as they are tall. This counsel isn't followed by many urban gardens be-



After 36 days in a humid propagating frame, culm segments with branches of* Bambusa vulgaris *developed roots under the sand* (left) *and in the air as well* (right). *This species is the world's most widespread bamboo.

Cultivation Table

SPECIES	POOR SOIL AND CLIMATE		GOOD SOIL AND CLIMATE	
	FEET APART	PLANTS PER ACRE	FEET APART	PLANTS PER ACRE
Bambusa longispiculata	15	223	25	80
B. textilis	12	348	20	125
B. tulda	18	158	25	80
B. tuldoides	15	223	25	80
Sinocalamus oldhami	18	158	25	80

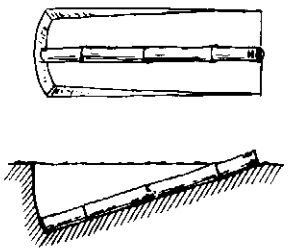
cause they haven't enough room, but for commercial production of bamboo it is an applicable rule. Plant 8–10 feet apart, 550 rhizomes per acre, roughly—depending, as with tropical bamboos, on local climate and soil as well as rhizome vigor of the species in question.

Propagation notes.
For reasons of economy, culms are usually taken up singly, but a unit composed of a new culm and its "parent" gives much surer and quicker results. The earth is dug away from the rhizome, and the culm or the unit is severed from its parent by a transverse cut through the narrow "neck" at the base of the rhizome. Too great stress cannot be placed upon the importance of care in digging and in making the cut. One careless stroke of the hoe or knife can ruin a bud, and this damage to the tissues can cause the loss of the plant or serious impairment of its growth through the introduction of fungi.

Bamboo species that normally lack branches, and even branch buds at the lower nodes, present a special problem. Make sure that the culm is severed at a point high enough to ensure the presence of at least one, preferably several, strong branch buds or better still, a complement of fully developed branches. Foliage, when present, should be reduced drastically, but a few leaves or parts of leaves should be kept on unless plants are likely to dry out. The aim of Chinese experts seems to be to keep the water in the plant moving upward, if possible, by keeping some foliage functioning continuously. It is claimed that chances of success are greatly enhanced if this condition is maintained.[20]

Whole-Culm Planting

SPECIES	NUMBER OF PLANTS PER 10 FEET OF CULM	AGE OF PROPAGATING MATERIAL IN YEARS
Gigantochloa apus	9.5	3
Guadua angustifolia	9.1	2
Sinocalamus oldhami	8.2	3
Bambusa ventricosa	7.4	2
Bambusa tulda	6.8	3
Cephalostachyum pergracile	4.1	2

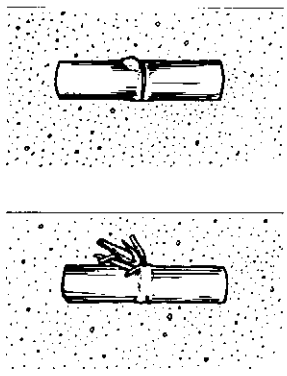


***Age aids vitality:** Meter-long basal cuts of* **B. vulgaris,** *var.* **vittata** *were used in an experiment to determine the effect of culm tissue age on the yield of rooted plants. Six age groups were tested, with a code indicating each group on the visible tip of culm segment above ground, as shown. Vitality increased steadily with age to five years, the oldest cuttings tried.*

AGE GROUP (MO.)	NO. OF CUTTINGS	PRODUCED ROOTED SHOOTS (PERCENT)	PRODUCED UNROOTED SHOOTS (PERCENT)	DIED (PERCENT)
<2	110	20	22	58
ca. 6	256	19	18	63
12–18	283	26	19	55
24–30	228	30	19	51
36–40	98	51	29	20
48–60	44	50	34	16

Whole-culm planting.
Although unproductive with monopodial species, experiments have shown that whole-culm planting works well in tropical bamboos. Species, position on culm, and age of material are three important variables.

Ten species were tested, with material one, two, and three years old. Material two and three years old was superior consistently to one-year-old



A single node of sympodial culm (a) is planted with bud or branch on uppermost side. Larger sections of two or more nodes (b) are more effective, but use more propagating material. Buds or branches are placed to the side when two or more nodes are planted; the uppermost portion of internodes is opened with a V cut or drilled and the internodes filled with water (c).

material. In six species, two-year-old material was better than three. In four species, three-year-old material was superior to two. The tip of the culm was most productive in thirteen cases; midculm, in nine cases; the base, in seven.[21]

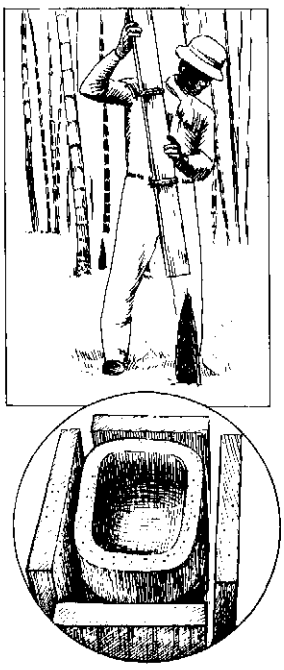
Marcotting.

In the Philippines, *marcotting* was 68.9 percent successful with *Bambusa blumeana*. Bend a one-year-old culm so that all nodes are within easy reach—easier to do if an undercut is made at culm base. Branches are pruned to about 1 inch, carefully, so that no dormant buds are injured. A mix of garden soil and leaf mould around each node is then wrapped with coconut fiber, old burlap, or other suitable material. This method is not recommended for hardy bamboos.[22]

Seed storage, planting, and international exchange.

Bamboo seeds are notorious for rapidly losing vitality. Seeds of *B. arundinacea* were used in Puerto Rico USDA experiments to determine best storage methods to enhance seed longevity. Storage over calcium chloride at room temperature gave best results. Storage over hydrated lime or charcoal was also good if refrigerated. Drying to a moisture content of 12 percent increased longevity of seed stored under refrigeration over hydrated lime. Drying otherwise had little or no effect. Exposed seed lasted longer than seeds sealed airtight.[23] Seed sewn ½ inch deep, 1 inch apart in rows 3–4 inches apart germinated in about a week. Seedlings grew rapidly, were transplanted to gallon containers at 6–8 inches, and to the fields at 2½–3 feet. "Growing the plants from seeds is undoubtedly the most economical and convenient method of propagating large numbers of plants."[24]

An international network of experimental stations should be established to share seeds as they become available from flowering species. Only a bamboo fool can know the intense frustration of walking a flowering grove of a commercially valuable species, ankle deep in places with fallen seeds, and no mechanism yet established to distribute them. Creating such an international exchange service, making seeds available to nurseries and parks, would be a significant act towards making the flowering of groves a positive rather than negative event.[25] International gatherings of bamboo researchers routinely agree that international seed collection, storage, and distribution are among the



Square bamboo is formed by placing long forms over growing shoots. The area in cross section enclosed by forms should roughly equal the area in cross section of the emerging shoot's base when grown.

The forms are tied together to allow expansion to the dimension of the growing shoot. The finished culm is used in the Orient for interior decorating.

highest priorities facing the world community of friends of bamboo.

HARVEST METHODS

Dating culms.
Bamboo should be three years old before harvesting. This requires a convenient system of marking the shooting year. One way is to rub the thin waxy film from a small area of a new culm with a piece of coarse cloth and paint on the year with India ink. Oil paint on a ½-inch brush also works. These methods last three to four years under ordinary conditions. Years can be color coded as well. A quick method used successfully at Savannah USDA groves is to stamp new culms with a small hammer and steel die which gives a permanent mark that needn't be so deep as to injure the culm. Mark all culms at same level for ease later in finding the year.

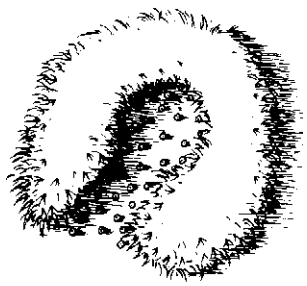
Clear versus selective cutting.
"Clear cutting at determined intervals and selective cutting are two general methods to manage groves. At first thought, cutting selectively, at a rate determined by ecological conditions, removing only mature culms three years old, would be the most natural procedure for maintaining a grove in a condition of sustained yield. The functioning of the grove as an organism is minimally disturbed, and removal of mature culms that would die eventually in any case would provide a natural stimulus to regeneration, similar to that produced by the moderate pruning of any plant.

"But economics might limit this biologically sound preference for selective cutting, which is several times more costly than clear cutting. Comparative, long-term yields, per unit of area and unit of time under the two harvesting systems must be determined by actual trial.

"A combination of the two methods may be best: immature culms, a small percent of the total stand, would be allowed to stand, providing a sustained source of nutrition to the network of rhizomes from which new growth would be produced."[26]

Harvest rules from Dehra Dun.
1. Cut no culms younger than three years or in the rainy season or from a flowering grove.
2. No cuts lower than second node or higher than 30 cm above ground.
3. Remove branches, culm tips, and all harvest trash: Debris obstructs growth, encourages disease, and makes later harvests more difficult.
4. Leave leaves for mulch. Their 6 percent silica helps harden later culms.
5. A minimum of six mature culms are left uncut in each clump of tropical species, to sustain grove vitality and insure steady yield.

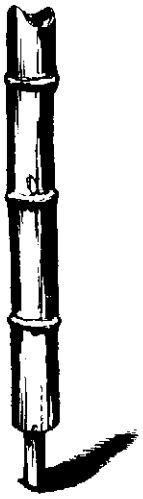
Horseshoe harvest.
Clumping, sympodial bamboo's growth form presents a harvesting problem. Centrifugal growth of new culms around the grove edge leaves oldest stems most fit for harvest surrounded by immature culms whose silica content, and consequent hardness, is still increasing. The solution is a horseshoe harvest. Cut into the grove from the direction that sacrifices the fewest younger culms. Store these separately for basketry or other use. Harvest third-year mature culms from within the grove, gradually extending the harvest year by year to ripening younger culms. Some feel it's better to cut smaller species with a saw to avoid leaving dangerous points to wound later harvesters.[27]



A horseshoe harvest is imposed by dense tropical clumps in order to cut a minimum of young culms on the periphery and reach the seasoned canes at the core. Dark circles indicate harvested culms.

Battle beetles better with clump-cured culms.
Harvest bamboo at the beginning of the dry season. Leave culms standing four to eight weeks in the groves, propped on stakes or rocks, with branches and leaves uncut to increase evaporation surface and diminish insect entry points offered by freshly cut skin. This clump cure not only reduces starch content, which the bamboo beetles seek, it also greatly decreases the tendency to crack while producing a pleasing uniform color on the culms. *Bambusa vulgaris* cured this way was 91.6 percent less attacked by beetles than untreated culms in USDA Puerto Rico experiments at Mayaguez.[28]

Removing branches.
Although bamboos harvested for construction obviously require less care than culms cut to make flutes



A stake in the basal internode keeps the culm off the ground during a clump cure.

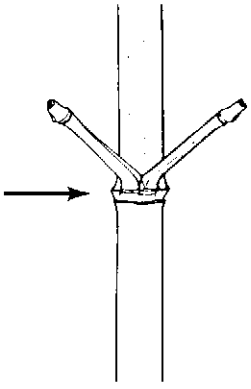
or furniture, scratching a culm diminishes beauty and value. One way to avoid scratching the culm when removing branches is to cut a third of the branch thickness from underneath with a hacksaw. (A molybdenum blade is best with eighteen to twenty-four teeth per inch.) Then snap down on branch. If cutting with a machete, always cut up-culm, that is, towards tip. Swinging down-culm tends to scalp the internode below the branch removed.

Making the crooked straight.

Practicing any of the following cures for the bamboo bends will quickly communicate the commercial importance of ramrod erect species like *A. amabilis* or *B. textilis,* which don't require the touch of human correction to find the shortest distance from toe to tip.

Low tech, long term: hang a curved pole, when freshly cut, by the tip in the shade, tying a stone or other weight to the base. Two to four months will straighten it, depending on the curve, the species, the weather, and the weight used.

Drive a line of nails at 16-inch intervals along a board or floor. Bind crooked culm to them where necessary, weight where it curves up from floor surface. Presoaked dry poles also respond to this treatment.



To remove branches, cut at arrow and snap down. Leave branch stubs or entire branches to support tomato, bean, and other garden crops without tying. (A **Phyllostachys elegans** *midculm node is shown.)*

Heat is the most common, fast, and effective treatment to straighten crooked culms: with wood or charcoal fire, with blowtorch, Bunsen burner, or gas stove. Steam heat, where available, is best. But all these alternatives, enacted on a large scale, are energy dear; so long-term bamboo development implies growing erect species, not burning up the local forest to straighten the local groves. Ridiculous waste levels, unadvisable for the individual, impossible for a planet norm, can no longer be so casually included in our cultural designs. But straightening a few culms over campfire is neither costly nor difficult. You can adapt the following method of professionals in India to your particular hearth and need.

Market preparations in India.

> Few forest operations in India are more interesting to watch than the preparations of raw bamboos for the market and the conversion of the rough, crooked, dirty-looking stem as it comes from the forest into the highly polished, rich brown lance stave or tent pole. Extremely primitive methods effect this remarkable change, as efficient as more up-to-date appliances. First, stems are cut to length and nodes are cleaned by a gang of small boys with sharp adzes. A broken skin means a ruined stem, so knot cleaning requires a certain skill. After an apprenticeship on cheaper grade bamboos, the boys become remarkably good, rarely making a bad shot . . . the *kammaggars* then warm each stem over a hot fire of two large logs. This supples the culm, imparts the fine brown color, and by melting the dirty waxy covering gives the stem a clean and polished appearance. Once the stem is sufficiently pliable, curve and kinks are taken out by handing with some force in an opposite direction. Two tools are used: for heavy stems, an upright pole, bored with slanting holes, is planted in the ground. The kammaggars put the warm bamboo in a hole and press with considerable force to bend it in the right direction. For lance staves and other delicate work, the kammaggar holds a stout stick with a groove in it in his right hand, in his left the stem to be straightened, which he works carefully along its entire length. Several firings may be required for perfect straightness. Considerable skill is necessary to warm without scorching the bamboo, then bend without breaking the fibers.[29]

Straightening *Arundinaria amabilis* in China.

"Each worker has a thick-walled earthenware fire-pot, without a chimney, in which a kind of smoke-

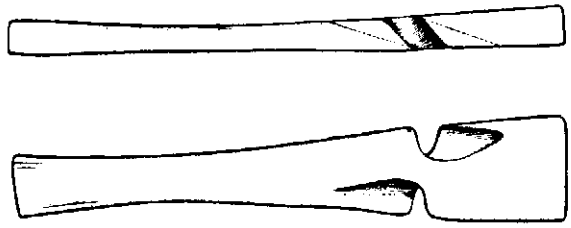
less coal is burned, a very hot bluish flame playing above the incandescent coals. Two large bricks are laid across the top of the firepot with a space of about 1½ inches between them, through which most of the flames pass. The bamboos to be straightened are stacked for a time, in their original bundles, on the racks which are about a foot above the firepots. Thus they are gradually warmed up. The worker sits on a low stool before his firepot, from which position he can reach and pull down the bamboos from the rack without rising. The culms are thrust, one at a time, into the glowing channel between the two bricks, kept there in motion for the brief space of two or three seconds, then withdrawn and subjected to a vigorous straightening process by means of a wooden tool. The various crooks in each bamboo are straightened separately, the heatings and bendings following each other in quick succession. In straightening the larger culms, some of which are 2 inches or more in diameter, a slightly different technique is used to get the necessary leverage, but the fundamental process is the same. They must be held rigidly in the desired position until the tissues are cool for a permanent set.

"Essentially the same technique is used to straighten green bamboo and bend semicured stems for furniture. The pectic compounds which cement plant cells together are soluble in hot water. Although the culms are comparatively dry after repeated sunnings, perhaps the water present is sufficient, when heated, to cause a softening of this material which makes possible the slight adjustment between the tissues necessary in the straightening process. When the tissues cool, the pectic layer then hardens again to hold the tissues rigidly in their new relation."[30]

Storage and shipping culm bundles.
After removing branches, cut culms to desired length and store by species in curing sheds that are rainproof but breezy. Store largest diameter culms lowest, on horizontal racks, with supports at intervals of a few feet to avoid sag and consequent bend in culms. If cost or time prohibits ideal storage, at least keep stems shaded, ventilated, and dry. Avoid leaning without turning as this creates bends.

To ship culms, tie in bundles roughly a foot in diameter tightly so that they don't scratch one another. Then wrap in burlap or similar material and wire the bundle securely.

A wooden tool used in China to straighten smaller culms after heating *(× ⅓).*



BUGS LOVE BAMBOO: PROBLEMS AND SOLUTIONS

Resistant Eastern species move west.
"After a number of years in Oriental countries, the writer in 1934 came to the Western Hemisphere tropics and was impressed by the absence of articles of bamboo in farm and household life . . . It quickly developed that there was one outstanding factor, in the West Indies at least, preventing much use of bamboo. *Bambusa vulgaris* was the most common species there, with culms comparatively soft and susceptible to boring insects. Articles made from this bamboo, often within a few months, were riddled by the small powder post beetle, *Dinoderus minutus*. Species of *Dinoderus* were widespread in the Orient, so we concluded that bamboo used for farm and industrial purposes in the Far East must be resistant to this borer . . . Numerous Far Eastern species were immediately secured to determine resistance to borer infestation.

"At Mayaguez, Puerto Rico, standardized tests were made, using *Dinoderus minutus* as the test insect. Bamboo samples of different species were placed in small cages of about 1½ to 2 feet of cubic space. Into each cage, five hundred powder post beetles were turned loose for thirty days. Counts of borer channels on samples then gave quantitative measures of susceptibility. Howard Plank continued and improved these tests. He found *Bambusa tuldoides, B. tulda, B. textilis, B. longispiculata* and *Dendrocalamus giganteus* notably resistant, and a number of still untested bamboos can be expected to be resistant. Age and maturity of the bamboo greatly alters resistance. Even *B. vulgaris,* if cut at five to six years and left standing four to eight weeks in the clump with branches untrimmed, was much less susceptible to borers than one- or two-year-old culms. Plank also established a relationship of carbohydrate content to susceptibility. The beetle is seeking starches and sugars, which explains the function of exhausting the carbohydrates by soaking in water, cutting five- to six-year-old culms, and hardening them in the clump after cutting."[31]

Puerto Rican tests and conclusions. Clump curing culms with branches uncut, leaving them to stand four to eight weeks propped in the grove, controlled up to 90 percent infestation. Best results if harvested in hot, moist weather; the culms remain alive a month or more and lose most of their starch. Shed curing at least eight weeks after clump cure reduced susceptibility even more. Infestation was reduced 94 percent by eight-week water cure of freshly harvested culms—but culms became stained, light, and brittle. Complete submergence for twelve weeks was ineffective. Clump curing before the water cure was better than water alone, and best was clump-shed-water.

Starch content largely determines susceptibility and is measured by the iodine spot test. Species, age, time of harvest, and physical properties of the wood are determining factors. *B. vulgaris,* with the most starch of eleven tested species, was most attacked. Relative susceptibility of one-year culms in eleven species varied from 44.2 percent in *B. vulgaris* to 0.3 percent in *B. textilis.* With minor variation, susceptibility diminished in ascending internodes of culms. Harvesting by phases of the moon, contrary to popular belief, does not influence durability. Kirkpatrick also found that traditional bamboo moonlore is not confirmed by tests, and claims ripe bamboo (five- to ten-year-old culms) is actually more subject to borer attack.

Bamboo cut with moon on wane
Will ensure financial gain,
But beetles bore it very soon
If cut upon the waxing moon.
Moreover it's a well-known fact
That ripe bamboo is less attacked.
So say the chaps who ought to know—
Alas! It really is not so.
For Science reared its ugly head
And knocked these superstitions dead:
The lunar myth is utter tripe
And borers like *their bamboo ripe.*[32]

CHEMICAL METHODS. Injecting poisoned water solution into sap stream was explored. Copper sulfate (by the stepping method) gave 93 percent control in two tests and was found more effective in dry weather for rapid absorption. Hydrochloric acid injected into sap stream failed to hydrolyze starch in culms and also weakened them. Other methods tested were also found unfeasible. Many other chemicals, including those used for lyctus control in lumber, were tried and found ineffective—and also stained culms or reduced their strength or quality. DDT, 5 percent in kerosene, brushed on freshly harvested culms reduced internodal infestation 94 percent at 2½ months after application. DDT, 5 percent in diesel fuel oil, a ten-minute dip, reduced infestation 98 percent at 3 months, 91 percent at 12 months, and was still toxic to beetles three years after application. Previous clump curing doesn't improve control in DDT treated culms, but splitting culms or breaking out nodes increases absorption and effectiveness of dip. Minimal handling of treated culms in storage is best—to leave residual coating of DDT intact; make only necessary inspections. At three months, a second dip is recommended. Water suspensions of DDT, preferably micronized forms, are better than oil solutions for culms to be glued.

Beetle populations in sheds can be reduced by spraying DDT on curing racks and inside curing sheds, workrooms, and wherever finished or in-process bamboo articles are stored.[33] *We report without recommending:* DDT is very foul stuff.

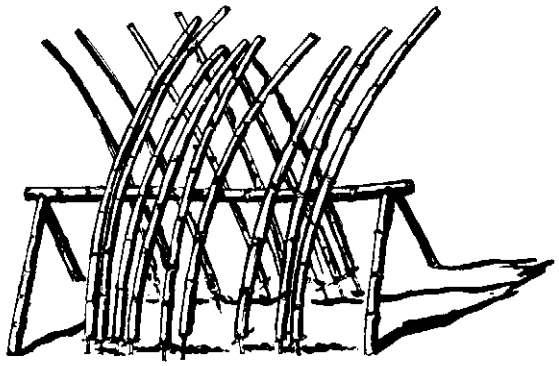
India: love, life, and hungry habits of the bamboo beetle. In India, the estimated life of a bamboo pole after cutting is a year to a year and a half, owing to the ravages of *Dinoderus minutus,* the bamboo powder post beetle—a creature roughly a quarter the size of an o on this page—whose total jaws are at this moment reducing tons of bamboo to dust around the world. In a heavily infested piece, you can hear them chewing. They bore holes a bit larger than their own diameter, tunnels made en route to laying eggs inside the culm wall.

Each female beetle lays twenty eggs. A few days later, tiny white dots—grubs—emerge and begin four weeks of burrowing in the culm wall, reducing it to powder and beautiful ruins. These larvae then enlarge the ends of their burrows to become pupae or nymphs. Some eight days later, they emerge from their cocoons as mature beetles and fly off to destroy a different culm or remain to further devastate their native pole. The few holes visible on the culm outside no more gauge the damage within than the number of doors on a building tell you how many people are inside using it. Successive generations use the same entrance and exit, so a culm appearing mildly attacked may be a labyrinth of dust.

In warmer areas, *D. minutus* can pass through five or more generations in a single year. Females usually outnumber males, but even figuring 50 percent females, beetles laying twenty eggs and passing through five to six generations between April

and October–November can multiply from 2 to 200,000 or even 2 million in a season.[34]

> A small number of holes may be a sign of resistance to beetle attack since they sample poles with ¼-inch holes and abandon those found least suited to their taste. The Timber Testing Section at the Forest Research Institute, Dehra Dun, has run strength tests which indicate strength varies greatly, pole to pole, independent of the number of holes. A distinct loss of strength does not appear until the number of holes approaches two hundred per pole. Storage methods can increase or diminish beetle attacks. Creosoted racks without contact between poles is best since beetles enter where bamboos touch surfaces.[35]



Curing in the sun is one way to preserve bamboo, but culms must be turned periodically to prevent the bending shown here.

Culms are often bundled for ease of handling when sunning, and the bundle maintains straightness of individual culms.

Treatments.

SUN AND SMOKE.

> Exposure to the sun can afford very effective protection. In fact, this is the principal device used in the Far East, where bamboo is so extensively used in making basketry, matting, and withes. In rural China, baskets and small bamboos for home use are often stored in the loft above the kitchen exposed to heat and smoke from fires, which provide effective protection.[36]

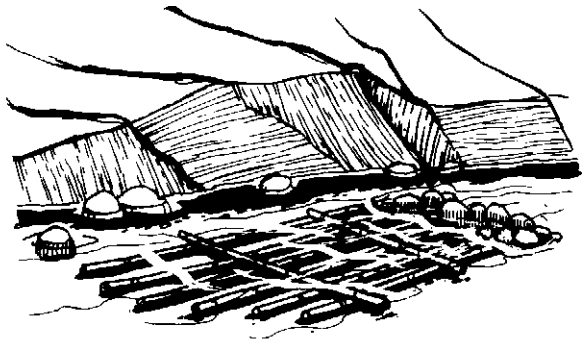
SOAKING. Preservation by soaking is the cheapest and simplest chemical treatment method. The culms, preferably green, have only to be kept immersed in a preservative solution for a period of five weeks or more, depending on species, age, thickness, and degree of absorption desired. Longer soaking is required for bamboo that will be in contact with the ground. Adequate absorption can be obtained by soaking: The disadvantage is the time required.

In split bamboo, the soaking period can be reduced 33 to 50 percent with 100 percent penetration of inner and outer wall. Rupturing the outer skin and use of high temperature hastens penetration. In full culms, knocking out nodes speeds and improves treatment. Soaking can be advised for the treatment of all bamboo for all purposes. It requires little equipment and technical knowledge, but the type and concentration of preservative and soaking time must be carefully worked out.

Make a simple tank: cut top and bottom off several oil drums, depending on length of bamboo to be treated. Weld together to form cylinder closed at both ends. Divide lengthwise.

1. Soak poles five days in water. A thick, shiny gelatinous substance exudes and is wiped off. This increases oil absorption.
2. Dry poles completely.
3. Soak forty-eight hours in Rangoon oil (a thick, heavy petroleum from Rangoon, Burma). Though stored in a beetle-infested area, fifteen thousand bamboos so treated were reported perfectly sound five years later.[37]

LEACHING. The most common preservative treatment for bamboo in the Orient is to leach out the starch, sugars, and other water-soluble materials sought by insects. This is done by weighting down and completely submerging freshly cut culms for three days to three months, preferably in running water since standing water can stain bamboo. Sea water is also an alternative if marine borers aren't present. However, water leaching at Mayaguez, Puerto Rico, was reported to result in excessive stains and brittleness of wood.



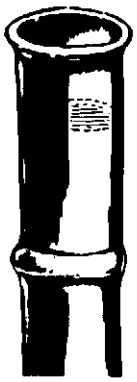
Bamboo grows well along rivers, so commercial or experimental groves are often planted at riverside locations for ease of transport. Water is therefore readily available to leach out the starch that attracts bamboo beetles.

Chemical preservatives.

The master disaster, the chief planet polluter, indirect cause of and carrier to distribute the New Poisons all over the maps, catastrophe par excellence of modern times, the car (and its extensions) is a recent inhabitant of earth that roams like a roaring lion devouring more civilized space than any old-fashioned species alive including its drivers, and certainly makes more impact per hour on the style and quality of our existence than any other single product of our culture.

By whatever name, the car looks as pretty approaching in all cultures, and smells as rank in its wake. Industrial countries are "advanced" in direct ratio to their pollution: superpolluted, superpower. Poorer countries, apparently, are determined to reenact the chemical disaster of modern settlement, transport, production, and agriculture as rapidly as possible. Each seems set to relive in turn the tale of the prodigal son, squandering limited resources and living like a hog before returning contrite, to the lap of nature mother's house to behave with ecological sanity *imposed,* not chosen, at last.

WICK ACTION, CULM-CUP CURE. Freshly cut bamboo with branches and leaves left on can be stood in preservatives to a depth of 1 to 2 feet (30–60 cm) for one to two weeks, allowing wick action to suck up the solution as the leaves and wood dry. Preservative can also be simply poured into the basal internode of an inclined bamboo or into a bike or



Culm-cup cure.

car innertube firmly clamped or tied to the base of the stem with the butt end elevated enough to let the solution soak down into the culm.

BOUCHERIE PROCESS. For freshly cut round bamboo with nodes intact, the "Boucherie process" is the most effective treatment. The preservative is gravity fed through pipes and rubber tubes clamped to stems from an elevated tank some 30 feet above ground, or pressured into culms at ground level by a simple hand pump, which considerably shortens the treatment period.

COATING. Whitewash, tar sprinkled with sand, and such coatings are effective only if they give a continuous coating at cut surfaces. Inner walls made accessible by splits in the culm cannot be effectively protected.[38]

Chemical cures.

Runner-up in the Dirty Derby of modern pollution, choking close to the exhaust of our National Car, is our National Chemistry Set. The chemical nightmare of industrialized cultures is an intimate cofunction of the car. In addition to large-scale tactics to clean up our air and water, we each have to drive less and purchase fewer poisons if we expect to reverse present trends. Chemical preservatives have been much explored to make bamboo unappetizing to bugs, but they are all too expensive for broad scale use among the people, quite apart from their environmental contamination. Selection of proper species, proper harvest and curing proved sufficient for centuries of marvelous bamboo use in the Orient before the appearance of modern chemical techniques. Bamboo strips used for military archives and grocery lists have lasted over two thousand years in China. We have mentioned the bamboo organ in the Philippines still sound since its construction in 1821, cured simply by a six-month burial in sand.

So, in light of the above, we have decided to exile advice on chemical cures to a tiny footnote. For those interested, Narayanamurti's United Nations publication on bamboo use provides extensive lists of recommended pollutants.[39]

Culm anatomy affects treatment.

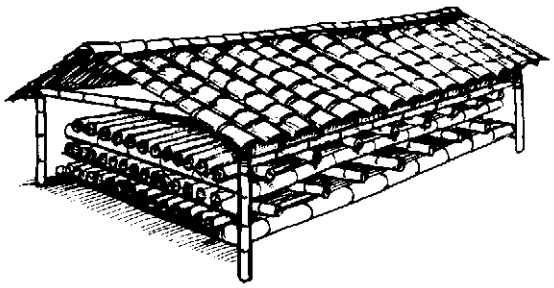
"The tissue of the bamboo culm is built up by parenchyma cells and vascular bundles consisting of vessels, thick-walled fibers and sieve tubes. The movement of water in the culm takes place through the vessels. The fibers are responsible for bamboo's strength. Nutrients such as starch granules are stored in the parenchyma cells which compose up to 70 percent of the tissue. The vascular bundles become progressively smaller in size and denser

towards the periphery. The orientation of all the cells is in the vertical direction. The culm is covered inside and out by hard waxy cuticles which offer considerable resistance to the absorption of water. (This characteristic is important when impregnation of preservative chemicals is required.) *Fibers* constitute 60 to 70 percent by weight of the wood of bamboo. Fiber predominates in the periphery; parenchyma, inside. Fibers are most dense in internodes at ¼ to ½ culm height, where longest, most mature and thick-walled fibers are found. Fibers gradually decrease in length, maturity, and cell wall thickness towards culm tip. Bamboo fibers vary considerably in shape, size, and wall thickness. They are usually long and straight with tapering ends, the length roughly one hundred times the diameter.

"*Parenchyma tissue* abounds in bottom internodes and inner wall, descreases towards the culm tip and periphery. The *vessels* occupy only about 15 percent of the culm. In internodes, vessels are parallel to stem axis, without branching or contact. Intensive branching inside nodes makes horizontal transportation of liquids possible, and pits connect vessels. The vessels, through nodes, connect culm walls and some go into branches.

"The distribution of vessels affects preservative treatment, which occurs not only at culm upper and lower ends, but also through cut branches at nodes, from where preservatives can penetrate culm in both directions. The number of vessels available for treatment generally decreases with height. When bamboo is dried, the sap in vessels dries up and the vessels fill with air. Pits inside the nodes close; pit openings of parenchyma cells are closed by their own dry cell sap. These factors influence preservative treatment of dry bamboos. If a preservative is to penetrate into the vessels, it has to overcome surface tension and friction forces. In order to enter parenchyma cells, it has to dissolve out dried sap closing their pit pores or diffuse through the cell walls."[40]

Storage: function and description.
At the storage yard, bamboo is air seasoned under cover six to twelve weeks to increase strength and avoid cracking. Kiln seasoning can do the same job in two to three weeks, though at risk of splitting the outer membrane of several species if the seasoning is too rapid. To reduce fungal attack, guard bamboo against wetting by rain or contact with soil. Good ventilation and frequent inspection are important. The storage ground should be thoroughly inspected



Curing and storage shed.

and cleaned before laying out, all refuse and useless timber and bamboo removed. Termite-infested areas should be sprayed with 4 percent emulsion of DDT or 0.2 percent emulsion of BHC or other suitable insecticide. Destroy termite colonies by breaking mounds open and pouring in insecticide. The ground should have good drainage facilities.

Bamboo should be stacked on high skids or raised platforms, at least a foot above ground for prevention of termite attack, stored so all sides may be readily and regularly inspected. Remove or treat attacked culms.[41]

Pests, smuts, and rusts.
Rats, porcupines, squirrels, hare, deer, and monkeys are reported to gnaw rhizomes, eat shoots and seeds. Goats and cattle trample rhizomes and devour foliage. Monkeys can also damage young brittle culms by leaping onto them, and elephants trample and feed on groves. To this list of bamboo enemies, some Indian authorities add wild pigs, thieving villagers, and mischievous boys—but the animals causing the most damage are the executives, agronomists, and field hands of transnational corporations, now landscraping with machines of immense dimensions but without the moral and ecological consciousness needed to manage safely a team of mules, as Wendell Berry remarks of the strip miners grunting after coal in Kentucky. As usual, the human race has been the chief nuisance to bamboo, exterminating vast tracts for cattle, cotton, or other crops. In other areas, deforestation occurs when growth cannot keep pace with indescriminate and untrained harvest.

Living bamboo holds its own very well against all pests but us, and most of the following are infrequent and minor visitors of its vitality. *Bamboo smut (Ustilagoshiraiana)* is a parasitic fungus related to the smuts of corn, wheat, oats, and other grasses. Its known occurrence is limited to the genus *Phyllostachys,* and it attacks only new twigs and leaves. Twigs swell, growth is checked, and

later the sootlike spore masses break through. All infested culms must be cut down and destroyed, and their rhizomes—where the smut mycelium apparently lives perennially—must be dug and burned. There has been no bamboo smut reported in the United States since 1909 when an outbreak accidentally introduced from Japan was arrested.

BAMBOO RUST. Of the dozen or so bamboo rust fungi reported from around the world, only *Puccinia phyllostachydis* Kusano is known to reside in the United States. It only attacks *Phyllostachys* bamboo and, although widespread, does not cause serious damage. The rust attacks new leaves, with brown powdery spots appearing on the underside, yellow spots above. Rust-infected leaves should be removed before shipping or planting propagules. Locate any contemplated bamboo nursery a goodly distance from any infected plants in your area.

Myers lists fifteen scale insects, nine miscellaneous bugs, four mites, and one thrip thriving in the United States, together with their locations, the species they attack, their occurrence elsewhere in the world, and when they were first apprehended by the USDA.[42] Stanford University campus enjoys the distinction of having hosted the first recorded bamboo pest in continental United States (1899). Young describes various bamboo diseases and remedies in a broadly available USDA handbook: fungi, which attack new growth, including new twigs and leaves, and nematodes or eelworms, which infect roots, are mentioned, but scales are more important.[43] "Bamboo scales (sucking insects that feed by extracting juices from the leaves and stems) assume serious importance only when because of neglect infestation becomes heavy." Heavily attacked canes should be cut and burned. "More lightly infested ones should be sprayed in the spring when the young crawlers are present. A white-oil emulsion diluted to 1 to 2 percent oil and fortified with 1½ pints of 50 percent malathion emulsifiable solution per 100 gallons of spray should be used for spraying. It should be repeated weekly about three times to kill all the crawlers as they hatch."[44]

Young's descriptions of the physical appearance of pests and the symptoms they cause in bamboo are detailed and useful for bug identification. Some of the cycles are complex. For example, the *bamboo louse,* or aphid, found under leaves of *Pseudosasa japonica* and other *Sasa* and *Bambusa* species—often in large colonies—is pale yellow, 1/10 inch long, with some light brown and dusky markings. It excretes sugar water that in turn becomes a medium for a mold that gives the plants a sooty, ugly appearance. It is controlled like scales.

A *roundheaded beetle* or grub that damages *Phyllostachys* rhizomes reveals its presence by wilting young culms. The infested rhizomes must be dug up and destroyed. Various *mites* are noticed by small white webs on leaves. Control in rhizomes chosen for propagation is helped by dipping them in hot water—122°F—for ten minutes.

A *fungus (Melanconium bambusae)* occasionally attacks medium to large culms of large species of *Phyllostachys.* Its presence is often first noted when new culms reach almost full height: Basal internodes turn purple black or brown, beginning at their base and extending upward. Eventually the culm dies, its walls full of mycelial threads, the vegetative parts of the fungus, which is thought to attack only culms previously cut, bruised, or injured in some way.

Bugs versus bugs: biological pest control.

> Two destructive insect pests attack growing bamboos in the West Indies. Both are scale insects—*Asterolecanium miliaris* and *A. bambusae.* Spraying a crop such as bamboo to kill insects is not feasible in tropical, heavy rainfall countries and is impractical for small farmers of limited means. An effective remedy, however, has been developed. The writer observed lady beetles which were feeding upon and destroying these scale insects in Venezuela, Panama, and Jamaica. . . . The director of the Mayaguez, Puerto Rico, experiment station imported from Brazil, Trinidad, and Cuba some six or eight *Coccinellid* species which prey upon these scale insects. Harold Plank brought in another from Texas, and the writer still another good predator of this type from Martinique. They are now effectively controlling these two scale-insect species in Puerto Rico. This procedure should be possible in other countries.[45]

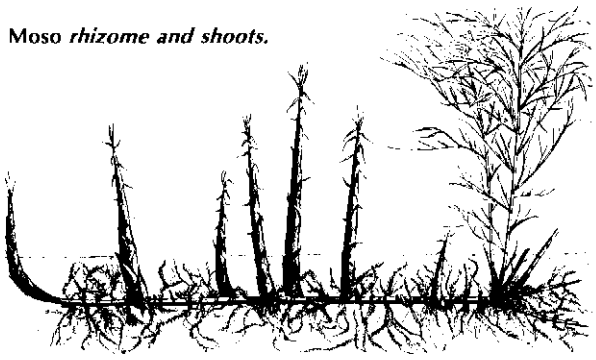
GROWING A GRACEFUL GIANT: MOSO CULTIVATION IN JAPAN

Hairy bamboo: *Phyllostachys pubescens.*

Moso bamboo was introduced into Japan from China by Zen monks, according to some traditions, early in the eighteenth century.[46] "Hairy bamboo," as it is called in China, reached Europe by 1880, the United States West Coast about 1890, and—by way of Rufus Fant's groves in Anderson, South Carolina—the USDA Savannah groves in 1926.

Softer tissued than *P. bambusiodes (madake),*

Moso *rhizome and shoots.*



moso culms are less valued industrially. But larger ones are prized as alcove posts in Japanese homes (the *tokonoma*), and many are used as floats for giant fish nets, each net requiring as many as a thousand culms. In Miyazaki-ken alone, some twenty thousand moso culms are used each year for these yellowtail nets, and many more are grown for export to Korean fishermen. Drainage pipes for ships, New Year's ornaments, flower vases, teapots, kettle pads, slop basins, trays, carved brush stands, dippers, cigarette cases, tea boxes, basins for wine cups, sake containers, tobacco cases, cups, rice bowls, soup cups, and confectionary packages are all made from moso culms of different types and from specific parts of the culm.

Some thousand boxcars of bamboo, each carrying about nine hundred moso culms 20 feet long with branches left on move from the coast to Tokyo each year at seaweed season. Young seaweeds (used widely in Japanese cooking) get tangled in the culms and branches and continue growing there. Because of its numerous branchlets, moso is also the preferred material for bamboo brooms. Culms are used according to their character: elastic ones with thick walls are used for lantern holders, and the framework for cages and fans. Durable culms become cages, wicker trunk frames, and winnowing baskets. Culms with toughest walls make small shovels and packing cases. Pliable poles make dippers and coat hangers; the most workable culms become combs, forks, knives, spoons, silkworm net frameworks, and varnished chopsticks.

Moso *sheath tip and blade.*

The sheaths of moso are less used than henon *(P. nigra* var. *henonis)* or madake sheaths, but large ones are used for wrapping. Thick ones stuff slipper soles, and charred sheaths are used as a remedy for bleeding, stomachache, and wounds. Moso rhizomes, like those of henon and madake, are used to make canes, whips, and umbrellas. These same rhizomes, living, are effective for erosion control on riverbanks and the 7–15-degree slopes where moso often thrives.

Edible shoots are the principal product from moso in Japan. Roughly 40 percent of Japan's 123,000 hectares (307,500 acres) of bamboo—about 50,000 hectares (125,000 acres)—are devoted to moso cultivation. The export of shoots has grown to be a major industry all over the country, particularly as Japanese cuisine, requiring bamboo in many recipes, has become popular in America and other areas of the world. Production staggers in the wake of demand, and crops are sold before they're canned.

Rhizome.

Since moso is of such economic importance, its habits of growth, soil preferences, and propagation methods have all been subject to scrutiny for many years. The moso rhizome is where the story properly begins. Sometimes as much as 6 inches in circumference, growing 12 feet or more in a single season, the rhizome grows about 29 percent of this in June and July, 50 percent in August and September, and 30 percent in October before coming to a sudden and full stop, lasting from early November to late May. Beginning with 10 percent growth per month, the rhizome gradually triples its speed until its abrupt halt in the fall. The life expectancy of a moso rhizome is a decade or more, but it is most active from three to six years of age. When the tip of a growing rhizome is injured, a branch rhizome

angles out from a bud behind it for 3–5 inches at an angle of 7–15 degrees and then angles back to run parallel to the original direction. In the eighth or ninth year, decay sets in and by the twelfth to thirteenth year it becomes complete.

Culms.
Moso culms complete their growth some forty days after the shoots appear above ground. They grow faster by day than by night and more in afternoon than morning hours. Maximum growth occurs some ten days before completion, when the culm grows more than 3 feet a day, eventually reaching 75–80 feet, making moso the largest—some claim the handsomest—of the *Phyllostachys*.

Cultivation for lumber is called a "grove"; edible shoot cultivation, a "garden." Moso garden practices include annual tillage to reduce weeds, relocating rhizomes more densely to increase shoot production in a small area, and dressing with mulch. Unlike madake or henon, moso grows fairly well in poor soil. Compared with other agricultural crops, bamboos have come through little artificial selection, so moso—like other grasses—is fairly resistant to disease and insects. Moso is, however, easily wind damaged owing to its luxuriant foliage, broad spacing in a grove, and shallow roots. Most rhizomes are in the top 1½ feet of soil, and few go lower than 3–4 feet. This means only 2–3 percent of its altitude is anchoring the moso culm, and high winds turn culms into 75-foot levers to uproot themselves.

Moso *shoot.* *New* moso *culm.*

Hillside culture.
Hillside lands with a slope not greater than 15 degrees are suitable for moso. They should slope towards sunlight, southeast, south, or southwest. Drainage is improved, and the slant catches more direct sunlight, hastening decomposition of soil nutrients and promoting growth of shoots in spring: A 10-degree rise in temperature can increase chemical processes in plants by 50 percent.

Soil types.
A clayey loam soil, which produces good sweet potatoes and taro, also yields excellent moso with bright color, soft texture, good fragrance and taste. In Fukuoka market, shoots with black soil on the sheaths sold cheaper than shoots with red soil. Crafty merchants would wash off the dark soil and rub on red, well known to produce top-quality shoots. Soil too heavy with clay (60 percent) should be avoided, however. Since clay is quite cohesive and a poor conductor of heat, there's less air and breath in the soil, which is always cool, thus slowing decomposition of organic matter and retarding moso growth. Humus soil (over 20 percent decayed vegetation) is easy to work but becomes acid easily, and the quality of moso shoots is not optimal. Marly soil (over 15 percent calcium carbonate finely divided) is one of the best for moso. Loamy soil (30–60 percent loam, 40 percent sand) is also satisfactory, but clayey loam is the soil most sought by Japanese moso growers.

Preparing land.
Shrubs and weeds are dug out, and soil is cultivated to a depth of 1½ feet. Moso rhizomes eventually go as deep as 3–4 feet, but most are in the top 1½ feet of soil so deeper cultivation is unnecessary and uneconomical, although clayey soil can be worked to 2 feet. One hundred workdays per acre are figured for hand clearing and cultivation. Fertilizer —manure, compost, hay, whatever—is worked in the summer before actual planting. Spot cultivation of scattered circular areas about 5 feet in radius is practiced when larger plantings cannot be afforded in a single year. Belt plantings 12 feet wide can also be staggered across a field. Contour belts on river-

Moso *branch complement.*

banks or sloping lands should be at right angles to the slope.

Drainage is very important. On flat lands with standing water, provide ditches to remove it. Soil acidity can be corrected with about 1,000 pounds of lime per acre, which will not only neutralize the acid but will also aid in making available otherwise insoluble nutritive elements and hasten decomposition of organic materials. Cedar or other trees should be planted as windbreaks to protect grove from cold winter winds in the area. Since moso uses liquid fertilizer, some water storage is necessary where running water is not available.

Choosing stock plants.

Vigorous young bamboo culms one to two years old are selected for stock plants, with a preferred circumference of about 5–6 inches. Older culms may initially produce more shoots around them—but it is rhizome development that's most desired in a new grove, and younger plants produce more rhizomes. Plants grown in sun are preferred for stock to shaded bamboos, which tend to be softer textured in culm, branch, and leaf. Early shoots are a recommended propagating material: They can be dug out easier since their rhizomes tend to be near the surface. They are marked for transplanting in the fall or the following spring. Clear cutting a grove in February produces a large number of slender shoots that are ideal for propagating material on a large scale. Rhizomes alone can also be used, cut into lengths 12–18 inches long with a minimum of five good buds on each length. Place immediately in a nursery bed, taking care they don't dry out. The bed should face south, with moderately wet sandy loam soil that is well tilled and fertilized with soybean cake or rapeseed oil cake. Make trenches about 2 feet wide; put rhizomes every 6 inches, and cover with a little soil and a straw mulch to preserve moisture and check weeds. Fertilize twice before September. In the first year, these rhizomes may produce some thin shoots resembling *Sasa* bamboos. In the second year, shoots may measure 2–3 inches in circumference. If the leaves of young plants turn yellow, use ammonium sulfate and soybean cake from September to October.

Transplant timing.

Plant bamboos any time except in extreme heat of summer or cold of winter, but best is March or October-November. Winter transplants should have a larger protective ball of earth; in summer, wet straw should wrap the roots and sometimes the culms as well. Transplanting is best when rhizomes have stored a sufficiency of food, in fall when growth is about over or in spring before it begins. One disadvantage to spring digging in a grove is the possibility of injuring emerging shoots. Nevertheless spring is preferred to autumn, especially in colder climates. The best day is a cloudy one with no wind, with a rainy day following. If possible, avoid transplanting on a rainy day.

Uprooting rhizomes.

Satow (1899) cites the Japanese tradition that a large bamboo clump requiring ten men to lift will establish itself in one year, and a bamboo propagule one man can manage will take ten years to reach mature growth. Choice of size depends on convenience, distance of transport, and other factors specific to each case. A trench is dug with a radius extending about 1½ feet around the bamboo to be transplanted, cutting off rhizomes at that point. Usually, rhizomes run in the direction of culm branches. In a tangle of rhizomes, be sure to cut only those belonging to the culm you're extracting. Strike the rhizomes with a piece of metal—a spoon will do—and listen closely at the culm for the most pronounced vibrations. Culms close together—6–10 inches—should be transplanted together.

Pry the clump up out of the hole with a stout pole, being careful not to hold culm when removing. Any pressure on culm can, increased by leverage, injure its delicate connection with the rhizome. Cut off branches with a fine-toothed saw to minimize drying and later wind damage: Tissue on cut branch or culm dies back locally to node but no farther.

Remove the soil from the rhizome and study

the buds: If buds are missing, damaged in digging, or not obviously alive, discard the rhizome. Vitality, not bud size, is the issue: It can be tiny as a soybean or already swelling. If possible, move bamboo with original earth around it; 120–200 pounds is recommended as optimal for a 2–3 inch culm. Wrap securely with rope, with burlap, then rope again.

Shipping plants.
Take care they don't dry out. Cover with mats or straw and keep shaded as much as possible. Avoid injury (by shaking and so forth) to delicate area where culm and rhizome join. Avoid injurying rhizome buds. If little or no soil is left on roots, wrap rhizomes in wet straw, then burlap, then rope and tie securely so that roots maintain snug contact with soil or straw. Ship by most rapid and economically feasible means. In one sizable moso shipment, there was 20 percent mortality among 135 rhizomes in twenty-seven days between digging and arrival at new location—even with these precautions. (See McClure's mud mayonnaise, pp. 210–211.)

Spacing.
Around 180 plants per acre—120 minimum, 240 maximum—is the rough consensus of moso experts, with 12–25 feet between plants. White (1945) recommends hexagonal plantings for maximal erosion control on slopes.

Planting.
The planting hole should be shaped according to the individual plant, larger than the ball of soil, and about 1½ feet deep. Rhizomes should run at right angles to the slope on inclined land. The old ground line is usually clearly visible on culms—green above, yellowish below. Replant at the same ground line, a little deeper on very windy land, a little more shallow where it's moist.

Fertilizer should be applied at transplant, under and around but not touching the rhizome—circling the plant on flat land, in a half circle on the uphill side on slopes. After transplanting, later fertilizing can be done in a 6-inch deep groove, then covered with soil to prevent runoff in heavy rain.

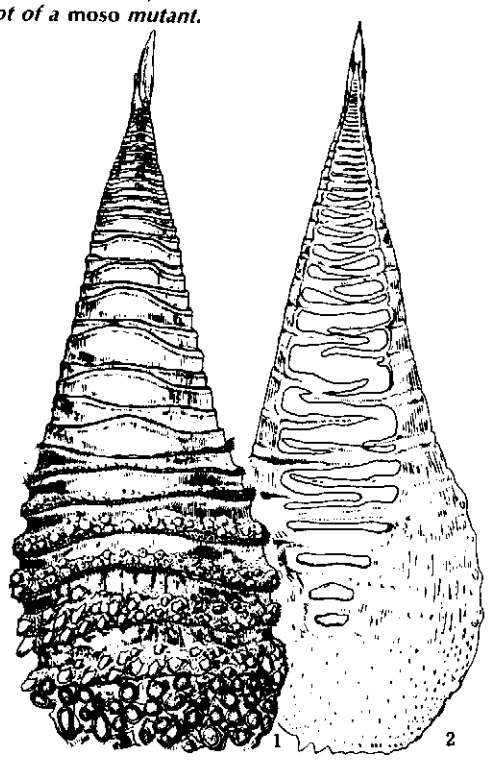
Use topsoil to fill planting hole, pushing and packing it with a thin stick so soil is snug around rhizome. Step lightly on ground around buried culms. Water to settle soil around rhizomes and give them a good drink. "Water culture" is practiced with plants that have drying roots and those stored a time after digging or transplanted in a dry season: In the bottom of a planting hole, water and loose soil is stirred to mud soup. The plant is placed in this hole which is filled with dirt, then more water is added. High success is reported with this method, although in clay or moist soils it can rot the rhizome.

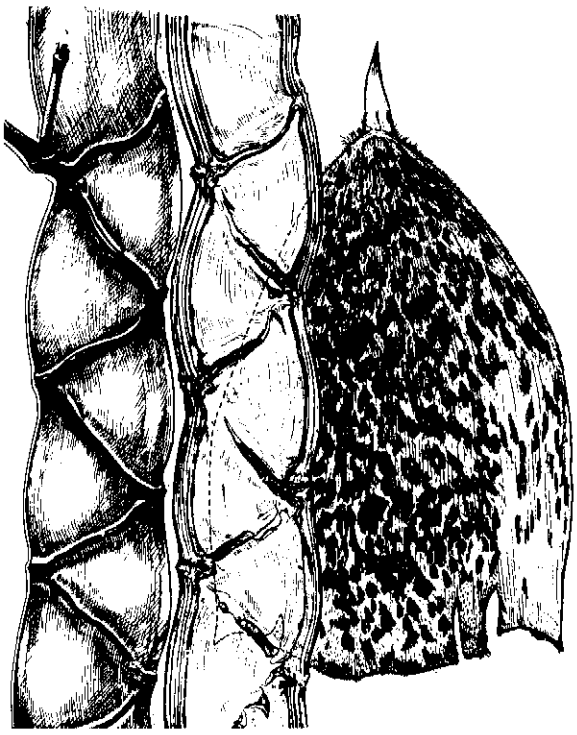
Mulch a 5–6-foot diameter circle around culms with straw or cut grass. Tie three supports to hold bamboo in place if the culm is tall enough and with enough foliage to catch the wind. Tie supports tightly to culm. Loose supports can do more harm than good.

Planting of root stumps—base of culm only with rhizome attached—requires more time for a grove to establish itself, but severing the culm makes transport much easier. Root stumps are best transplanted just before emergence of new shoots. Select culms free from disease, two to three years old that have vigorous rhizomes with at least five new buds. Plant 70–80 in a quarter acre.

Extending grove area.
Bamboo rhizomes naturally extend towards nutrients and friable soil. Bamboo can cross a stone bridge on the soil falling from hooves of passing horses an old proverb says of the plant's readiness to move. So the easiest way to increase bamboo land is to fertilize and cultivate immediately around

Turtleshell bamboo, a new shoot of a moso mutant.





Culm of turtleshell bamboo.

a grove, preferably immediately after shoots emerge in spring. Remove earth 1½ feet deep, in a 12-foot belt around the moso grove. Place compost or stable manure in the bottom, refill with soil cleaned of roots and rocks, and mulch 2 inches or more deep with straw or other cover—or sow a cover crop, especially a leguminous nitrogen fixer that grows fertilizer on the spot instead of having to be lugged there. Fertilize the moso grove well to encourage rhizome development; moso rhizomes grow some 12 feet annually, so each year groves can be extended in belts of this dimension.

A ravine or ditch along a grove can sometimes be filled with soil to extend a grove area. Sometimes bridges of large culms up to 6 feet long are constructed across narrow but deep ditches. Nodes are knocked out, and culms are filled with soil. Rhizomes then grow through them to establish the grove on the other side.[47]

YIELDS

Yield figures for bamboo vary greatly, depending on the species, length of time since previous cutting, location, and grove management. Figures are sometimes for green weight of entire plant or culms only, sometimes for air-dry weight. Weight sometimes refers to clear cutting, sometimes to selective cutting of only mature culms. The following accounts are sample yields of a number of species from several locations around the whole wide world.

Louisiana.

"To test yield in the Gulf Coast area, cuttings were made at the Avery Island bamboo forests, where over 80 acres are devoted to sixty-four varieties. Clear cutting 1 acre of fourteen-year-old *Phyllostachys bambusoides* yielded 22,491 canes, 146 tons to the acre. One acre of fourteen-year-old *P. edulis* yielded 15,876 canes, a gross weight of 143 tons. Neither of these two plantings had before been disturbed by cutting." Twelve years later, in 1944, half the culms from a half acre were cut from these same groves, a total of 1,200 bamboos, up to 62 feet long and weighing up to 76 pounds. The half-acre yield was 39.6 tons. "Clear cutting 2.44 acres of *Bambusa argentea* and *B. Alphonse Karri* from a fourteen-year-old grove without previous harvest yielded 111,941 canes, weighing 349 tons gross. These two varieties of *B. glaucescens* are bunch-growing types, whose canes grow so closely together that even a dog cannot pass between them. Twelve years later, in July 1944, the same area was cut, removing two-thirds of the canes, yielding 24,600 canes, weighing an average 6 pounds each or 73.8 tons."[48]

Other figures for McIlhenny's groves for plantings five to six years old were summarized by

Louisiana Yields

SPECIES	HEIGHT (FEET)	CANES PER ACRE	TONS PER ACRE	
			GREEN	DRY
**Sasa japonica*	17	37,144	55	37
Arundinaria gigantea	11	61,299	45	22
***Bambusa multiplex* (argentea)	29	65,195	244	138
***Bambusa multiplex* (Alphonse Karr)	23	46,746	105	58

**Pseudosasa japonica* ***Bambusa glaucescens*

Sineath from an unpublished communication of Polly McIlhenny Simmons:[49]

Alabama bamboo experiments.
Bamboo experiments were begun in Auburn, Alabama, at the agricultural experiment station there in 1933. Fishing poles for local markets were the initial focus of interest. In the 1950s, search for new crops to replace those in surplus production and an increased interest in bamboo for paper pulp prompted extension of experiments to Camden in 1959. Results of thirty-five years experience with bamboo cultivation in the area were published in 1968 on the twenty-eight species included in the plantings, mainly *Arundinaria* and *Phyllostachys* varieties.[50]

P. rubromarginata, in addition to being among the three most hardy of the species tested, produced the largest tonnage of dry wood per acre and showed the highest survival in propagation by rhizomes (86 percent).[51] Clear cutting of seven species showed a yield of poles 15 feet or longer from 11,000 to 39,000 poles per acre; selective cuttings, 2,000 to 10,000 poles per acre per year, depending on the species, with larger species such as *P. bambusoides* yielding about 1,000 per acre per year. By weight, the yield of dry wood varied from 17 to 54 tons per acre excluding leaves but including stems and branches, depending on the species, from groves fifteen to twenty years old that were clear cut.

Bamboo cut in 10-foot strips every five years produced yields of 18–45 tons of dry wood per acre, with a four-year average of 28 tons per acre. Strip cutting was found much more productive than clear cutting since grove recovery was much more rapid from rhizomes bordering the cut. Green leaves were found to compose 10–16 percent of plant weight; limbs, 11–21 percent. In one experiment comparing loblolly pine *(Pinus taeda)* and *P. bambusoides,* the pine produced 8 tons of dry wood per acre eight years after planting; the bamboo, 14 tons. The numerous tables of Sturkie (1968) provide more detailed figures for the tested species.

Alabama.
Oven-dry yields (per acre per year)[52]
Phyllostachys aurea: 1.31 tons
P. aureosulcata: .98 ton
P. bambusoides: 1.83–3.16 tons
P. meyeri: 2.57 tons
P. rubromarginata: 3.43–5.70 tons (highest yielding species)
P. viridis: 1.67 tons

Georgia.
According to the unpublished correspondence of R. A. Young in 1935, studies of a well-established grove of *Phyllostachys bambusoides* at Savannah show a per-acre per-year yield of some 8–9 tons. Yield experiments with six *Phyllostachys* species at the USDA Savannah groves from 1956–1965 showed harvests ranging from an average 1.32 to 4 tons per acre per year.[53]

India.
In Chittagong Hills, east Bengal, figures of 1,200–6,000 culms per acre have been reported on a three-year rotation (Ahmed 1954). One thousand culms of *Melocanna baccifera* weighted 4.4 tons green, 2.5 tons air dry. These counts would mean air-dry weights of 3 to 15 tons per acre. In India, dry internodes for paper production gave 4.6 tons of *B. polymorpha* and 4.1 tons for *Cephalostachyum pergracile.* In Burma, *Melocanna baccifera* yielded 8.3 tons of dry culms per acre. *B. arundinacea* yields varied greatly from 1 to 14.5 tons of dry internodes per acre, with average of larger areas said to approach the higher figure.[54]

Japan.
Fresh-weight yields of culms (per acre per year)[55]
Phyllostachys bambusoides: 2–5.6 tons
P. nigra (henon): 1.2–2.8 tons
P. pubescens: 2.4–7.6 tons

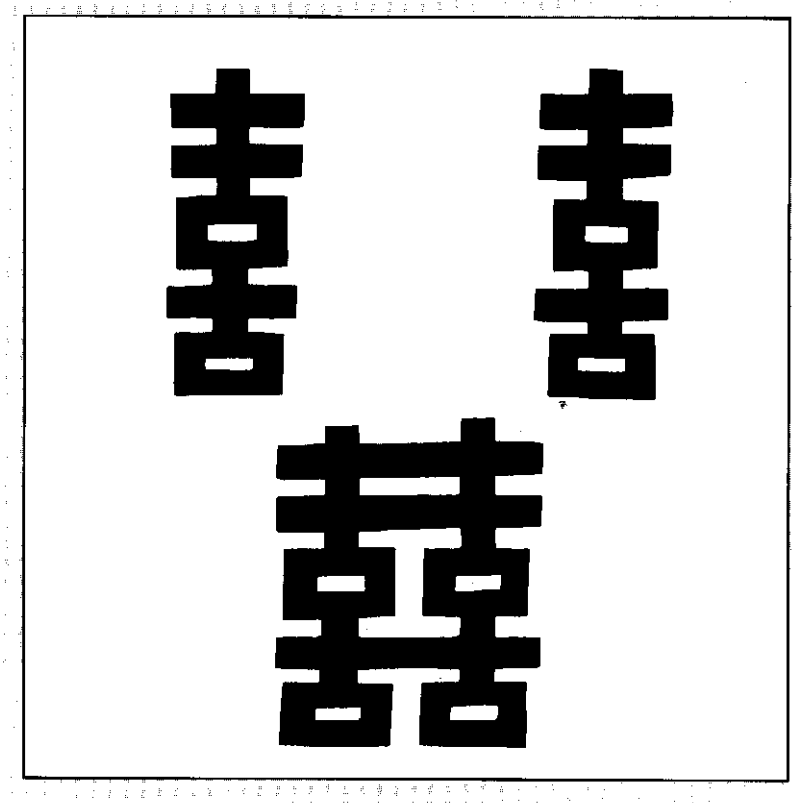
China. See p. 290.

Taiwan. See Chapter 10, pp. 304–305.

CHAPTER 8.

1. McClure 1952b:6.
2. McClure 1961a:18.
3. See also Lessard 1980: 56, 95, 129, for the question of bamboo control in forest management.
4. McClure 1963a.
5. McClure 1948b.
6. Austin 1970:205–6.
7. McClure 1933.
8. McClure, "Bamboo Notes for El Salvador," unpublished manuscript.
9. Austin 1970:206.
10. Hodge 1955:123–7.
11. Lawson 1968:21.
12. McIlhenny 1945:124–5.
13. Fairchild 1903.
14. McClure 1958:56.
15. Fairchild 1903:20.
16. McClure: 1938c:14.
17. Ibid.: 15.

18. McClure 1957b:307–8.
19. White 1948:16.
20. McClure 1938c:5,6.
21. McClure 1966:232.
22. Lessard 1980:105.
23. White 1947.
24. White 1948:13.
25. Lessard 1980:30.
26. McClure, unpublished *Guadua* notes, abridged. Available at Grass Library, Smithsonian Institution, Washington, D.C. (see p. 305).
27. Varmah 1980.
28. White 1946a:268.
29. Wright 1921.
30. McClure 1931: 302–3.
31. Lee 1944:128.
32. Kirkpatrick 1958.
33. Plank 1950. He and colleagues published some fourteen articles on bamboo beetles from 1937 to 1950.
34. Stebbing 1910.
35. Trotter 1933.
36. McClure 1952b:5.
37. Stebbing 1910.
38. Narayanamurti 1972:21–6.
39. Ibid.: 91–2.
40. Ibid.: 17.
41. Ibid.: 6–7.
42. Myers 1947.
43. Young 1961:58–62.
44. Ibid.: 60.
45. Lee 1944:129. Lessard (1980) briefly reports on biological pest control in China bamboo work.
46. Oshima (1931) forms the basis of this section on moso, roughly 10 percent original length of USDA translation, available from the Grass Library, Smithsonian Institution (see p. 305). Cf. also Oshima, bibliography.
47. For moso cf. also McClure 1957a:51–3. Lawson 1968:127–8. Young 1961. These are abridged in the treatment of *P. pubescens,* pp. xx–xx.
48. McIlhenny 1945b:122–3.
49. Sineath 1953:11.
50. Sturkie 1968.
51. The other two most hardy were *A. fastuosa* and *P. viridis.* Three species suffered severe damage during the three hardest winters of the twenty years' observation: *P. aurea, P. bambusoides,* and *P. meyeri.*
52. Sturkie 1968. USDA 1978:3–4.
53. USDA 1978:3–7.
54. Huberman 1959: 40, abridged.
55. Ueda 1960. USDA 1978:3–4.



9. USES OF BAMBOO

Bamboo is both road and map
where use and beauty overlap
with learning in a roomless school
for the wisest or the fool,
for ancients creeping back to earth
or infants dripping fresh with birth.

Bridges, baskets, paper, flutes
in summer, shade, at dinner, shoots-
all from groves whose rhizomes will
mantle an eroded hill.
Count its uses? count instead
fingers of the thankful dead.

CRAFTS

Creating creation.

If people were created in the image of their creator, as it says in an old black book, we were created creative. A fluid creativity is what chiefly distinguishes our species from the many millions of others here with us. Cultures giving maximum outlet to the creative energies of the people will experience themselves as "expanding," independent of any economic index. And a culture that somehow, by accident or design, smothers or reduces creativity among its members will never be able to distract its people, by a show of material prosperity, from a certain contraction they feel in the womb of their spirit, which never bursts the water and comes to term.

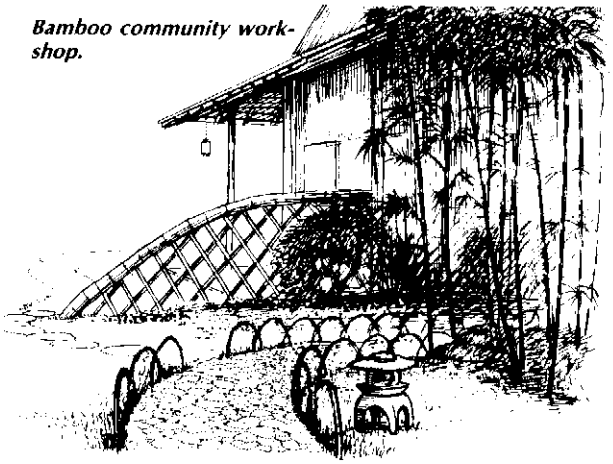
We are not encouraged in our culture to go to the root of a dis-ease or dis-comfort, but to apply palliatives. But in the present case, all the mattresses in the kingdom will not rock us to sleep, because the pea is in the princess: A deep defeat of creativity is built into the very design of our culture. "Everything that rises must converge." Creation is always an uprising, and a great impulse towards union is the very bone of its blood. This impulse towards creative union in the United States now confronts a production system based on fragmentation and schools preparing their "products" to fit into it.

Any philosophy of economics or style of education that declares competition the base of its design rather than creation and that cheerful collaboration that creation requires of us in all its fuller forms, is doomed to a shrivelled existence. The implied objective of capitalist psychology is not to relate and create but to get the best of the bargain; not to meet, but to dominate. But "friend" means "free," according to its German root.

Perhaps bamboo became the Friend to the people of China and other countries in the Orient not so much for the things and shelter it provided, but for a richer gift: it created creation, made it more possible for millions for centuries to discover the endlessly inventive cunning, the nimble intelligence of human fingers.

"Shared bliss," a popular symbol in Chinese iconography.

BAMBOO COMMUNITY WORKSHOPS. It's good to gather together to do anything, but especially learning, meeting the new, is best practiced with others. Harvesting bamboo is easier in a group, buying it by



Bamboo community workshop.

the bale is cheaper, sharing discoveries and projects is more inspiring than everyone off in private corners, pursuing personal happiness. So in these reflections on bamboo use, we have imagined not only private individuals, but bamboo neighborhood workshops, bamboo introduction in schools, bamboo camps and travel for training. In its simplest beginnings, all this can simply mean two or three gathered together to work with bamboo or dig and transport and replant rhizomes in pots on their windowsills. When you come across or hear of someone tearing up part or all of a grove, it helps to have several hands ready to plant, and a place waiting to store and cure culms. Work in the local community prepares for work between communities, and between countries: the dimension finally implied by bamboo work is international.

FRIENDS OF BAMBOO. The Japanese teahouse seems an appropriate point of departure in the development of bamboo community workshops in the urban West. In its early "grass hut tea" format with Rikyu (1521–1591), it was intended as a popular form whose skillful embodiment did not imply pedigree blood or inherited fortunes, but a certain constellation of attitudes available to anyone. It was the tiny Temple of Friendship, in which the harmony of the participants rather than the grandeur of the architecture measured the significance of the ceremony.

The depth of a lake
is not in its fathoms
but in its dragons.

The height of a mountain
is not in its peaks
but in its people.

—Chinese Proverb

DO-IT-OURSELF. We have always kept in mind the *bamboo group*. No plant or animal flourishes alone. In traditional cultures, the family is the basic unit, and bamboo was in many areas the symbol of it: a group of apparently isolated individuals secretly single beneath the soil. In leaving the family and village world, modern people have come by certain new sets of freedoms—but we have lost touch with many central human joys, junked as slow-fashioned and out-moded en route to the Supermarket and Freeway.

We have traded a certain sure-durable hum of traditional ways for staccato bursts of sensation and insight, great leaps forward followed by brand new forms of catastrophe, all the dizzy rhythms of modern urban existence.

URBAN EXILE. Our schooling, mainly in books, and our living, mainly in towns, don't encourage us to fully inhabit our bodies. We stand in them less as owner and operator than as tenants who have rented a corner of their total range of possibilities. Psychologists announce that we use some 2–3 percent of our intelligence, and the accomplishments of Eastern yogis make clear that we have reduced ourselves to a similar shallow percentage of possibilities in our bodies as well. We automatically distinguish between the brain and the body, mental and physical, as if that distinction could ever survive except in our own minds. This assumption is but another example of our alienation from wholeness, our exile from Eden. Crafts, building, gardening—all help us reenter the body and earth. Plugging into bamboo could be an appropriate fad for do-it-yourselfers in the United States and other highly industrialized cultures partly because the simple hand tools required are a welcome relief from the high-energy norm in the home workshop bristling with equipment that has to plug in to function.

Tools.

The equipment binge of many people entering a new fascination is a way of avoiding coming too close to creation. Like the best hardwoods, the best tool box expands slowly, with reticence and restraint. Working with bamboo should be scaled down to tools you can carry with ease. A permanent homebase and workshop is a proper center of this edge. "Ponder 10,000 volumes. Wander 10,000 roads." The ancient Chinese prescription for an art braided of tradition and experience, firsthand, of the land, the people, and the materials of

Bamboo Tools

TOOL	USE	RECOMMENDED SPECIFICATIONS
Machete	Miscellaneous: felling and trimming culms and cutting to length; removing fragments of diaphragms from bamboo boards.	Preference of the user decides blade selected; long, fairly heavy blade recommended.
Hacksaw	Felling culms, removing branches, cutting to length.	Large size; ample supply of molybdenum steel blades, with eighteen to twenty-four teeth per inch.
Tripod or trestle	Elevating culms and holding them firm for sawing to length, cracking nodes.	May be made locally, following the pattern locally preferred.
Ax	Cracking the nodes of large culms to make boards.	Lightweight ax with a narrow yet thick, strongly wedge-shaped bit.
Hatchet or small ax	Cracking the nodes of smaller culms for making boards.	Similar to the ax, but smaller in size and fitted with a short handle.
Whetstone	Sharpening tool edges.	Carborundum: coarse-grained on one side, fine on the other.
Spud	Removing diaphragm fragments and excess soft wood at the basal end of bamboo boards.	Long handle, broad blade set at an angle to operate parallel with surface of board.
Adz	Same use as spud, which is more convenient, but the adz is more generally available.	Standard design, best quality steel.
Gouge	Removing diaphragms to make troughs and drainpipes from split or opened culms.	Curved (front bent). 1 inch and 1½ inch bits.
Chisel	Making holes in culms to accommodate lashings for end ties.	Best steel (molybdenum if available) ¾-inch bit.
Drill	Making holes to accommodate bamboo pins or dowels.	Hand or power-driven drill; *metal drilling* bits, best steel, assorted sizes, ⅛ inch–½ inch.
Wood rasps	Leveling prominent culm nodes.	Large size, with one flat side, one convex; coarse, medium, and fine teeth.
Splitting jig	Facilitating the splitting of whole culms or sections into several strips at once.	
Splitting knives	(a) For splitting small culms. (b) For making bamboo withes.	(a) Short handle, broad blade. (b) Long handle; blade beveled on one side only; to be specially made.
Rods of reinforcing steel	Breaking out the diaphragms of unsplit culms.	Suggested minimum: one each of ¾ inch by 10 feet and ½ inch by 10 feet. Other dimensions to meet special needs. Hardwood or bamboo pole may be substituted.
Wire pincers	For handling wire used for lashings.	Conventional type with long, narrow jaws and wire-cutting feature.

an art in all four corners of its kingdom—this design for the incubation of artists should be kept in mind in times ever more centralized and homogenized in experience. The diversity of modern living is mainly in the *content,* which is funneled through formats that abstract it from the sweaty, balmy, or freezing physical world into the comfortable uniform temperature of tv, radio, newspapers, schools of all sorts. Actual physical first-hand experience of the earth is becoming more rare as it becomes more reported and available as information you don't have to alter your life in any serious way to reach. Instead of program or book A, you just select B.

But the issue, finally, of what we make and build is quality rather than quantity, the maker rather than the made. We need tools that make us

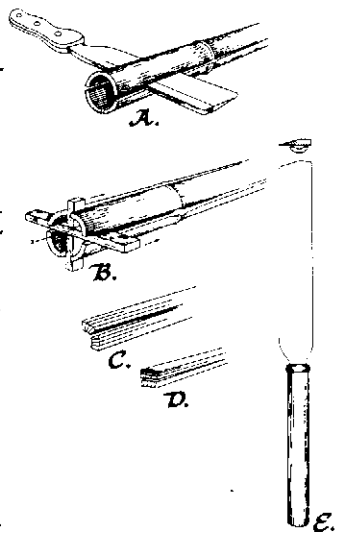
more human rather than less. In general, the more we *have* beyond the strictly needed, the less space for our necessary existence to *be*, with the necessary physical and cultural mobility *being* implies in its most ample state. Crude tools in master hands outwork the molybdenum of dabblers. The junkmen of China built the tools that built their junks from cast-off horseshoes from England.

We live surrounded by such an abundance of tools that the advantage of a material that requires few tools, and those hand powered and even handmade in many cases, is not so apparent in industrial centers as in the hinterlands where bamboo is most abundant.[1]

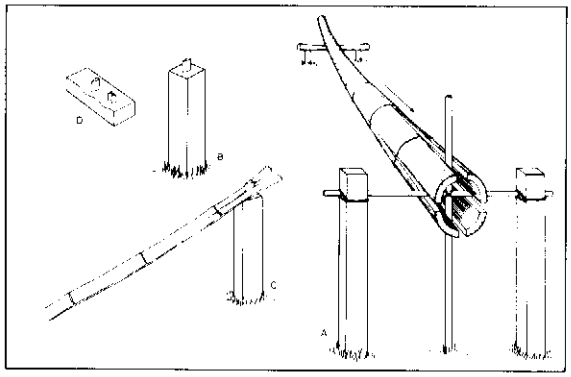
Bamboo's high silica content is famous for dulling tools. Tool effectiveness will be increased, time spent sharpening reduced, and work in general cheered by using molybdenum steel or an equally hard alloy. Many a bamboo house has been machete built, but more tools are demanded for more refined work, some peculiar to processing bamboo and therefore unavailable at standard tool sources. The Chinese bamboo tub and bucket maker requires some thirty different tools and gadgets to measure, cut, fit, and assemble his wares. Buy tools as the project requires. Begin simply. Make your own. The list on page 237 provides a fairly complete bag for building purposes.[2]

Techniques.

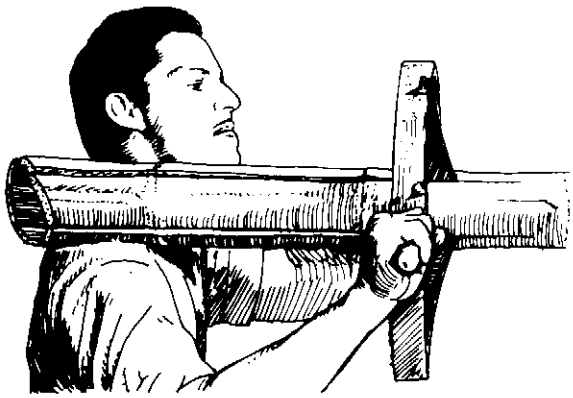
CUTTING. Bamboo is most easily cut into desired lengths with a hacksaw, eighteen to twenty-four teeth per inch. Molybdenum blades are best. (See pp. 219–220 on removing branches.)

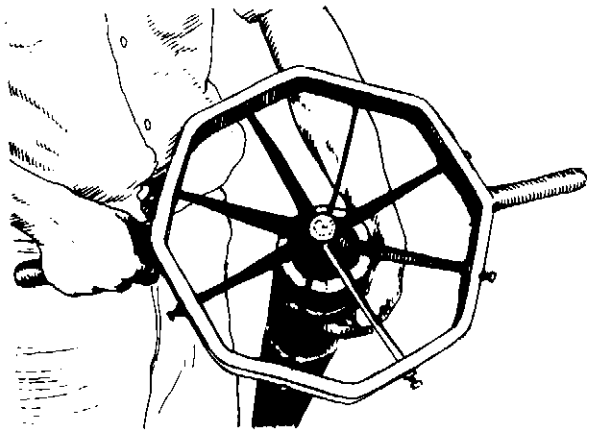


Splitting moderate-size culms to make withes for weaving and lashing. Quartering a culm: (A) Starting four breaches at upper end. (B) Driving a hardwood cross along the breaches to complete the splitting. (C) Dividing quarters radially, making center splits first. (D) Splitting radial divisions tangentially; the hard outer strip is best, and the soft, pithy inner strip is usually discarded. (E) Long-handled knife used for dividing and splitting; some workers hold a strip of bamboo on the blade to add to its effective thickness when they wish to speed up the work.



Devices for splitting heavy culms. (A) Cross of iron or hardwood bars (about 1 inch thick) supported by posts (about 4 inches thick and 3 feet high) firmly set in the ground; with an ax, two pairs of splits are opened at right angles to each other at the top end of the culm; these are held open with wedges until the culm is placed in position on the cross; the culm is then pushed and pulled, by hand, in the direction indicated by the arrow. (B) and (C) Steel wedge for splitting quartered culms. (D) Block with single and paired steel wedges for mounting on a heavy bench; adjacent faces of the paired wedges should be slightly closer together at the cutting edge than at the back.

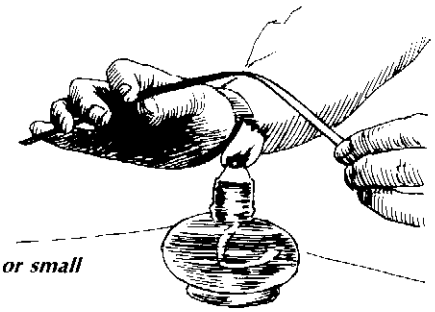




A splitter with changeable blades.

SPLITTING BAMBOO. This is ordinarily done with a good sharp machete. In larger bamboos, the blade is pounded along the culm like a wedge used on a piece of firewood. Ways have been devised to accelerate splitting when dealing with large quantities of bamboo. See illustration. For smaller pieces, for whittling kite frames or small models, use a knife with a replaceable blade. (See Kitebones, p. 253.)

BENDING. For large bamboos, see p. 220 on commercial methods used in India for straightening bamboo. A hot coal campfire is the best way to bend bamboo for furniture or comparable projects.

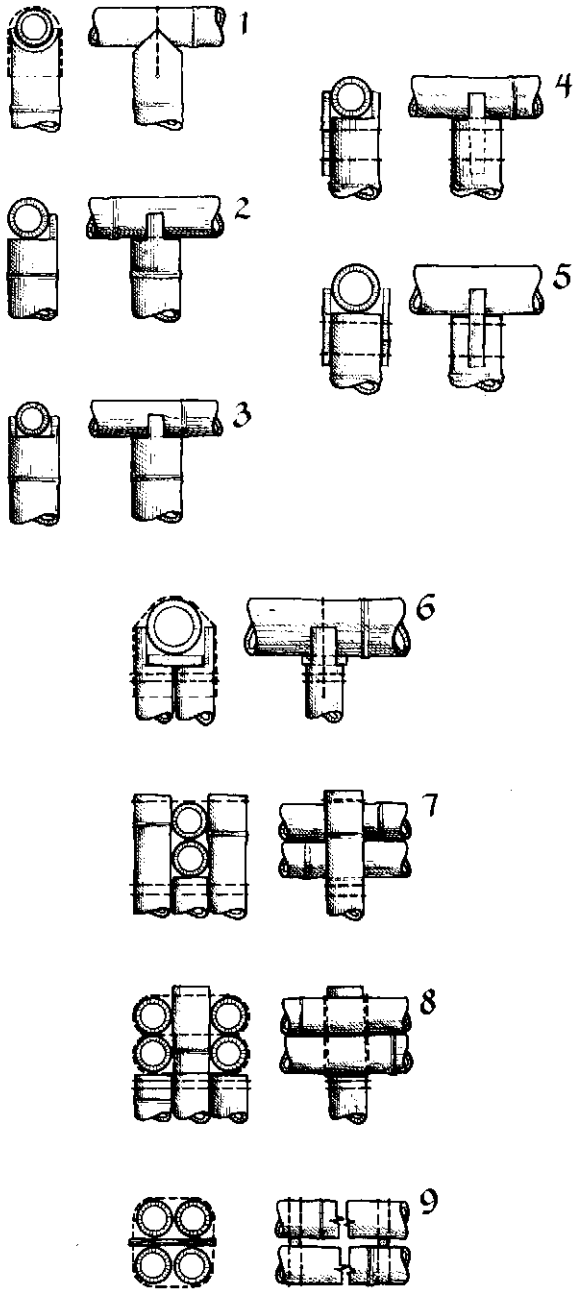


Bending strips or small culms.

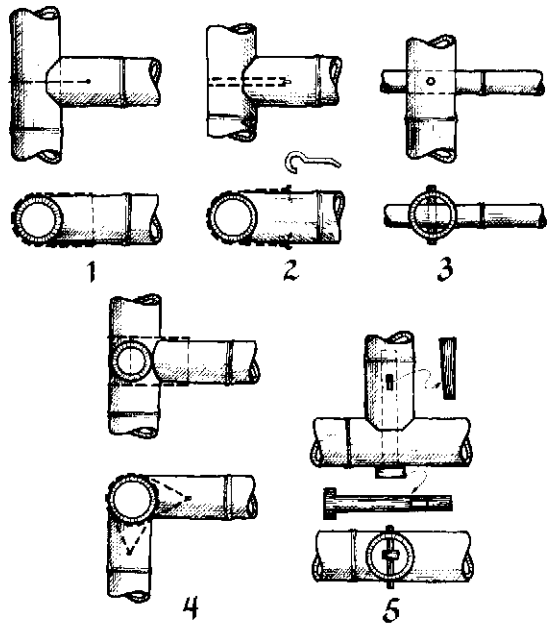
For kites or other miniworks, soak the pieces to be bent overnight in water with a dash of ammonia, then tie in desired shape around a mold to dry. You can heat small pieces in a candle flame. The mortar holding the fibers in place becomes flexible with heat and permits bending to chosen shape, which is retained after cooling. Take care not to scorch or burn bamboo by leaving candle too long in one position. Try using a bucket of hot sand to shape small pieces, as eyeglass doctors do to shape plastic frames. Don't force the bamboo's pace, nor try to bend it too far, or you'll crack it.

JOINERY. Bamboo, hollow and round, demands different systems of construction from those used in building with wood. Nails split bamboo unless gently hammered into holes drilled with a diameter slightly less than their diameter. For lashings, galvanized wire, strong rope, nylon cord, vines, or bamboo strips from the tough culm surface are used.

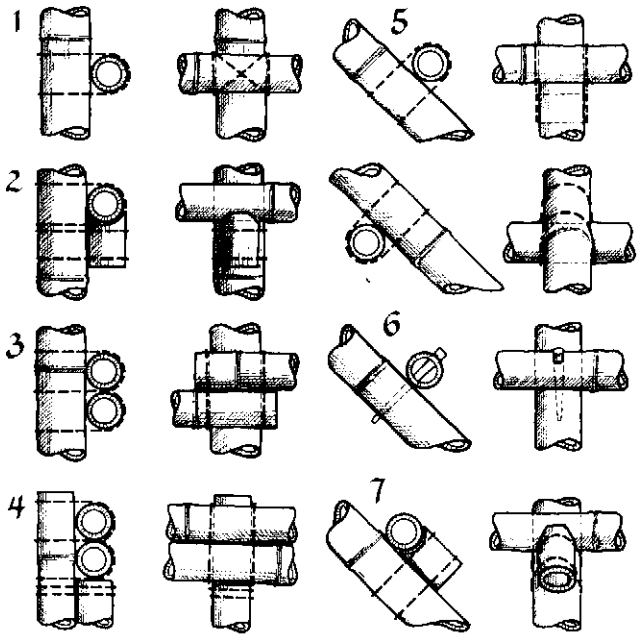
COLUMNS AND BEAMS. Angled "ears," easy to cut with a machete, are used in walls, footbridges, or wherever a vertical bamboo supports a horizontal member of lesser diameter (1). One-eared supports in wall construction should have the ear outside, to brake the shove of the roof's weight (2). Two ears, cut neatly with a hacksaw, are an option to (1) above (3). For larger horizontal members, one or two ears can be added with small pieces of bamboo (4,5). The ear should be roughly ¼ the full length of the piece. Double columns to support a large horizontal beam are cut as shown, with a strip of bamboo or wood added beneath to distribute the load (6). Double beams can be used for large spans or heavy weights (7). Four horizontal beams can be used for especially heavy construction, or when larger bamboos are not available (8,9).



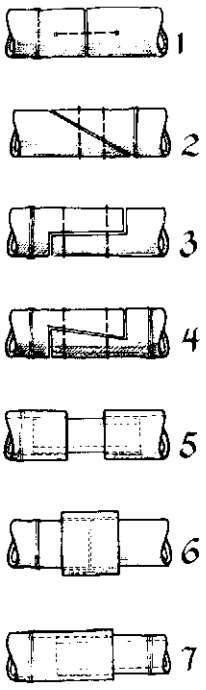
T JOINTS. For use in fences and walls (1). Lateral hooks can be used (2), or a pin permitting easy removal of the horizontal bamboo in gates or other constructions (3). T joints in corners (4). The horizontal members should not support much weight. Pins, of wood or bamboo, can be used when the beam is not under much weight (5).



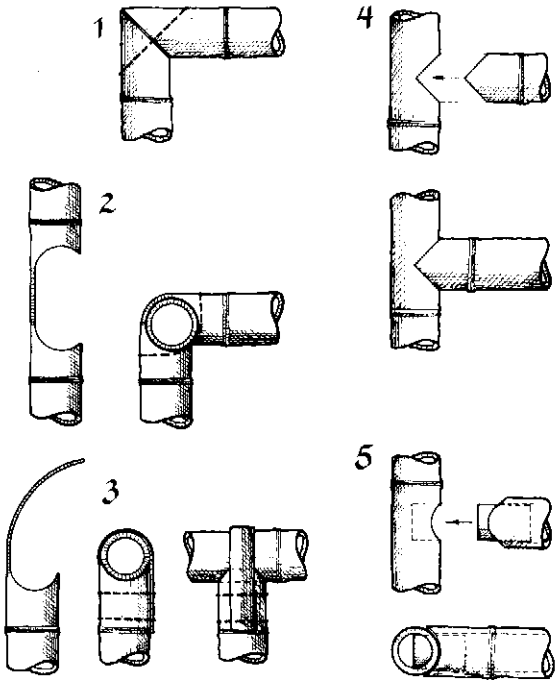
RIGHT ANGLE UNIONS. In joining horizontal to vertical members, the load-bearing capacity of horizontals can be increased by lashing on an external support, doubling the horizontal member, or both combined (1,2,3,4). Unions of joists and rafters in roofing permits various possibilities (5,6,7).



JOINING TWO HORIZONTAL MEMBERS. Of the seven alternatives, 4 is especially useful in furniture making, 5, 6, and 7 for bamboo pipes.

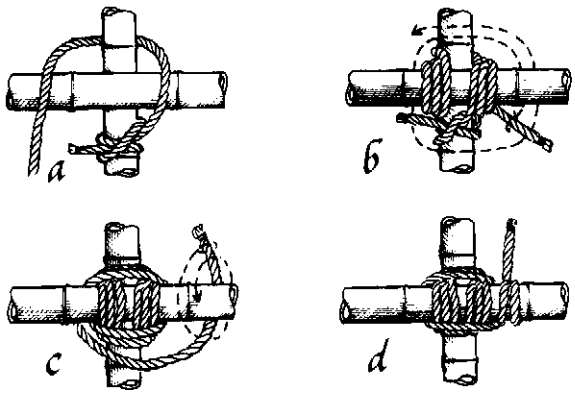


FURNITURE. Glue is required for 4 and 5, a plug of wood or bamboo for the latter.

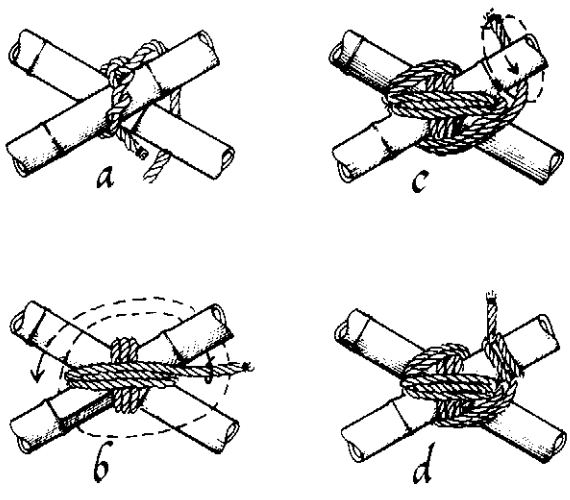


Knots and lashing.
The stability of a bamboo construction depends on the strength of the material itself; the right tight knots; and the rope, wire, vine, or bamboo used for lashing. The following are useful for all types of construction, the scaffolding, and vertical lift of construction materials. Hidalgo, the most complete source in this matter, provides 15 pages from which these have been selected.[3]

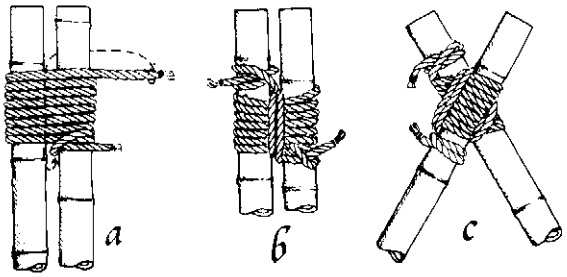
RIGHT ANGLE LASHING. This begins and ends with a clove hitch (see below).



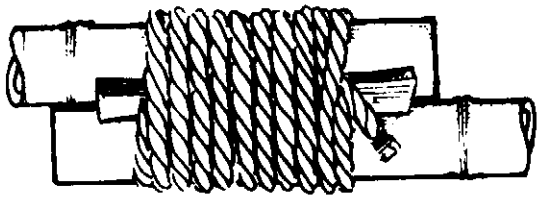
DIAGONAL LASHING. Used for diagonals of bridges or scaffolding. Begin as indicated and conclude with a clove hitch.



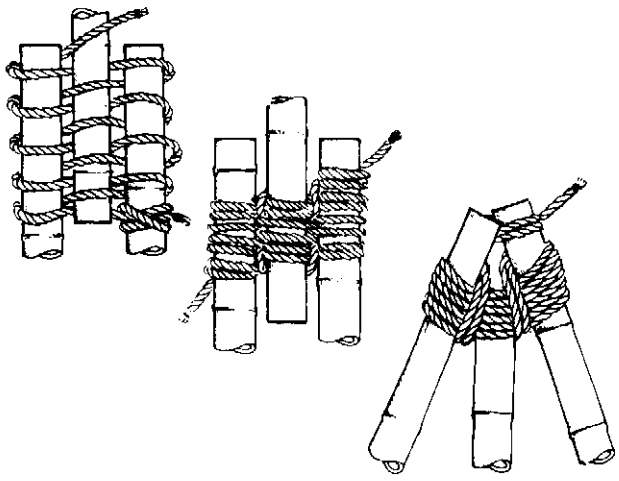
SCISSORS. To tie two bamboos together to hoist weights, the poles are placed parallel, a knot tied around #1; 7–8 turns of rope tied horizontally around both (a) are followed by 2 vertical turns (b). The rope is tied off around #2. Lashing must be loose enough so that legs open to required distance.



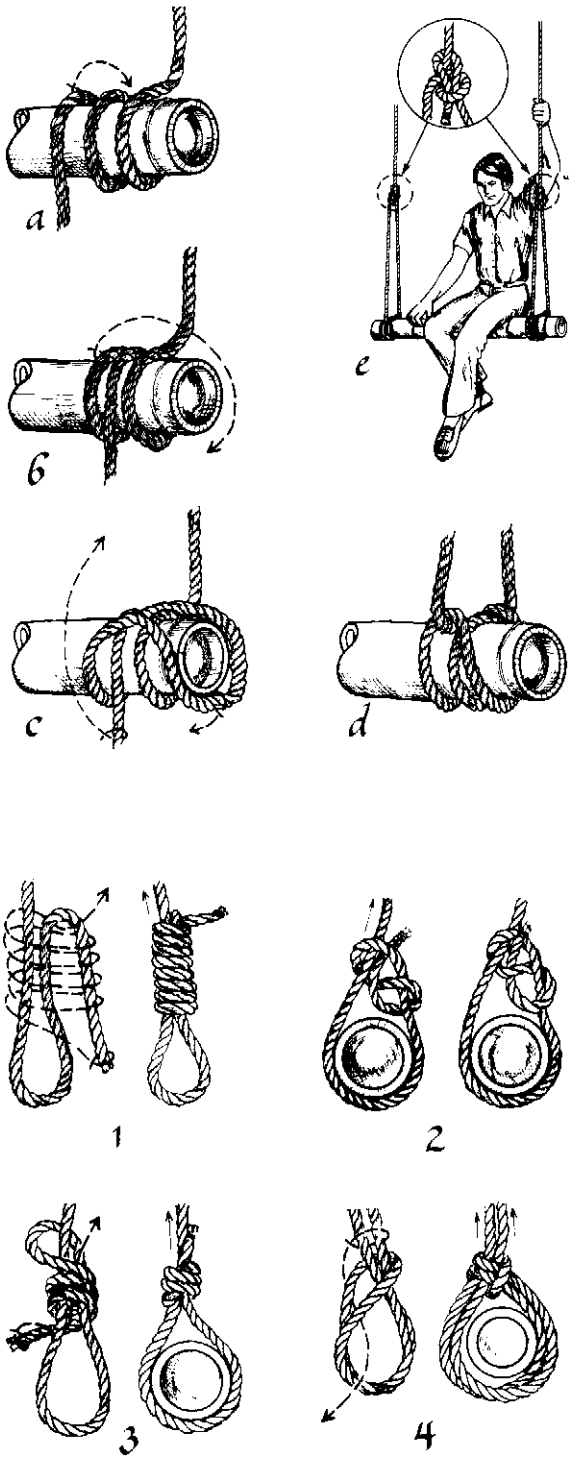
EXTENDING LENGTH. To unite poles at their ends to form a longer structural member, the same lashing is used, but tight and further tightened by inserting wedges of wood or bamboo. The final knot is tied around both poles.



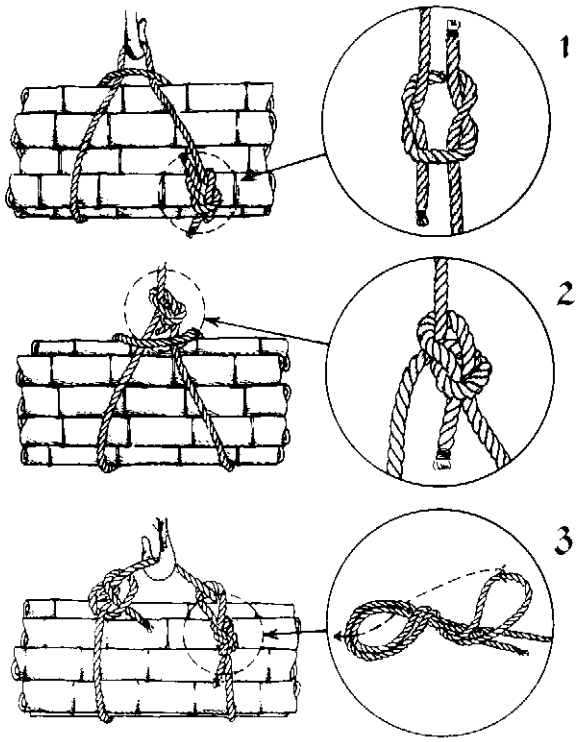
TRIPOD. Rope is tied to one pole, then woven horizontally around all three, as shown; then, before or after opening, it is woven or wound vertically through or around horizontal lashing and tied off. Lash loose enough and tight enough so legs just open to required distance.



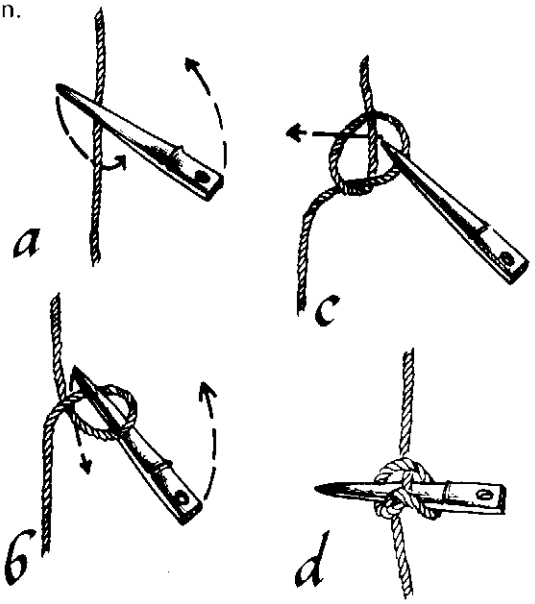
SCAFFOLDING. For hanging scaffolds, the rope is lashed as shown (a–d) and tied off (e). Other options to extend—but far from exhaust—your possibilities: the hangman's knot (1); a figure eight running knot (2); a running knot used also for vertical lifts in two versions (3); a knot hard to untie (4).



LIFTING MATERIALS. Three ways are shown, for use with or without a hook. Knot (3) under scaffolding can also be used.

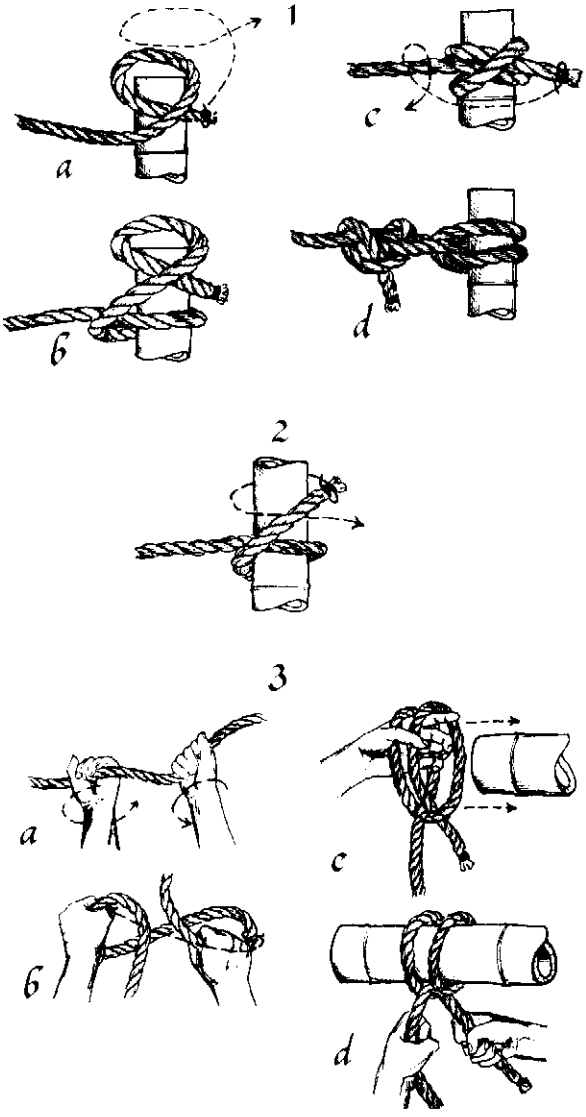


REDUCING ROPE LENGTH. Used to increase tension.



CLOVE HITCH. A basic knot with many uses in bridges, scaffolding, and turnbuckles; also useful for starting or concluding other knots (1). Another

method is used when the top end of the pole is too high to reach (2). The knot can also be made first, and the pole inserted (3).



The cracking problem.

"In China and Japan where bamboo is an everyday commodity, humid climatic conditions both indoors and out are such that splitting of bamboo culms is a very minor problem. Not so in the United States, where in our dry overheated homes particularly, bamboo articles, when made from whole culms at least, are regularly subject to the danger of splitting."[4]

"Splitting of bamboo furniture results from uneven moisture absorption and loss in the tissues of different density in the bamboo. *Bambusa vulgaris,* for example, is well known for its tendency to split; it has soft pithy tissues on the interior while the outer tissues are much more compact and absorb much less moisture from the air. Fortunately, species with more uniform culm tissues are less susceptible to splitting. The problem is lessened by use of these species, or types of construction which call for split bamboo. Designs can sometimes be carved in the hard outer surface which permit expansion or contraction due to moisture absorption and loss."[5]

Seasoning behavior of nine species was tested in the round by the Wood Seasoning Branch.[6]* The study on seasoning behavior in air, kiln, and over open fire revealed that bamboos in the round are generally liable to considerable degrade in the course of drying in the form of surface cracking, splitting, collapse, and sometimes even fungal decay and borer attack. Air drying is the most practical and satisfactory procedure provided care is taken against too rapid drying in hot and dry winds, which aggravate cracking, and sluggish drying, which causes fungal decay. Air drying is completed within about three months in clear weather. Of the nine species, *B. arundinacea, D. hamiltonii, D. membranaceus,* and *D. strictus* dry with relatively little cracking or collapse in mature culms. Immature culms are liable to collapse. The rest of the species suffer severe collapse and excessive shrinkage in drying besides cracking.

"Sharma in 1972 successfully conducted trials on chemical seasoning of round bamboo for handicraft items without any cracking or splitting. The species used was *D. giganteus.* The antishrink chemical polyethylene glycol-1000 in a 50 percent solution was used for a soaking (diffusion) pretreatment of the bamboo wall in the green condition, after which no cracking occurred in air drying, which is a problematic proposition in round bamboo."[7]

To reduce the likelihood of splitting, keep bamboo objects from direct sun. Don't keep valuable bamboo objects in the open in a heated room. Put them in a glass case with an open container of water or store in tight containers, preferably in a room with 50 percent humidity. Lutz (1975) notes the propensity for brush pots to crack on the uncarved side, which suggests that carving breaks the tension, gives room for fiber expansion and play, thus reducing the tendency to crack.

Splits that occur can be filled with lacquer, glue, paint, wax, or epoxy. In case of a wide crack:

**Editor's note: B. nutans, B. polymorpha, B. tulda, D. calostachyus, D. longispathus,* and the four species resistant to cracking listed below.

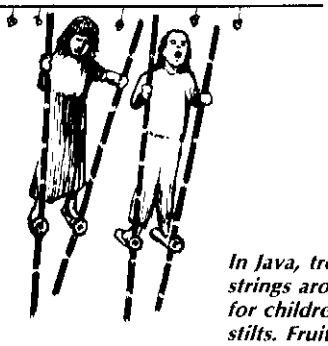
put brush pot, flute, drum, or whatever bamboo object in a covered bucket with water in the bottom. Rest bamboo on brick above water level overnight or longer. The crack may narrow enough to glue and bind. Tendency to split depends in part on age of the culm at harvest. "Unripe" bamboo—under five years at harvest time—was four times more likely to split than "ripe" five-to-ten-year-old culms in Trinidad experiments.[8]

In South Carolina, Clemson College tests on bamboo studied the absorption of water-and-oil-soluble wood preservatives by bamboo culms to prevent splitting, among other problems.[9] Freeman-Mitford suggests soaking bamboo generously in linseed oil to avoid splitting.[10]

Kids love bamboo.

THE EFFORT/EFFECT RATIO. A two-year-old swings a door on its hinges, open and shut, again and again —amazed to move so easily something so much bigger than myself! Astonished such little effort yields such great effect.

The effort/effect ratio is also high in bamboo, which may be why the reaction of children to the plant is immediate and intense: a six-month-old baby can wave an 8-foot pole. A two-year-old shouldering a 20-foot culm grins with a sense of accomplishment. With a bundle of a hundred 6-foot by 2-inch *B. textilis* poles, five-year-old preschoolers can autoarchitect their own playground.



In Java, treats are hung on strings around nose level for children on bamboo stilts. Fruits and candies must be bitten off, without use of hands.

BROKE IS BEAUTIFUL. Schools everywhere are passing through a severe economic crisis. But in institutions intended to make people smart, broke is beautiful. Indigence is the great grandmother of invention. "Guerrilla economics" means inventing projects that pay their own way so the ticket is built into the trip. Educational systems have to increase designs for productive homework that then earns the cost of the course. Bamboo propagation or construction can diminish expenses and even create income—or useful home furnishings, as in bamboo school projects in the Philippines. Bamboo plants are particularly in demand just now, if we can trust the reports of plant sales at botanical gardens, so a bamboo nursery might at this moment make both dollars and sense, neatly combining earning and learning.

LEARNING DESIGN: NEW SCHOOLS AND STUDENT-CREATED CURRICULUMS. The explosion of numbers on the planet demands that we learn, rapidly, a planetary culture. This involves inventing new ways to pass culture on as efficiently as possible.

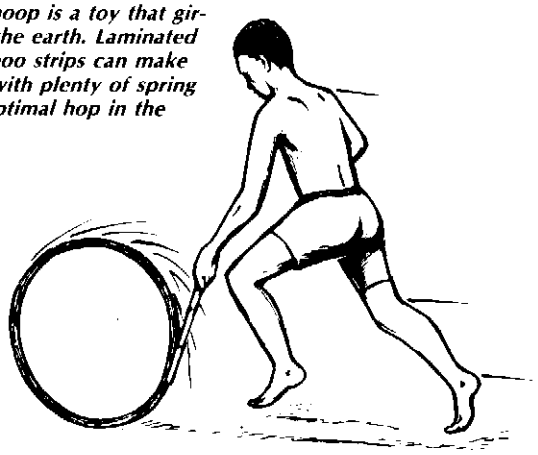
Bamboo childhood.

"I was born and raised in a house surrounded by bamboo. All my earliest memories are enmeshed with its sights and sounds: the changing seasonal colors; the whispering of leaves tossed by wind; the sharp cracking of huge culms, weighed down by heavy blankets of snow. In the narrow valleys, there wasn't a village that wasn't surrounded by groves. Even the poorest child could not help but become intimately aware of bamboo. The children played in the groves, they watched the harvesting of shoots; they saw brokers who came to railway station towns to bid high prices for the coveted sheaths of the madake bamboo *(Phyllostachys bambusoides)* once they had fallen. Many children would sneak into the groves, bundle sheaths, and sell them to their landlord, who in turn might sell them to the local butcher to use as wrapping for his meats.

"Making bamboo dragonflies, insect cages, and flutes were winter pastimes, and almost every household had children who became skilled in these crafts. My father was a carpenter, and his winter hobby was making shakuhachi from madake bamboo. After selecting the proper culm and getting permission to cut, he would have to age the piece. Then came the painstaking labor of carving, cutting, chiseling and polishing. From beginning to end the entire process took almost three years to finish one shakuhachi. I observed my father's great love and reverence for each piece of bamboo he handled; I can still remember it clearly today."

Tsutomu Minakami (Takama 1983: Introduction.)

The hoop is a toy that girdles the earth. Laminated bamboo strips can make one with plenty of spring for optimal hop in the hoop.



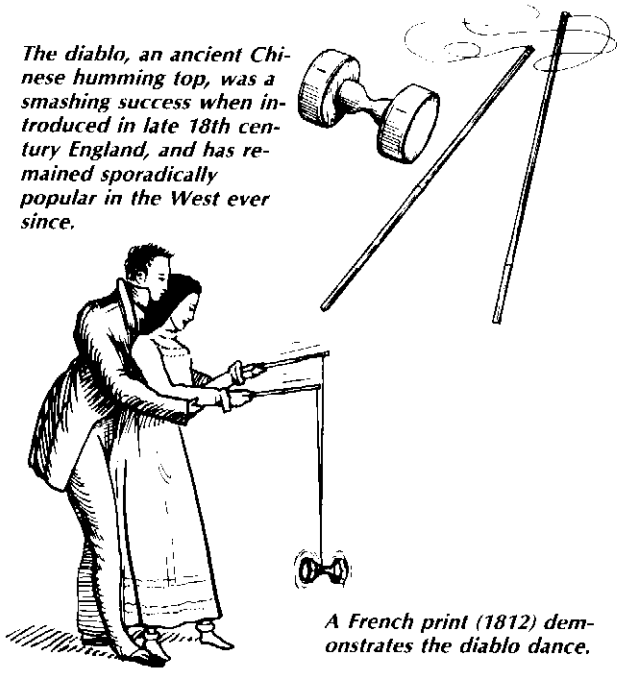
The old educational models are hierarchic: one teacher in front of a roomful of students. You don't have to work it out on the blackboard to notice that 1 faucet + 100 buckets = wait in line. The old design can serve as much to restrict information flow as to encourage it, as many of us have experienced in conventional schooling. So we are now all students of the homework presently assigned our species by our planet: Design an educational system or non-system that teaches people to teach themselves; phase out the hub-spoke model of the teacher's individual talent or data heap, and phase in the creative collective imagination of the taught.

More projects must be designed that turn the students loose with their own capacities to interact with their fellows in a cooperative rather than competitive manner. This frees up the teacher to wander among the students as a gentle guide, dealing with them one by one as a more experienced equal rather than directing them en masse from a distant height. Bamboo fits this decentralized, more active and interactive model admirably.

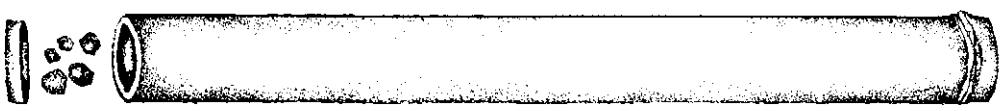
THE PROPER STUDY OF PEOPLE IS PLANTS. Bamboo also recommends itself as an agent of revegetation in a time of ecocrisis on the earth when the homework of all children should be to plant and recover the planet with its ancient green blanket, snatched from Mother Earth in the dark night of industrialization. Now more than any time in history the proper study of people is plants. Maria Montessori calls the students of her dream-school *Erdkinder*—Earth children—because their education is based on agriculture, the basis of all culture and culture's earliest job.[11]

LOW-TECH CREATION COMPLETES HIGH-TECH CONSUMERS. Surrounding customs and personal taste confine us to routine mirrors of who we are already, but we are really completed, complemented, by our opposite. A society of high-tech consumers needs low-tech doing and creation to balance itself out. We don't need weekend amusement innovations that require more power tools screaming in the bored basements of a million home workshops. Untamed, unmanufactured, nonelectric, nonpollutant, lots of oxygen in abundant leaves—bamboo is an upright natural high that, broadly embraced in industrial cultures, could help unplug people from current, ease neon-withdrawal, reduce useless motion, and maybe even diminish driven driving in Americar, more full of distance than destinations. Genuine growth in a hypermobile world sometimes comes most readily without movement. Loaf and

The diablo, an ancient Chinese humming top, was a smashing success when introduced in late 18th century England, and has remained sporadically popular in the West ever since.



A French print (1812) demonstrates the diablo dance.



Rattles of bamboo, for the newly born and for percussion instruments; try beans, grains, pebbles, screws. Where thick- and thin-walled bamboos are available, let children experiment with different sounds of different species, and with sound progression in internodes of varying lengths.

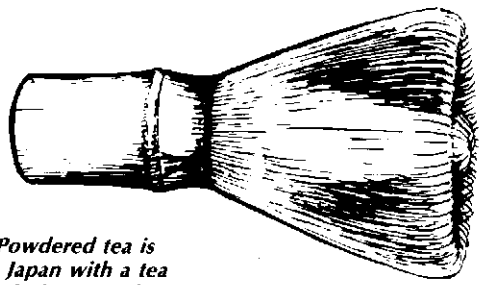
invite your most intimate creation. Carve a small object for neither applause nor profit. "Have the innocence to enjoy yourself."[12] Stop lashing your life to increased achievement and start lashing bamboo.

Prayer of a bamboo bum.

Preserve me, Buddha, from distress
of riches, wisdom, or success.
Grant me, rather, an immense
and creative negligence,
while my dry detractors flee
about with ulcered industry
till, plagued by Profit, they confess
the opulence of Idleness.
But let them wake too late to mend
their anxious, honored ways, Amen.

FRIEND TO CHILD FINGERS. "As iron sharpens iron, friend sharpens friend," according to an Old Testament proverb. Bamboo, the "friend of the people" in Chinese folklore, has indeed sharpened the skills of many oriental cultures. For centuries in Japan it honed capacities for patient repetition of detailed processes that demanded rigorous exactitude. The deft hands and minds that matured making finely woven baskets and minutely ribbed fans, were, in the twentieth century, designing electronic circuit boards.

Although one of the main teachers of the Orient, this friend is largely unknown in Western education. Through the influence of educators like Montessori, who demonstrated the imbalance of excessively bookish schooling in an Italian slum, *things* are finding their way back into the educational process to counterweight the dominance of words and print. "Words indeed are excellent, but things are still to be preferred," as William Penn opinioned in his seventeenth century reflections on education in the New World. If things are missing from schools, let the first thing be . . . providing them. Planting bamboo and other crops that can be incorporated into our curriculums would seem self-reliant homework to encourage.



Chasen. Powdered tea is stirred in Japan with a tea whisk made from a culm about an inch in diameter split just above a node into as many as 120 fine tines, delicately arched. The chasen is witness to the trim fitness of both the bamboo fiber and the fingers shaping it.

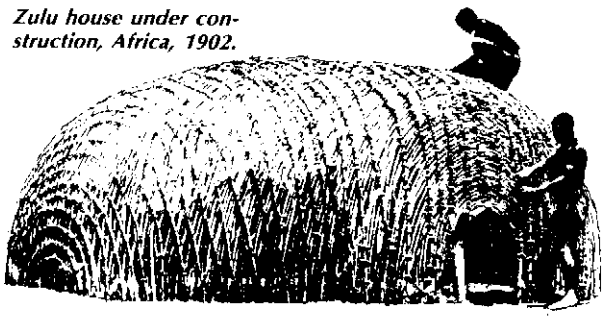
Some experience in gardening becomes increasingly vital for populations increasingly urban. The more our feet are exiled from earth on cement, the more urgent it becomes for health and sanity to spend at least some time with our hands in the dirt. Modern city children are starved for this experience. Neither their need for nature nor their need for work is adequately nurtured by the usual schooling in most industrialized countries.

We have mentioned a Western botanist's observation that a "Bamboo Age" preceded the ages of stone or bronze. Primary grades can reenact this cultural evolution for the child by providing bamboo as one of the earliest materials that unskilled but eager young hands can learn to work, after paper and before wood. Wood is a harder material than bamboo, requires heavier tools, and implies a greater age in the craftsperson. If you take a stroll around the Global Village, you'll notice that children of basketmakers are helping their parents sooner than the children of carpenters. There are years of schooling before children begin "shop" when they could be tooling up their craft capacities with bamboo. And the groves supplying culms for their crafts will also offer summer shade and winter windbreak, as well as a mellow green softening the sharp corners of whatever buildings they surround.

"Bamboo is one of those providential developments in nature which, like the horse, the cow, wheat and cotton, have been indirectly responsible for man's own evolution" (Porterfield 1933). Like the embryo in the womb, reenacting the physical descent of our species, growing and shedding gills and tail, the child in school relives the cultural evolution of the race. The complete absence of any knowledge of bamboo in our schools is an unfortunate gap in this theater of our collective past: unfortunate for our culture as well as for our children, because the educational process is perhaps *the* key point where the useful beauties of bamboo could be introduced to the West with maximal long-range impact.

Megaschool.

Only quite recently have people gotten the idea of educating everybody in a culture. They've gotten it,



Zulu house under construction, Africa, 1902.

in all countries of the world, at a time without precedent for the closeness of human packing on the planet. This morning more people got up and went to school than at any time in the whole past history of the world. We need roofs over the heads of these millions, materials for these hands to work. What shall it, what can it be if we want to design for everybody? What is a feasible physical embodiment for school ideas? As wood and metal become more scarce, bamboo becomes more apparent as an alternative for many school systems going broke: to grow their own . . . or buy from a more southern school.

We suggest beginning with models because they require little material of good quality. Scrap or broken pieces of bamboo shades and screen and other artifacts found free on the street in large cities are one source; thrift stores are another. In models, any size of any bamboo, even some common dwarf bamboos fit for little else, can be used. This cheapness encourages a relaxed exploration of the material, a period of getting to feel and know bamboo in the hands, working with it in a small space like the kitchen table or, better, in oriental fashion, on the floor in some corner. Best, if you have a yard and space available, is a tiny shack of bamboo where you can keep the few tools you need to work it. By sitting on a mat on the ground, oriental people acquire an extra pair of hands, their feet, to grip bamboo when they're dealing with larger pieces.

Miniature magic.

ARCHITECTURAL LITERACY THROUGH DWARF DWELLINGS. We're no longer satisfied with a few professional readers in a village, and the rest listening. We should encourage, in our schools and lives, the practice of architectural literacy. Standing under dripping roofs, behind windy walls, crowded into dehumanized spaces, we're waiting for architects, construction workers, city planners, and real estate agents to take care of our shelter needs. Since housing is a primary need, architecture should be a primary and universal study—from preschool through adult education.

Making dwarf dwellings, models of schools, playgrounds, towers, and bridges, on a scale of 1 inch to 1 meter, we discovered how people are drawn to the diminutive. Stopping at the workshop window to study the little bamboo knobs on the bamboo doors swinging on coconut leaf hinges, people of all ages broke into appreciative smiles. There was much interest in nearly everything the workshop produced, but the miniature obviously had an extra special magic for everyone.

Working with small models requires little bamboo per project—of significance when working in groups, schools, or community workshops with bamboo. Errors waste less. The careful measuring and cutting required are excellent preparation for later, larger projects with bamboo or other materials, for precision and attention to detail in general. Tools and supplies are also simpler and cheaper: a machete to split, a hacksaw to cut pieces to length, a file or sandpaper to refine cuts and smooth edges, occasional use of a drill and a few small bits, a ruler,

Nyakusa chief's house, southwestern Tanzania, c. 1900. The wall slope—outward here, inward in the Kinga house following—completely alters the external appearance and the inward feeling of space.

Kinga house, southern Tanzania, c. 1900. The trimmed bamboo rhizomes at the tip of the roof presumably represent ostrich heads. "Ostrich eggs were widely used to decorate apexes of roofs and were sometimes reputed to act as lightning insulators." (Denyer)

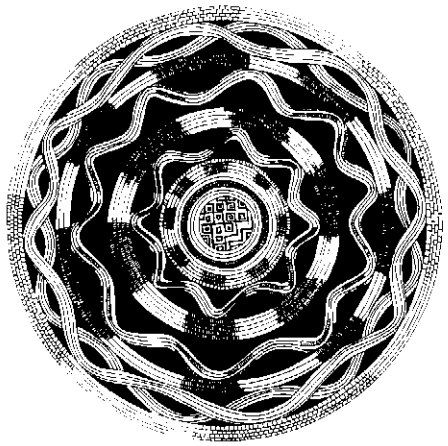
shoemaker's glue, some oil or varnish for finish, some strong thread.

Old bamboo curtains or broken baskets are frequently out on the streets in large U.S. cities. They are an excellent lumberyard for making small models. Keep your eyes out, pick up any bamboo you see, prop in a corner until inspiration strikes. In yards or parks, offer to clear out dead poles. You will soon have a regular harvest route. Get to know the gardeners in local parks and ask them to alert you by phone or card when a clearing of the groves is scheduled. Bamboo is often just thrown away if nobody's asking for it. If you yourself have excessive riches of bamboo, don't call the dump, call your local school. Children can harvest and carry it off—along with a few rhizomes.

A workshop in model making with the *Instituto*—a grade school–high school—in Rama, Zelaya, Nicaragua, led to the students preparing an exhibit on possible uses of bamboo in Nicaraguan education, both as material for classroom construction and for use in the curriculum in a variety of ways. Among twenty-five hundred exhibits prepared throughout the country by some eighteen thousand participating students in an appropriate technology science fair, the bamboo project came in third.

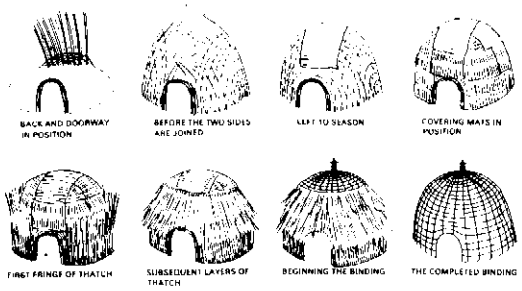
The "house" is a primordial toy, naturally fascinating to the child. How can we wed this fascination to bamboo, a primordial material for houses? From scale models to playground structures to child- and adult-sized schools or houses: This would seem a good teaching progression. California high school students are now building suburban houses. There is no reason students can't learn to build their own schools.

Fulani roof interior, Guinea, 1956. "The apex was filled with a basketwork panel." (Denyer)



Pre-school Building Project.

Birds beat us to it in song, flight, and shelter. The youngest children can experience the pleasures of building in structures that are most nestlike. Here's one from Denyer's (1978) densely, wonderfully illustrated *African Traditional Architecture*. Cattail and any thin, pliable bamboo—*Pseudosasa japonica* is a common species that would do well—could serve as thatch and frame. A woven bamboo structure such as this could also support the cement-gunny sack construction mentioned in Chapter Four. Begin with a small model, about a foot in diameter, then one perhaps 4 feet in diameter and 3 feet high, just large enough for one or two kids to creep into. Work up to maybe a 9-foot diameter, building miniature bamboo scaffolding as necessary. Alexander's (1977) *A Pattern Language* is to be recommended, perhaps more than any other single volume, for inspiration in teaching the bones of architecture to children young enough for them to grow up with a sense of the possibilities of humanized space in their bones.



Swazi house construction, Swaziland, c. 1945.

SHELTER STUDY: AGRO-ARCHITECTURE. Teaching architecture in schools implies some attitude toward the traditions of architecture. What will we set out to do, exhibit slides of the imperishable beauties of the Parthenon to a restless audience of sixth graders? Bernard Rudofsky, in *Architecture without Architects* (1964), voices an articulate departure from academic consensus. Instead of focusing on the familiar set of world wonders, he examines the virtually unexamined: popular anonymous architecture around the globe. His defense of the wisdom of this perspective, condensed above (pp. 115–116), contains hints for the design of a curriculum for architecture in grade schools and high schools that is quite different from the standard fare of university architecture departments. Architec-

tural beginners should be taught the beginnings of architecture.

In the context of a renaissance of popular architecture, bamboo is especially relevant. As the earliest component of popular architecture in Asia, bamboo development is an appropriate tactic for agro-architecture in a broad temperate-tropical belt around the world. Putting housing back into the hands of the people implies and depends on first putting the proper plants back into their consciousness, gardens, forests and fields, for hardwood foundations, bamboo framing, and the best local species for thatch.

THE HOMEMADE HOUSE: MAIN PLANET TOY. "We have to cross the frontiers of our civilization into what until recently we used to call the world of savages to encounter children untouched by industrial toys and mechanized entertainment; whose curiosity has not been deadened by programmed activities; who never felt the breath of the child psychologist on their neck . . . With Nature as their inexhaustible toy shop, children in primitive societies get far better ideas of how to have a good time than the most zealous kindergarten teacher. 'The children in Uganda are very well behaved,' noted an explorer; 'I was struck by the way in which they amused themselves. Instead of making senseless mud pies, they made miniature villages which were almost exact copies of the dwellings around them. They would be thus employed for hours together, day after day, and would persevere until their models were completed.' . . . Kpelle children build houses which they furnish with household things made by themselves . . . Their power of observation is uncanny, their devotion to what they are doing total. Transition from work to play is imperceptible; when the children accompany their elders to the fields, they are given a small hoe and sickle to play with. It was Plato who counseled parents to 'give real miniature tools to those three-year-olds.' In Africa and Oceania, wherever the native life style is still intact, children make their own tools. On Borneo and the Gilbert Islands they build their own houses and canoes. 'The natural imitative skill of the primitive child knows no bounds,' says Miller. Ethiopian children playfully set up small-scale huts and corrals and stock them with snails, shells, and pebbles that are their cattle, goats, and sheep. The children of the Warega, a Congolese tribe, do not only build entire model villages but act out an accelerated version of a full day's community life. Preparations begin on the eve. In the morning the children proceed to a river, catch fish, and roast them on fires in front of their own little houses. This done, they go about their work much like their parents. At a certain moment, one of them calls out, 'It is night.' Whereupon they retire and pretend to sleep. After a while another one imitates the crowing of a cock, they awake and recommence their work."[13]

Ethiopian children at play. A school is a womb, and schooling in essence provides an accelerated reliving of the cultural life of the race.

"Japanese and other northern children build snow houses. The snow is cut into slabs, 4 inches thick and 15–20 inches wide, and set up in an ascending spiral to form a domed roof. The chinks between are filled with soft snow which hardens in ten minutes. Three skilled kids can build a snowhouse 9 feet in diameter and 6 feet high in about 45 minutes."[14]

PLAY MAKES COMPLETE PEOPLE. "The privileged children of Europe, by way of contrast, have been presented since the sixteenth century with the doll's house, complete with parquets and stuccoed ceilings, wallpaper and embroidered rugs, veneered tables and chests of drawers, chairs upholstered in silks and brocades, quilted bedspreads, glass chandeliers, marble fireplaces, and gilt-framed mirrors of Lilliputian proportions. Too precious to be touched by clumsy little paws, its function was reduced to a showpiece."[15] The German poet Schiller maintained that "play alone makes man complete. Man plays only when he is in the full sense of the word a man, and he is wholly man when he is playing." But prefabrications of the international toy industry miss the inventive spontaneity at the heart of true play. Schiller's later compatriot, Rilke,

Early bamboo shelter and baskets.

Early house history reinforces interest in the building process, as well as increasing confidence that we can do it ourselves. A glance at early shelters provides hints on how a bamboo camp could auto-construct itself with materials found or grown on location and shaped by the active energies of the sheltered kids.

POTS BEGAT HOUSES. As early as 7000 B.C., prehistoric peoples living in caves and in excavated holes crudely roofed with branches were already competent potters. The size of early pottery dwarfs later ceramics; large pots were used for storing oils, wine, grains and dried fruit, and as coffins. In time, people saw that they could not only cook their soup and keep their dead in their crockery, but live in it as well; the crock became the cottage. Wattle and daub construction evolved from basic basketry techniques combined with pottery. Uprights are warp to a weft of withes lashed with vines and coated on one or both sides with mud, the most abundant building resource in the world.

BASKETS BEGAT POTS. Baskets, even more ancient than pots, provided one early method of making pots. They were coated with clay and fired, consuming the basket and leaving the pot. Hidalgo (1974) gives the most detailed guidance for applying this ancient technology to cement over a basket for water storage and to the use of bamboo mesh as reinforcement in building panels.

lamented that playing with dolls and doll houses provided an "initiation into the rigid passivity and emptiness of life." With ready-made toys, Rudofsky concludes, "the child picks up ready-made notions and acquires mental deformities that later put him in good standing with society."[16]

KID-BUILDABLE PLAYGROUNDS. Superlight, kid-liftable bamboo can be used as mobile components around wood or metal constructions in a playground. Instead of a fixed space, imposed once and forever by adults only, the playground could become more fluid, with children's own creative imagination at last welcomed as an ingredient in the design.

Tipis, pyramids, bridges, ladders, towers, minihouses, climbers of all sorts can easily be made with bamboo. Climbing is a need deep in the feet and hands of children—a denied need or inadequately met in our urban architecture with its tragic absence

Bamboo observation perch.

Try building a chair with the seat about the height of your neck, rungs on the sides a little higher than your ankles, and others in the front and back a little higher than your waist. Climbing up into it whenever you want to sit down will give some notion of how uncomfortably we design our houses for our children.

Our architecture could be adjusted in many minor ways with major impact on a child's learning. One important example: children are fascinated by food preparation and many other forms of adult domestic work. But we provide no elevated space for them to watch it happen. An observation perch can readily be constructed of bamboo or whatever available material. It can be, in fact, the giant chair we began describing above, but built to facilitate ascent rather than frustrate it, a seat-tower light and small enough to move easily about the house to witness all action occurring at levels not conventionally available for inspection to those with eyes at the height of our knees. Ordinary high chairs are good substitutes for a really giant chair, but they aren't usually designed to be climbed, and lack the dramatic extra foot or two we have in mind: they are for sitting with adults, not for a panoramic vision from which to survey what's going on in the room. Infants in them are frequently arching their neck for a taller vision. All this may seem a farfetched suggestion, but if you have children in your home, make height available at will to them—and watch them use it constantly to watch. There is almost no simple, cheap piece of furniture we could introduce that would more transform the home for children than a giant, towering chair. Children of most traditional cultures are spared this vertical exile. Food preparation and most else still happens on the floor, readily accessible to be explored. Maybe the "generation gap" has something to do with our "norm" of chairs and tables that, through all the earliest years of their most intense capacity to learn, leave our children wondering on floor level what's going on. If we want to remain close to them when we are old and grey, we must let them come close when they're young. The house, the space we share, is the main tool we have to accelerate their learning in their early years, but domestic architecture rarely escapes the ghetto of adult-mind. Alexander *(A Pattern Language)* is, lamentably, *un*characteristic of modern builders in his attention to these themes.

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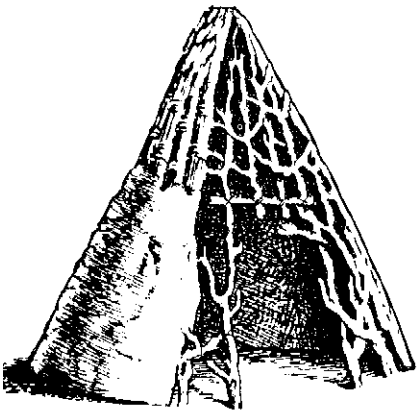

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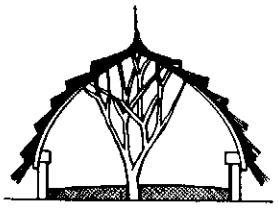

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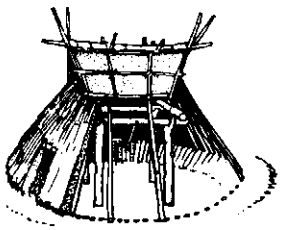

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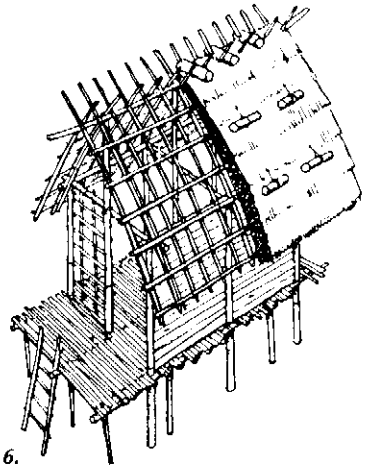

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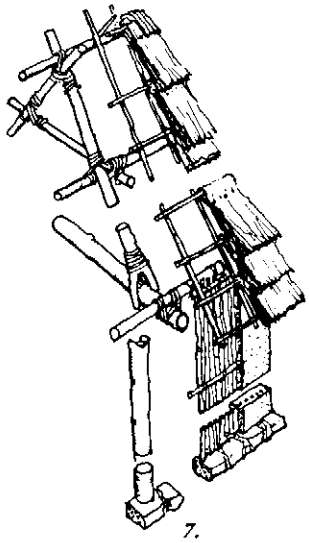

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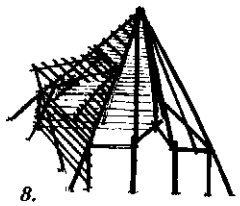

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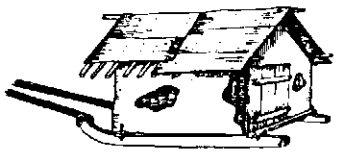

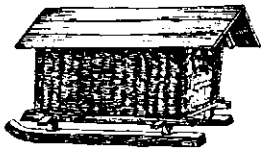

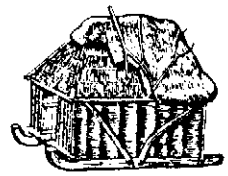

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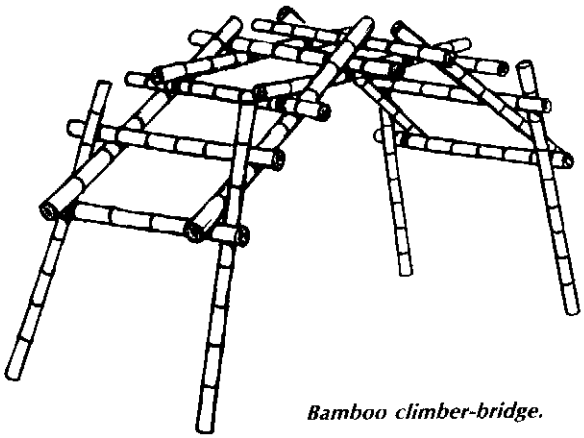
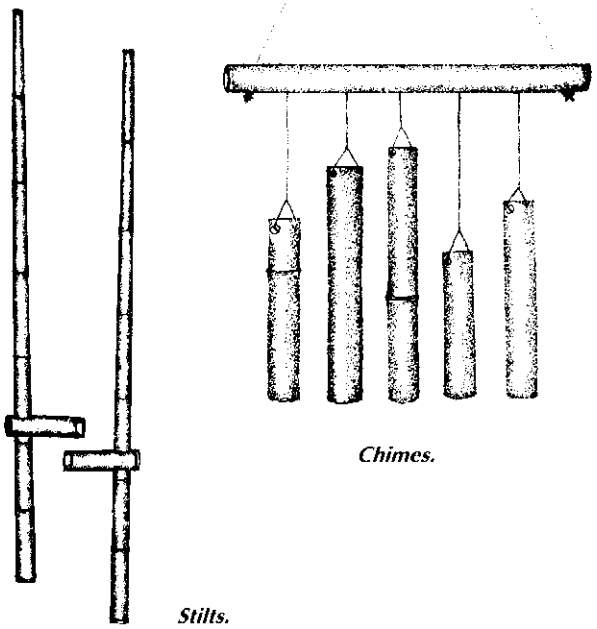
Shelter genesis, shelter games. Kindershelter, *a curriculum of shelter games for pre-school or post-school architects. (1) "The First Building," after Viollet-le-Duc. (2) These late visions of early architecture are reproduced from Rykwert's* Adam's House in Paradise, *an intriguing study of the idea of the hut in architectural history. (3) Use of living trees is a constant in early shelter. (4) Sectional view of a Dinka hut about 40 feet in diameter discloses an umbrella construction, with the tree's branches supplying the spokes. The roof consists of layers of cut straw, Upper Nile. (Rudofsky 1977:132.) (5) Neolithic shelter, northern Japan. (6) Pole and bamboo stilt house, southern Japan. (7) Framing and thatch details. (8) Pyramid hut framing. (9) "Sleigh huts of Bulgarian nomads house entire families." (Rudofsky [1974:142ff] surveys sleigh houses from 3500 B.C. pictographs.)*



Bamboo climber-bridge.

of trees. Granted its height, bamboo is an excellent material for constructions whose main purpose is up. Up is beautiful—anything that puts children awhile bigger than big people, lets them look *down* for a change on the adult world instead of forever up at it.

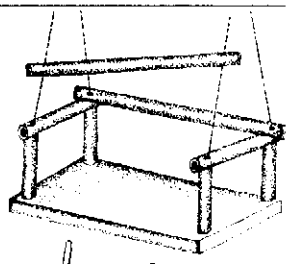
Chime-mobiles and a whole percussion orchestra for kids to knock and drum on as well as the *booloo perindoo* or giant flutes doubling as ladders —the possible parts of a bambooed playground are virtually endless, and a bamboo craft shop on location would make it practical for older children to go on experimenting and building components. Playgrounds, a major hangout for children, deserve more conscious study by adults. In Japan, park designers wait to construct paths where people wear

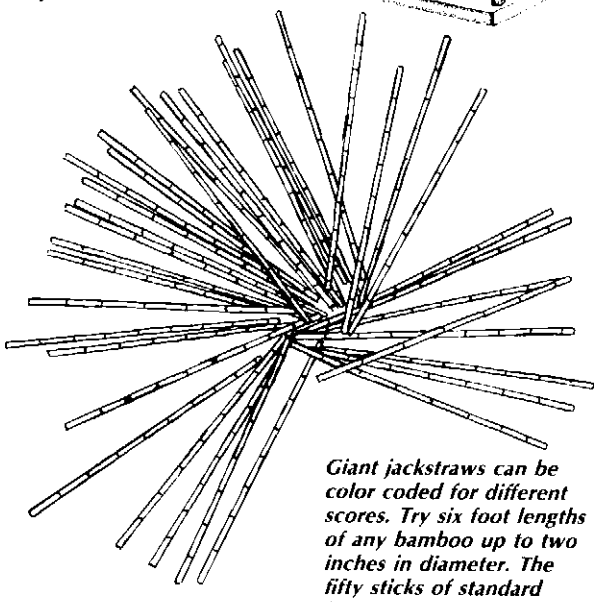


Chimes.

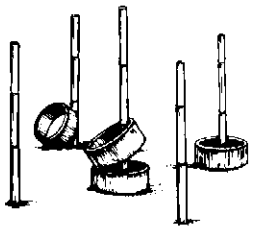
Stilts.

An extremely simple swing to construct. The seat can be of bamboo or wooden board. Four holes drilled in the corners of the seat permit a single rope on each side to run through all pieces of bamboo.





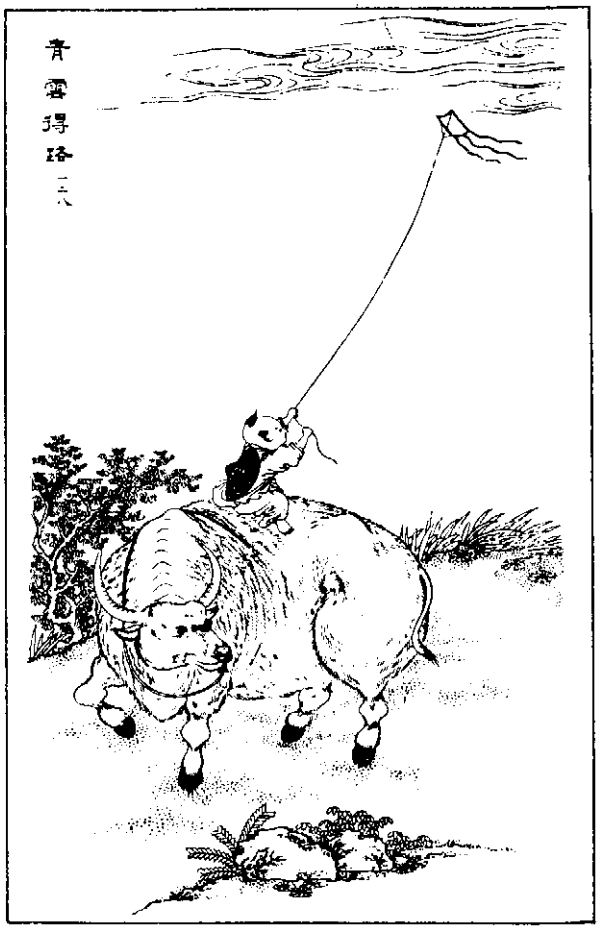
Giant jackstraws can be color coded for different scores. Try six foot lengths of any bamboo up to two inches in diameter. The fifty sticks of standard jackstraws can be reduced to a less bulky number.



Bamboo horseshoes or quoits can be made of large culm cross sections or laminated bamboo strips if larger species are unavailable.

them. The space is shaped partly by the spontaneous impact of those who use it. How can we extend that principle to playgrounds and invent processes that gradually phase children in as architects of their own kid-designed, kid-made environments?

KITES LIFT MORE PLEASURE PER POUND. It is time for academic culture to adopt—seriously and playfully —this tallest child of popular imagination around the world. Interest in kites, which dipped briefly after the invention of airplanes, is soaring again. You can learn more about flying by building a kite than by boarding a jet. Making them is an excellent project for schools alert to teaching the principles of aerodynamics in a format more vital than print. Kite crafting is an inexpensive introduction also to working with bamboo, requiring little material, producing more conscious fun per culm than almost any other bamboo project you could choose. Bamboo forms the bones of kite history, the spine of the art.



"The kite began not as the reasoned invention of a scientific mind, but as a wondrous and even magical link with the heavens. Early kitemakers felt a very special relationship with this toy or tool which allowed them to become a part of such a distant and powerful force."[17]

"Nature must have intended bamboo for kite frames. It is modular, each module structured like a bird's bone, probably stronger than steel for weight, and very easily worked."[18]

Sometimes bamboo whistles add an audio dimension. Kite lutes and wind zithers were also explored by the curious and nimble Chinese fingers, making these airy instruments for the winds to play. Ancient toy and stratagem of battle, modern instrument for experimental research, the kite is an ideal early learning device that unites botany and agricultural studies in growing the plant, the physics of flight, the industrial art of microdelicate handcrafting a material, experiments in papermaking, graphic design, drawing and painting. All are found in the simple, cheap, ancient, profound homework of kite construction.

Cost per pupil can be reduced to near zero by cultivating your own supply. Be alert to groves in your neighborhood producing an excess: bamboo needn't be a "problem"; integrate it with the local school.

A whole candy store of modern supertech from Mylar to fiberglass is available in kite stores in New York, San Francisco, and many other cities and towns. Newman lists forty-two kite organizations, shops, materials sources: forty United States, one English, one Canadian.[19] These refinements are not available in poorer countries, but the lightweight strength of the most old and widespread material for kite frames, bamboo, is broadly available already and could easily be made sufficiently available for all children everywhere. For the Global Schoolhouse of the Global Village, kites are a cost-possible planetary norm.

KITEBONES. Traditional framing materials for oriental kites were cypress and bamboo, both still favorites for their lightweight strength. Weight critically affects flight potential, especially in a light wind. The most versatile kite-framing material is bamboo—extremely light, flexible, and easy to work. A machete—or large kitchen knife and hammer—can be used to split large pieces. Once rough size is reached, use a sharp carving knife and sandpaper for details. Shave finely with blade perpendicular to surface: scraping off minute pieces gives more control, necessary for Indian fighter kites, for some oriental designs using varying thicknesses of bamboo in their construction, and for any highly refined flier. Chinese designs employ sizes ranging from solid, small-diameter shafts for the spine, un-

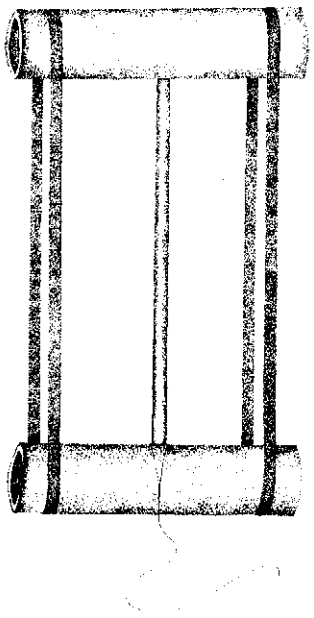
Birds, dragons, fish, insects of all sorts—the styles of Chinese kites are virtually endless.

tapered strips for standard secondary spars and spines, broader and thicker slats of bamboo as center spines or as spars near the leading edge, and especially thin reedlike strips to serve as guide strings along the outside edges.

For the bow of a fighter, a ¼-inch piece will be fine. Trim rough edges, taper ends slightly, bow strip to sight irregularities, and pare nodes and other thick sections with a knife. Avoid overcutting. Moving knife blade back and forth quickly, perpendicular to strip, shaves small slivers, further refining the bow. Constantly check curve symmetry while cutting and shaving. The bow is the key to a good fighter kite. One of the last steps: sand the bamboo. "The finished bow is a work of art."[20]

Kite frames are a good introduction to the art of bending bamboo. Remember that overheating makes a brittle, fragile flyer. Bend to slightly less than exact shape desired: This maintains the frame's structural tension, the kite's shape and spring, which help it adjust to minor wind changes.

KITE SKINS. Kite skins have been made of bamboo twigs and plaited leaves of various plants, of plaited straw by Caroline Islanders, of a wide range of vegetable fiber. But the first kite cover was silk (prohibitively expensive), then paper of many sorts in many countries: tissue paper in India and Bermuda, fine bark paper in Japan. Making the paper teaches more per square inch than buying it. Once mastered, papermaking is an art with polyapplications: lampshades, room dividers (Japanese *shoji*), window blinds. (For paper, see p. 277. For more on kites, see p. 48.)



A bamboo hummer. A thin branch section running between the middle of larger sections is fitted snugly in burnt holes and braced against the inside of the culm wall. Thick rubber bands at the ends hold the hummer in tension and provide the hum.

Make a note of it.

Bamboo music in the Global Village school has not yet arrived. No bamboo musical instruments are presently available in the general school systems of many countries where bamboo is plentiful, for the usual musical direction of these countries is away from their own roots. Their ear is listening to the new sounds of the international music industry.

Bamboo wind and percussion instruments form an important element in the musical traditions of many oriental and Latin American countries, but they are often virtually unknown in schools, even when present in the surrounding (and vanishing) popular culture. In Nicaragua, plastic flutes from Hong Kong are available in the Masaya market, but no wind instrument more sophisticated than a toy whistle is produced locally, and cheap musical instruments for school use do not exist.

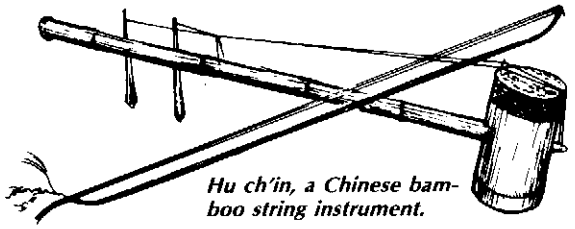
The massive introduction of easy homemade instruments seems indicated in schools as appropriate homework at this point to keep time with present-day harsh economic realities and dehomogenize our musical education. Many global sounds will soon be silenced unless honored in their region's curriculum. Participation is the keynote of appropriate music: making music, not merely listening, and ideally making the instruments as well. We need a highly graphic inventory, detailed enough so skilled craftspeople can pick up subtle aspects of construction of the most successful bamboo instruments throughout the world.[21] Until the happy day when we have that resource, here are a few notes on the global bamboo band. (See also, musical instruments, pp. 52–54, 82–87.)

BAMBOO BAND. A number of simple instruments can be easily constructed of bamboo. *Rhythm sticks* are among the simplest: Tape or tie together six or so bamboo plant stakes that florists and nurseries stock. Two-foot by ⅛-inch stakes work fine. Two-foot lengths of an old split bamboo curtain serve the same purpose, or use a piece of whole bamboo of a comfortable length split to about 4 inches from one end left intact as a handle. Philippine *tinakling poles* are pairs of 8–10-foot canes 1–2 inches in diameter played like this: Two people sit at the ends, a pole in each hand, and a small log or wood block maybe 2 feet long in front of them, on which the poles are tapped while a third player

dances in and out of the poles, in imitation, it is said, of the long-legged crane pacing the reeds by the shore of a windy lake. Left foot, then right hopping between the bamboo poles as they tap, tap the logs: Then the poles clap together with the dancer-crane hopping outside them.

Finger castanets are a small percussion instrument of bamboo requiring only two nodes cut from a pole about 2 inches in diameter. From the internodes between, bamboo *wind chimes* or panpipes can be cut. For *panpipes,* experiment with lengths of bamboo roughly ½ inch in diameter. For a C scale, try the following lengths, which are a little long to permit tuning: C–6¾ inches; D–6 inches; E–5¼ inches; F–4¾ inches; G–4¼ inches; A–3¾ inches; B–3½ inches; C–3¼ inches; D–3 inches. Lash the nine pieces together with two strips of bamboo on each side. These can be glued first for easier lashing. Tune pipes by putting clay in the lower ends.

A bamboo *fiddle?* From the base of a pole, cut a section leaving a node at each end. Cut a groove under two strips in such a way that they remain attached at both ends and lift them from the surface of the culm with bridges cut from another piece of your bamboo. For the bow, cut a piece from the tapering end of the culm, leaving a node at one end, with some 4 inches beyond the next node at the other end for a handle. Hollow out a string, leaving it attached also at both ends and raising it with



Hu ch'in, a Chinese bamboo string instrument.

bridges. Rub violin-bow rosin on the strings of fiddle and bow. In Nigeria, some eight to ten of these segments are laced together to form a zither.

Shepherd's pipe: In a 12-inch piece of bamboo with at least ⅝-inch inside diameter, cut a slanting ½-inch air hole 1 inch from the blowing end. Cut a 1-inch cork or wood plug with an air passage along the top slanting from 3/16 to ⅛ inch. Try the plug in the bamboo and enlarge the air passage slightly if the sound is weak. Tune pipe to lowest note by sawing off the end, ⅛ inch at a time. These measurements should give a C scale going up from middle C. Draw a line from the middle of the air hole to the opposite end, marking the finger holes beginning 2 inches from the end of the pipe. Drill a 3/16-inch hole at C, blowing to test the pitch, which is raised by enlarging the hole slightly on the side towards the mouthpiece or lowered by enlarging on the side towards the other end. Tune each note before drilling the next.[22]

The *didgeridoo* of the Australian aborigines is an impressive bamboo wind instrument made from a hollowed tube of bamboo 5–6 feet long, 2–4 inches in diameter, with a mouthpiece of beeswax. For an extended account of the complex subleties of the didgeridoo within the music of an amazing people, see "Traditional Music of the Australian Aborigines."[23]

Experiment freely. In some islands of the Pacific, bamboo bands with up to thirty different types of instruments are found. Rampant innovation is a bamboo norm.

FLUTE-MAKING IS EASY: A TRAVELER'S ART.[24] A friend came through a few years ago, an itinerant flute-maker. Before we knew it, we were making flutes, and bamboo became central to our lives. Making a flute is simple. Get a re-bar red hot over a fire and push out the membrane at the nodes. Any thin piece of iron will do, you end up inventing your own tools. I like to clean out the inside as well as possible and sand down the nodes inside flush with the inner walls of bamboo. In some traditions, they're very casual; pieces of the membrane are even left in. In others, the bore is well sanded and given several layers of lacquer, so there are extremes either way. Just do it. There's no "right way." You experiment, pick up on what people say, and feel your way, finger by finger.

After you clean the inside, you make an edge for the breath to flow over for end-blown flutes or a hole for side-blown flutes a few centimeters from one end. Traditionally in Japan the edge is sawed, but I don't like the feeling, so I file the edges. Making an edge isn't that complicated, and when you've got your edge, you've got your tone.

I look at a piece of bamboo and decide whether I want to make an end-blown or side-blown flute and how long it's going to be. I like to

put both ends on a node, and the flutes I make are 54–70 cm (21½–28 inches). My own preference, for tone, is 60–65 cm (24–26 inches). I decide what scale I want to put the flute in, and starting from the low tone of the flute, I feel it through. There's the

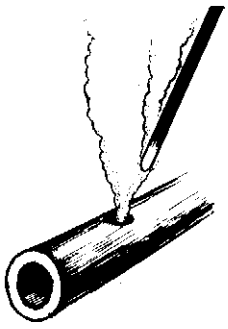
traditional shakuhachi scale, Arabic scales of various sorts, and I use another scale I made up. I went to bed one night, heard a series of tones I thought would be fine in a flute, so next morning I made them and it worked out well. Now I make a lot of flutes in what I call the "river scale."

The end-blown flutes I make are narrower in diameter, the tone somewhat dark. The side flutes have a larger diameter and much brighter tone, both in the shakuhachi scale and in a kind of Hasidic scale somewhat similar to the blues scale. I've heard that the traditional shakuhachi scale was derived from where the fingers feel comfortable, and I made a flute like that once with the little girl next door. We just marked the points where her fingers felt good and punched out the holes. When we played it, I couldn't believe how close it was to a pentatonic scale.

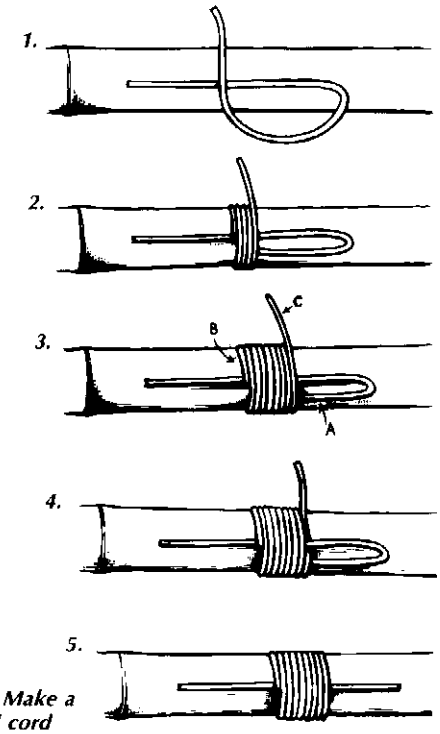
Generally, though, I measure very carefully. For the traditional shakuhachi formula, for example, the first hole is put in $\frac{2}{10}$ the length of the entire flute. The second, third, and fourth holes are spaced $\frac{1}{10}$ the length apart, and the thumb hole underneath is $\frac{2}{3}$ of $\frac{1}{10}$ the length behind the fourth hole. I measure the flute and vary the formula according to wall thickness and bore diameter. I put the holes in small and get a flat tone. Taking into account at each step what I've learned from the hole before, I put in all the holes and then enlarge them carefully to bring it into correct tune.

After the holes comes the finish. The bamboo is so beautiful—sometimes you want to touch it, sometimes you don't. The skin isn't absorbent unless it's sanded, so sometimes I sand the outside and use Haines walnut oil liberally, pulling a piece of towel on a string through the flute to oil the inside. The Japanese don't use oil. If you don't sand or oil them, your fingers will rub down the skin if you play a good deal, and the oil from your hands gets into the flute so they're changing constantly if you play a lot, especially if the walls are thin.

Naturally, you want to protect a flute. I thought about lacquering them and preserving them in various ways and finally decided, nothing's permanent. They're going to crack eventually—or they're not. I do keep them well oiled so they don't get too dry or too damp. The problem is the skin: if the fibers dry up, they shrink and separate. If they're too wet, they swell and crack the rigid skin. Binding helps prevent cracking.



Burning a hole.



Flute knot: (1) Make a loop. (2) Wind cord around the bamboo and the loop, pulling tight at each turn. (3) Pull tightly at A until B is tight. Pull cord tight at C and cut off. (4) Insert newly cut end through the loop and pull both ends of cord. (5) Loop is pulled under the wrapping where friction holds it tight. Cut ends off flush with binding.

A day or two workshop in flute-making would be easy in schools at a minimal cost. Even buying by the piece, you can get a 9-foot, ½-inch diameter pole for about $2–3. This is good for a number of flutes and leaves end pieces to play with. When we sold at fairs, we always had a box of little flutes made from the scrap ends of poles, free to those who got a tone out of them—and nearly every kid who really tried could play them. I started making scrap wind chimes too, out of cracked or end pieces, or flutes with an inaccurate scale. We spent a lot of time on the beach so we collected shells and combined them with bamboo.

Materials: Metal rods to burn holes. Hacksaw

to cut length. File: "Dragonskin"—a rough metallic sandpaper to wrap around dowels.

Inward Oz.

If I can talk, I can sing.
If I can walk, I can dance.

—African Proverb

Making a flute, like weaving a basket yourself or turning out your own first piece of paper, is one of those simple, wonderful things you could just this afternoon stop and do for the first time in your life. Even if your fingers are ten idiot thumbs, they can heat a poker and burn a hole. No matter how you botch or muff details, you will receive a shock of pleasure, discover an inward Oz through holding a rare modern artifact: Made in Me.

Though the casualness of this approach may horrify experienced flute-makers, what of the mute, musicless millions with nothing but an AM dial for their fine fingers? Elite artists, in gifted isolation from the norm, must add to their gifts the art of sharing them with others, the rest of us here in the culture. Honor beginner's mind. We must escape professional performance as the norm: as is is OK. Otherwise we stifle people's willingness to explore their ignorance without nervousness. Making one's own first clumsy flute can completely change one's relation to music. This music is light and easy to carry anywhere, requires no batteries, invites you to take it out anytime and visit a note. Soon enough you'll want to make a better one.

Wonders of mountains and forests
travelled by people become a market.
Triumphs of art and music bought and sold become merchandise.
—Ming dynasty epigram

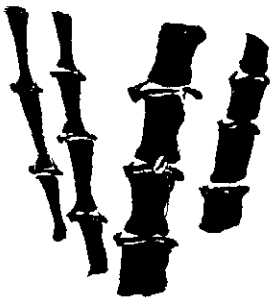
FLUTE-MAKING IS HARD. Support the fugitive flautist and small press: consult Shepard (1978, 1979) and Levenson (1974) for loving instructions on how to shape and toot your future flutes. Flute-making is an endlessly complex art and science that will always recede before the rippling centrifugal circumference of your competence, leading you on in delight to kiss the flute as it flies before you into unknown areas of skill.

CONSTRUCTIONS

Fiber grass.

Bamboo is an abundant resource for shelter that known land-management principles globally applied could make superabundant. Contemporary scarcities of tensile fiber through deforestation and high energy costs for steel manufacture coincide with a new respect for tensile structures as Western culture turns away from a long history of heavy monumentalism, stone piled on stone. Bamboo fibers embedded in pith make for a lightweight and flexible strength, useful to the plant in wind and to people in scaffolding, quake-zone shelter, and basketry. Architecture has imitated this composite structure: Bamboo-adobe dwellings of tensile culm and compressive earth, the yin-yang of popular architecture, are found worldwide.

Much of contemporary Western technology also imitates bamboo's shrewdly composite design. Combining tensile fiber and compressive filler is the structural design of "two-phase" materials such as fiberglass and reinforced concrete. Contemporary skeletons of steel are also heirs to millennia of bamboo engineering. The bamboo ancestor of the Brooklyn Bridge spans 750 feet over the River Min in Szechuan, China. So bamboo anatomy is reflected in new materials, and traditional bamboo engineering in modern structures historically descended from it. The following notes on bamboo construction techniques complement earlier con-



Wonder Lumber. Few life forms in nature come so ready to use as bamboo. Imagine a tree without bark, with few or no branches, growing in sizes fit for immediate use, splitting easily into equal parts, easily bent to shapes it will hold after heating over a simple fire, straight as an arrow and light as the feathers on it, with a natural finish that requires no planing or sanding or any preparation apart from simple scouring with wet sand. It would be a wonder lumber. And is.

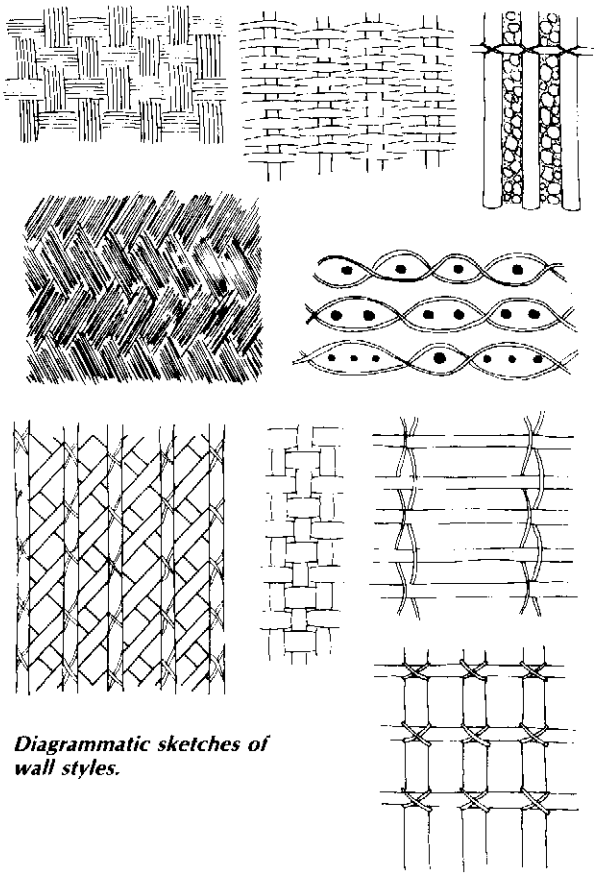
siderations of the subject (see pp. 97–102, 104–107, 126–129).

FOUNDATIONS. Bamboo is not generally used in direct contact with the ground in house foundations. Stone or hardwood is preferable. If used, treat bamboo with a preservative or put in gravel postholes to accelerate drainage. Where large bamboos are not available for main pillars and beams, smaller stems can be bound together to form large structural members.

FRAMES. See pp. 99–100, 104–107, 127.

FLOORS. On ground level, grade earth floor slightly to provide natural drainage. Place bamboo boards (see below) on loose soil, then compact. A raised floor of bamboo boards offers a sheltered spot below the house for adults to sit, children to play, chickens to nest, tools or farm equipment to be stored—however you'd like to use the area. A first floor raised 6 feet or more off the ground is more hygienic, more breezy in hot climates, and doubles a one-story dwelling space. The bamboo boards are easy to sweep clean—many cracks let the dirt fall through. They are resilient, so require more supports than wood floors, but are more pleasant to walk on or sleep on. Floors can be built of large whole opened culms, many small whole culms or main branches of large species, or strips cut from the culms of the larger bamboos.

WALLS. If using whole culms, half culms, or strips, remember they drain better vertically than horizontally. Mat walls woven of whole opened and flattened culms of thin-walled bamboos (for example, *Schizostachyum* species in the Philippines) are one of the most efficient and attractive low-cost housing alternatives in areas of bamboo abundance. They can be prefabricated in 10-foot-by-30-foot panels, rolled up and delivered by ox cart, and moved easily to another location when necessary. A design success for millions over centuries of low-cost bamboo technology throughout the Orient, this type of wall has a possible future in Latin America (lacking

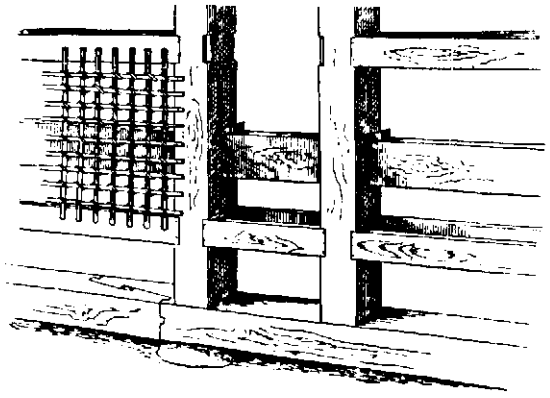


Diagrammatic sketches of wall styles.

20 million homes), which has not yet been seriously considered.

BAMBOO BOARDS: ESTERILLA. Where large bamboos are available, boards are made by splitting and opening the whole culm, minus the tip and basal parts, of species with thick walls. The process in Colombia, Ecuador, and other parts of Latin America is described by McClure: "The picador holds the bamboo culm in position on the ground with his foot and strikes the blade of an ax* into each node at intervals of an inch or so right around the culm. The incisions in the different nodes are short and entirely independent so that the wall of the culm clings together as a fabric in spite of the great num-

**Editor's note:* Sometimes this is done with a well-greased bit. The ax may also be used to remove diaphragms at nodes, or else a machete, adze, or curved spud can be used.



Side framing in Japanese construction.

ber of splits with which it is rent. When every node through the length of the culm has been cracked in this way, the picador makes a single continuous split from one end of the culm to the other. The culm opens out and may be pressed flat. Debris at each node is removed. The boards are stacked with first inner then outer surface uppermost, alternately. The stack is weighted with stones to prevent curling, and the boards dry out flat."[25]

BAMBOO-CLAY WALLS IN JAPAN. "Even in developing countries, where modern construction techniques have been introduced, cement and synthetic materials have been replacing, little by little, the use of clay as a covering for walls, to the point that it is now used only in isolated rural buildings or houses of people of quite limited means. Nevertheless, in spite of the fact that Japan is the most industrialized country in Asia using the most modern construction technology, the Japanese continue to use the traditional clay wall, not only in their houses but also in contemporary buildings of steel and concrete, in which they use the same materials and techniques of construction employed in building the most refined houses of the Middle Ages in Japan. The reason for the persistence of this tradition lies in the tone and beauty of its texture as well as its low cost and stability in weather changes, although it is not extremely resistant to daily wear and tear.

"The clay wall is generally constructed in a wood frame formed by structural elements of the house such as beams and columns, to which is fixed, as reinforcement, a grill or framework of thin canes or strips of bamboo. This framework is given greater strength by interlacing it with crosspieces of wood, horizontally and/or vertically. Once this is made, three to five coats of specially prepared clay are applied to both sides.

"The bamboo framework is made of thin canes 8 to 13 mm (⅓–½ inch) in diameter and/or strips of the same dimensions split from larger poles. These canes or strips are divided into primary and secondary members. The primaries are 30 cm apart, vertically and horizontally, with their ends tied into the wooden structural elements forming the frame and to wooden crosspieces by means of mortises or notches cut into these. Secondary members are placed between primaries at a distance of 2.5 to 4 cm, tied to these with straw cord having an average diameter of 5 cm. (2.5 cm= 1 inch.)

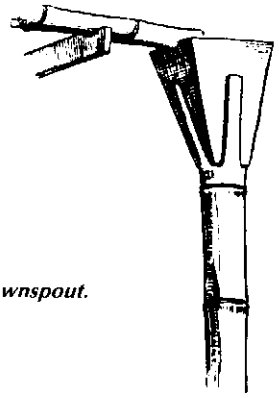
"The wall is made of three to five coats of clay of different mixtures applied to both sides of this bamboo framework. Only three coats are used generally, the composition of the final coat depending on the climate and traditions of the site. For the initial coats, clays of different colors and consistencies are used, mixed with fibers, glues, lime, and sand, all of which give distinct qualities to the clay. Fibers are used to prevent cracks in the clay produced by contraction when drying, Among the most common materials used are: fibers of raveled hemp 1.5 cm long; fibers of raveled manila rope in lengths 2.5 cm to 5 cm; separated, raveled, and chopped fibers of jute; manes of horses and hair of other animals which has little use for other purposes in Japan; cut up Japanese paper; chopped straw of various sorts. Straw 2.5–10 cm long is used for the first coat. Straw from the waste of mats and ropes in 2.5–5 cm lengths is mixed with the second coat. Fine straw 2.5 to 3 cm is mixed with the final coat."[26]

MUD-STUFFED BAMBOO WALLS. On the floor or cement footing, a wooden or bamboo footing is laid on which bamboos of equal dimensions are placed upright no more than a foot apart. A horizontal of bamboo or wood holds them in place above. Diagonal lathing of bamboo should be added to reinforce the whole structure. On this are nailed horizontal lathes at least 4 cm wide, 8 cm apart—(1½, 3¼ inches) far enough to let you get your hand inside. The *cascara* or outside wall of bamboo should be nailed against the structure, with the inside (*corazon* or "heart") facing towards the worker. Mud is then packed in well between the two bamboo walls of the wall, leaving it level with the outside surface of lathing. Then it dries four weeks before the surface coat is applied.[27]

Standard mud recipes include mixing earth, straw, dung—often cactus boiled and added for adhesive assistance—and a liter of the local lightning for seducing neighborhood cronies to lend a hand in the work.

ROOF. "Because of their high strength–weight ratio, bamboos are used to excellent advantage for structural elements in roof construction. In designing the roof, account must be taken of the nature and weight of the roof covering to be used, whether it be grass or palmleaf thatch, halved bamboo culms, bamboo shingles, corrugated sheet metal, or tiles. The dimensions, spacing, and framing of the individual structural units that support the roof covering are varied to conform to the requirements of the case."[28]

ROOF NOTE. Around 50 miles north of Lima, Peru, big groves are visible from the highway in Chancay, startling enough after many miles of desert to make one investigate how they came there. In November 1980, we found Don Guillermo, already ancient, who fifteen years earlier—around 1965—had planted twelve bamboo windbreaks, each about 1,000 feet long, to protect his large orchards of oranges, mandarins, and tangerines. He got them originally from the *Escuela Experimental de la Molina* in Lima, and showed us, with some pride, the roof of the attractive, even sumptuous, home he had designed. Bamboo rafters were treated with 4 large tablespoons of oil and insecticide poured into a ⅜-inch hole drilled in each internode and then sealed with plaster. Nylon fertilizer sacks treated with a waterproof material lie under a roof of earth with 50 percent bamboo leaves mixed into the soil to lighten it. "Earthquakes don't affect the construction because the roof is so light. With a heavy cement roof, when the earth moves, the walls move too. And a conventional roof would be four to five



Gutter and downspout.

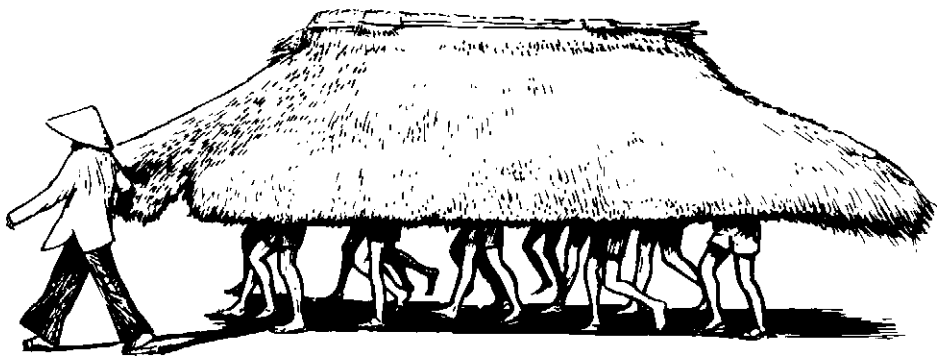
times as expensive as this one I've designed of bamboo."

Bamboo, the "wood of the poor" in India, remains the experiment mainly of the well-to-do in much of the West. How much he saved on his roof doesn't really matter to Don Guillermo personally. He lives in Miraflores—a posh section of Lima; one son is the local lawyer for Braniff, another a doctor somewhere else, and so forth. The class of people who could most profit by his inventive uses of bamboo are his neighbors, the impoverished villagers — who don't respect or seek bamboo and don't have the economic margin to be culturally curious.

GUTTERS. "The usual form of gutter for conveying water from the roof consists of a large bamboo split lengthwise, with nodes removed. This is held to the eaves by iron hooks, or by long pieces of wood nailed to the rafters, and notched in the upper edges to rest the bamboo. This leads to a bamboo downspout with the upper end cut to leave four long spurs, whose elasticity holds in place a square and tapering funnel of thin wood forced down between them."[29]

Thatch.

If you have ever lived and lounged in a huge, cool cavern of high-pitched and softly rustling thatch



Moving day in Vietnam.

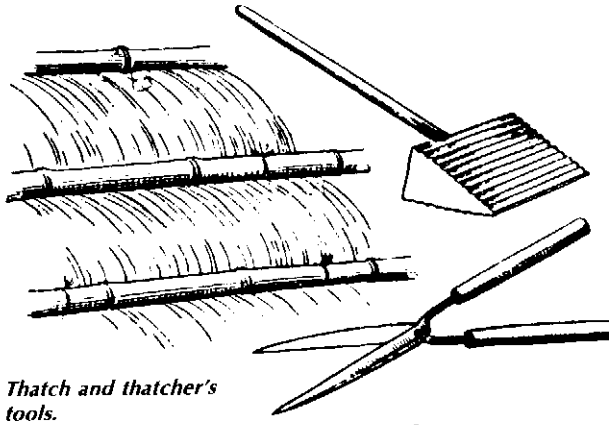
roof on bamboo framing, you will know thatch has no equal for vitality: eaves alert to the least wind; intricate innards and shelter to various communities of insects complete with lizards in pursuit; birds borrowing a tiny portion of your mega-nest to tuck into theirs. No machine-stomped material feels quite so amiable and fresh to flesh as this dry fiber, unprocessed, earth color that, from a distance, gently stitches shelter and land into a seamless garment, the human artifact of housing smoothly continuous in shade and contour with the hill.

If you have climbed tall palms to cut thatch, high above most surrounding jungle, with a tossing sea of green leaves below you; if you have dived down under a lake to cut the cattails where they bunch at the base some 8–10 feet below the surface and then slowly shoved a raft of them down shore to patch your hut—if you have ever been even briefly involved in the technology of thatch, you know there is no more deeply and simply satisfying task than to cover a space with fronds and grasses —the warp to a woof of bamboo or other lightweight raftering—and then to sit dry and satisfied as toast while the afternoon storm breaks loose in all its rambunctious tropical glory. The same lavish rains that produced your thatch will test your hand at using it.

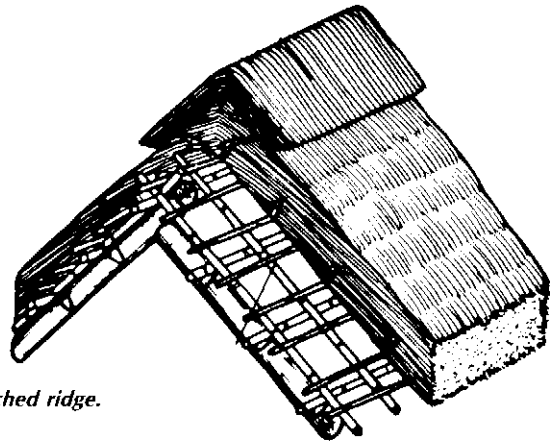
"It is indeed a matter of wonder that someone in building a house in this country [the United States] does not revert to a thatched roof. Our architectural history shows an infinite number of reversions, and if a thatched roof were again brought into vogue, a new charm would be added to our landscape. The thatched roof is picturesque and warm, and makes a good rain shed. In Japan an ordinary thatched roof will remain in good condition from fifteen to twenty years, and I have been told the best endure for fifty . . . When properly constructed, they shed water very promptly, and do not get water soaked, as one might suppose.

"It is customary in the better class of houses having thatched roofs to pave the ground with small cobblestones, for a breadth of 2 feet or more immediately below the eaves, to catch the drip, as in a thatched roof it is difficult to adjust any sort of a gutter."[30]

"The thatched roof is by far the commonest form of roof in Japan outside the cities. The slopes of the roof vary little; but in the design and structure of the ridge, the greatest variety of treatment is seen, each province with its own peculiar style, probably due to isolated life in feudal times . . . Straw, grass, reed, and rush are various materials



Thatch and thatcher's tools.



Thatched ridge.

employed for thatch. Rafters and framework should be close enough together properly to secure and support it. A bamboo framework is sufficient for a small roof.

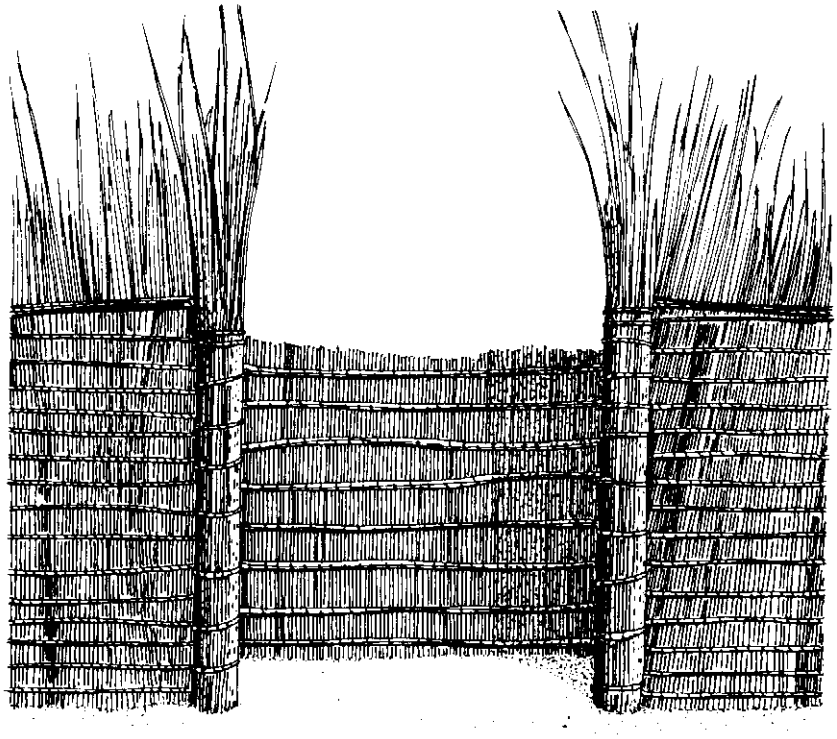
"The thatch is formed in suitable masses, combed with the fingers, secured to the rafters and bound down to the roof by bamboo poles which are afterwards removed. While the thatch is bound down in this way, it is beaten into place by a wooden mallet of peculiar shape. The thatch is then trimmed into shape by a pair of long-handled shears . . . When a roof is finished, it presents a clean, trim, and symmetrical appearance, which seems surprising, considering the nature of the material.

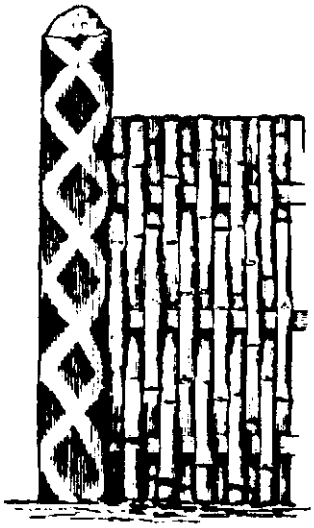
"North of Tokyo, in many cases the ridge is flat, and supports a luxuriant growth of iris, or the red lily."[31]

FENCES. Fences consume more raw material than any human artifact except buildings. Bamboo has probably made as many miles of them as any other earth resource.

FENCE SHACK. Once a fence is built, there's only three walls and one roof to go before you have a

Gate of Ganda Palace, Uganda, c. 1910. "The palace was surrounded by a tall woven fence about 3.5 meters high made of elephant-grass and supported at intervals by stout posts cut from wild fig trees, which eventually took root. In the palace there were about 450 buildings for the Kabaka and his wives, and hundreds of smaller houses and cooking huts. The main buildings were built in a similar way to ordinary houses, but of much larger proportions and with much finer and thicker thatch, sometimes as much as 30 cm [1 foot]. To build just one, two hundred men would be at work for at least two months." (Denyer 1978)





A simple and effective construction method using strips or whole culms of bamboo wedged in an alternate weave between three horizontals. For low-tech decoration, the hardwood post is stripped of bark, wrapped in wet straw or rope in any desired pattern, and the spaces between burned lightly or deeply over hot coals. (Japan c. 1880.)

Basket-fence. The walls of the basket are woven with bamboo or any available materials, and periodic reinforcements hold them in place. The fence shown is of Guadua angustifolia, *in a design from Colombia. This is an especially durable species, but bamboos are not generally recommended for use in direct contact with the soil.*