

A VICTORIAN PALM COURT

(An Interpretative Brochure for
The New York Botanical Garden)

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and

PALM SURVIVAL IN A TOUGH WORLD

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INTRODUCTION

Palms comprise a very useful plant family, second only in economic importance to the grasses which supply us with wheat, rice, barley, oats, and other grains. Palms provide the world with food (dates, coconuts, palm oil, hearts of palm), beverages (coconut milk, palm wine), clothing (raincoats, hats), medicines (betel nut), construction materials (thatching, irrigation pipes, logs), rope, fiber, carnauba wax, and hundreds of other products. Often the appearance of a graceful palm stimulates thoughts of exotic white-sand beaches and tropical paradises. We hope your stroll through our Victorian Palm Court will stimulate your feelings of appreciation for this remarkable plant family.

Spend 10 minutes or 2 hours, whatever you choose, and return often to observe the palms as they grow and progress through their life cycle. Each plant is different, and each one has its unique story.

The numbers in this brochure correspond to the numbers at the bases of selected plants in the gallery. They begin with the large palm near the courtyard (southwest) entrance and progress counter-clockwise from that point. Following each number is the botanical name (genus and species), English common names, if any are known, and the plant's nativity.

Longwood Program

1. Arenga pinnata -- Sugar Palm -- Malaya

This amazing palm will produce a trunk up to 40 feet high with some of the largest leaves in the plant kingdom, 20-30 feet long. The plant produces flowers and fruits only once in its lifetime, perhaps because it takes so much energy to develop the numerous flower clusters created in the process. The first cluster develops from the uppermost leaf with the next flower cluster just below it. This continues at each leaf until the bottom one is reached. Then the plant dies. Under favorable conditions this occurs when the plant is about 12 years old and generally takes 3-5 years to complete.

The common name of Sugar Palm refers to the sap produced by the flower clusters, which is a source of palm sugar, or jaggery. It is made by boiling the sap into a syrup and allowing it to crystalize. The sap can also be fermented into palm wine or distilled into an alcoholic beverage called arrack.

The fruits are inedible and may cause a skin rash because they contain calcium oxalate crystals. The same harmful properties are also found in the common houseplant, dumbcane (Dieffenbachia). New shoots, however, are sometimes cooked and eaten as a vegetable. The leaf bases have fibers which are used for making brooms, rope, and thatching material

for roofs. This multi-purpose palm has been widely cultivated for centuries in India and tropical Asia. (Illustration of a flower developing from the leaf axil.)

2. Washingtonia filifera -- Desert Fan Palm -- Western United States

Notice the palm with a "skirt" of dead leaves covering the trunk. While many people consider this an attractive feature, it can be a fire hazard. This is the only palm genus native to California. It was named after George Washington who became the first President of the United States in 1778. It grows to a height of 75 feet and has a massive trunk that can grow to 3 feet in diameter.

Native Americans had numerous uses for this wonderful palm. The leaves were used for building shelters and the leaf fibers for making baskets. The fruit can be eaten fresh, dried, or as a ground meal. The young growing tip, or heart of the palm can be roasted and enjoyed whole. Please see the next palm for additional information about hearts of palm.

3. Syagrus (formerly Arecastrum) romanzoffianum -- Queen Palm -- Brazil

Queen Palms reach a height of 60 feet in their native lands of Brazil. The beautiful, plume-like leaves give it a "royal" appearance. The fruits are

fed to pigs and cattle, and occasionally eaten by humans. Another food from this species is the tender white palm heart at the tip of the trunk. It is made up of immature leaves that are forming inside the older visible leaves. However, this is the only point where the palm grows, and when it is cut off for harvesting, the palm dies. It is no wonder "Hearts of Palm" salad is often referred to as "Millionaire's Salad." imagine the difficulty of harvesting the very tip of a 60-foot palm!

4. Chamaedorea elegans -- Parlor Palm -- Mexico, Guatemala

This graceful little palm was often used as a houseplant in parlors during the Victorian period because of its tolerance of low light and low humidity; thus, the common name of Parlor Palm. As an ornamental, it has some very attractive features. The flower clusters are bright yellow when young and provide a beautiful splash of color. As the flowers mature, they fall off or turn into jet black fruits while the flower stalks turn brilliant orange. Frequently, the orange flower stalks remain on the plant after more yellow flowers are produced, providing a striking display.

The botanical name comes from the Greek *chamai*--dwarf, and *dorea*--gift, referring to the fruit's location which is a convenient height for picking. The juice of the fruit contain a skin irritant (calcium oxalate) which breaks down when cooked. Young flower buds are also cooked and eaten.

5. Cocos nucifera -- Coconut -- believed to be Southeast Asia

The coconut palm is the most important commercial palm in the world. It is grown so extensively that presently there is at least one coconut palm for every family on earth! The name comes from the Portuguese *coco*--monkey, and refers to the resemblance of the fruit to a monkey's head.

For millions of people, the coconut supplies much of their needs for housing, household goods, implements, food, drink, and fuel. The fiber of the outer husk, called coir, is made into door mats, ropes, and baskets. The shell of the nut is made into utensils and bowls, as well as into a high-grade charcoal used in air purification. The juice makes a nutritious and refreshing beverage. The white meat can be grated and used in cooking or dried into copra. From copra, coconut oil is expressed, and used in margarine, cosmetics, and soaps. The trunk is used in construction, and the leaves are used for mats, baskets, and thatching. The palm flowers and fruits continuously for nearly 100 years. (Illustration of some of the products mentioned.)

6. Acoelorrhaphe wrightii -- Everglades Palm -- Florida and Central America

One of the most attractive native American palms is the Everglades

Palm. It has the unusual characteristic of tolerating brackish water. It makes a beautiful landscape plant in warm areas and grows well in pots, tubs, or greenhouses. It does not tolerate temperatures below 55 degrees Fahrenheit. When young, the plant produces undivided leaves. As it matures, it produces the fan-shaped leaves that you see here. (Illustration of the different types of leaves--undivided and fan-shaped.)

7. Livistona decipiens -- Weeping Fan Palm -- Australia

The common name refers to the leaf shape which is fan-like, botanically termed "palmate." This shape is one of the palm family's basic leaf forms. The other form is feather-like, botanically termed "pinnate," and those plants are referred to as a pinnate palms.

This genus honors the Baron of Liviston, Patrick Murray, who founded the Royal Botanical Garden in Edinburgh, Scotland, in the 17th century. The leaves are sometimes used for hats, fans, temporary roofing, and thatching material.

8. Chrysalidocarpus lutescens -- Yellow Butterfly Palm, Areca Palm --
Madagascar

The genus name comes from the Greek word *chrysos*--gold, and

karpos--fruit. It is a popular landscape palm in warm climates. Because of its tolerance for low light and near-drought conditions, it is one of the most common palms grown in containers for interior use. Indoors with its roots confined to a container, it grows to about 6 feet. However, outdoors or in conservatories where the roots are allowed to spread, it will reach a height of 25 feet. Notice the attractive rings on the trunk. These are scars left behind after the leaves fall off.

The areca palm exemplifies a "cluster" palm, because it develops new shoots from the base of the plant. These new shoots are commonly called "suckers," and, if carefully removed, can grow into a new plant. Other palms such as the coconut have a single-stemmed habit of growth.

9. Neodvpsis decarvi -- Peacock Palm, Tricorn Palm-- Madagascar

This plant was appropriately named after the French botanist and plant collector Decary who specialized in plants of Madagascar. This genus is native only to that island (termed endemic). One of the attractive features is the triangular appearance of the trunk which is actually formed by the positions of the leaf bases. A larger specimen is located near the Everglades palm (# 6, Acoelorrhaphe wrightii).

10. Socratea (Formerly Iriarteia) exorrhiza -- Stilt Root Palm -- Central America and Brazil

These unusual and very striking palms produce a pyramid of above-ground stilt-like roots, which support the trunk. New roots continually emerge above the older ones as the lower roots die. Sometimes only 3 or 4 roots supports the whole plant. These stilt roots can grow so high that a person can easily walk under them. This palm reaches a height of 100 feet in the Amazon rain forests.

11. Dictyosperma album -- White Princess Palm, Hurricane Palm -- Mascarene Islands

The genus name for this palm comes from the Greek words *diktyon*--a net, and *sperma*--seed, referring to the netted coating on the seeds. Notice the beautiful woven appearance of the trunk which is caused by the splitting of the leaf bases . This natural phenomenon may have inspired people to weave baskets. These palms will grow 50 feet tall with leaves 12 feet long.

12. Musa textilis -- Abaca, Manila Hemp -- Asia

Not all plants in this room are palms. The Manila Hemp is a member of the banana family, (Musaceae) but it produces inedible fruit. The bottom portion of the leaf, however, produces a very strong fiber which in the past was made into a high quality marine rope.

13. Pandanus utilis -- Common Screwpine -- Madagascar

Although not a palm, this plant looks like one. It has its own family, Pandanaceae. The common name refers to the spiral arrangement of the leaves on the trunk (which look like a screw) and the appearance of the fruits (which look like brightly colored pine cones). The fruits are edible, although some species are eaten only in times of famine. The leaves are commonly used for making baskets and mats.

14. Washingtonia robusta -- Mexican Fan Palm -- Mexico

Although these palms look identical to the desert fan palm (# 2, Washingtonia filifera), they differ in many ways. Their leaves are brighter

green and have shorter stems. Their trunks are much slimmer and tend to flare out at the base. Commonly reaching over 100 feet, they grow much taller than the California fan palm. In fact, a specimen at the Los Angeles State and County Arboretum is estimated to be 140 feet tall--the tallest palm in the U.S.A.

Notice the roots which appear to be pushing the plant out of the ground. This is another example of roots sprouting from the base of a trunk. This root structure is a characteristic of palms that enables them to survive in shallow soils. It also benefits landscapers and gardeners who want to transplant large palms because they can be moved with relatively small root balls.

15. Carvota mitis -- Burmese Fishtail Palm -- Burma, Malaysia

Although morphologically different from Arenga pinnata (#1), Carvotas have many of the same uses and characteristics. Both palms produce a sugary sap which can be boiled down and crystalized into jaggery or fermented into an alcoholic beverage. The sap is collected first by beating and bruising the developing flower clusters, then by cutting the flower stem and draining the juice. From the trunk, both palms produce sago, a food high in carbohydrates. Both have leaf bases which provide a fiber for brooms, thatching, and similar products. Both have inedible fruits containing calcium oxalate which can cause a skin rash. Also, both palms

Longwood Prairies

flower only once, from the top down, and then the stem dies. Fortunately, this species of Caryota is a clumping palm with many trunks, so the plant will continue to live and grow after each individual trunk flowers and dies.

Caryota is the only genus of palms with leaves that are divided twice, thereby termed "twice-pinnate." Imagine how this palm got the common name of "fishtail."

16. Wallichia disticha -- Straddleleaf Wallich Palm -- Himalayas

Like Arenga and Caryota, this plant flowers and fruits only once before it dies. It is named after the Danish botanist Nathaniel Wallich who was the Superintendent of the Botanic Garden in Calcutta, India, in the middle of the 19th century. The species name comes from the botanical term "distichous" which refers to the arrangement of the leaves--two distinct vertical rows on opposite sides of the trunk. This causes the plant to appear flat. Generally the palms within this genus are trunkless and low-growing, yet this species can produce a beautiful netted trunk up to 20 feet high. (Illustration of a flat palm.)

17. Phoenix canariensis -- Canary Island Date Palm -- Canary Islands

Some people believe the genus is named after the people of

Phoenicia, who grew date palms, (Phoenix dactylifera, # 31). Others believe it comes from the Greek term *phoenix*, meaning purple or red--the color of date fruits. Still others maintain this genus is named after the mythological phoenix bird which is reborn from its own ashes. This plant grows to 60 feet with leaves 15-20 feet long. It is a common landscape plant in Florida, California, and Hawaii. It does not produce edible fruit.

18. Ravenala madagascariensis -- Travelers' Palm -- Madagascar

Although commonly called the Travelers' Palm, this plant is not a palm, but a member of the banana family (Musaceae). The tree is so named because the bases of the leafstalks form cups that hold considerable amounts of water. According to a popular myth, thirsty travelers drank from these natural cups. In reality, this water would be barely potable and used only in extreme emergencies. Yet, the name remains. The seeds, however, are edible, the sap is used for sugar, the wood is used in construction, and the leaves are used for thatching material.

19. Phoenix dactylifera -- True Date Palm -- W. Asia and N. Africa

This palm has been cultivated since prehistoric times and is believed to have been grown in Babylonia 8000 years ago. One of the earliest

representations was carved on the walls of Queen Hatshepsut's temple in Egypt. She died in 1481 B.C. making the picture more than 3500 years old. There are many biblical references to this plant. For example, Jesus was welcomed to Jerusalem by people waving date palm fronds.

Date palms can develop a massive trunk up to 100 feet tall with leaves 10-20 feet long. To many inhabitants of the desert, palms represent life itself. In many areas, date fruits are the only available food for much of the year. The palms leaves and wood are used for building huts and fences. The leaf fibers provide rope and baskets. When mixed with camel hair, the fibers are fabricated into cloth for tents.

Commercial dates are produced in Arizona and California, but most of the world's crop comes from Iraq, where over 20,000,000 trees are grown.

20. Roystonea regia -- Cuban Royal Palm -- Cuba

The royal palms are named after the U.S. Army engineer, General Roy Stone, who served with distinction in Puerto Rico during the Spanish American War. These are some of the most beautiful and impressive palms in the world. They make excellent avenue trees, attaining a height of 70 feet, and providing an air of grandeur. Because of their resistance to salt water, the trunks are used for wharf pilings and construction. In the West Indies, the young palm hearts are cooked and eaten as a vegetable.

21. Butia capitata -- Jelly Palm -- South America

Many plants have mutually beneficial interactions with insects or animals. The jelly palm is one of them. Female scarab beetles have been observed rolling the palm's fleshy seeds away from the mother plant and burying them in moist sandy places which are ideal for germination. The beetle then lays her eggs next to the seed. It is believed that the young grubs feed on the palm fruit, but they do not harm the seed.

People also use this fruit. Its sweet, juicy flesh can be strained and made into jelly or fermented and made into wine.

22. Coccothrinax crinata -- Old Man Palm, Thatch Palm -- Cuba

Because of the long, shaggy fibers surrounding the trunk, the common names fit this plant well. The name of the genus comes from the Greek words *cocco*--grain or seed, and *thrinax*--3-pronged fork or trident, which refers to the forked tips of the leaf segments. The hairs on the trunk are used to make brooms and stuff pillows. In its native habitat, it will grow up to 30 feet tall.

23. Rhopalostylis sapida -- Nikau Palm -- New Zealand

This palm was very useful to the Maori Tribes of New Zealand. They used the leaves extensively for covering walls and roofs of their dwellings, and they wove the leaves into baskets. The soft growing tip, or palm heart is a good food source.

24. Phoenix roebelenii -- Miniature Date Palm -- Laos

Although these palms are relatively small, they are some of the oldest plants in the Palm House, dating to 1942. Notice that the trunk loses its "hair" as it ages--leaving just leaf scars, which resemble teeth. This is a highly prized ornamental because of its small size and feathery appearance.

25. Bambusa oldhamii -- Oldham Bamboo -- China and Taiwan

Bamboos are the giants of the grass family (Gramineae). This species grows up to 60 feet tall in its native habitat, and have stems 3 inches in diameter. The stems are hollow, yet very strong and flexible. Some species are used for construction, however, this one is usually planted for its

ornamental value. Bamboos are grouped as either "runners" or "clumpers," depending on their growth habit. Runners send out underground stems which contain nodes where new shoots develop. These runners are very strong and can be damaging by causing sidewalks to heave and pavement to crack. Clumpers, such as B. oldhamii, grow new shoots from one central clump, and are generally less invasive. (Illustration of runners and clumps of bamboo.)

26. Sabal palmetto -- Cabbage Palm, Palmetto -- North Carolina and Florida

The Seminole Indians of the southern United States used these trunks for constructing huts and wharfs because of the wood's resistance to decay. Cross sections of the trunk were used for table tops, and the leaves were good thatching material. They were also used for roof tops, baskets, and mats. Some Indians ate the fruits and the leaf buds.

The American colonists used the trunks as well. On June 28, 1776, men on Sullivan's Island off the coast of South Carolina repulsed the British fleet from a rather primitive fort made of palmetto trunks. The state seal depicts the fort and commemorates the event. The palm reaches a height of 90 feet.

27 Howea forsterana -- Forster's Sentry Palm -- Lord Howe Island

This palm is named after Senator William Forster of New South Wales, Australia. It is commonly called Kentia Palm; however, there was a mixup among botanists when it was first discovered, and that name now properly belongs to another group of palms. They are popular for interior use as they are tolerant of relatively low light, temperatures, and humidity--conditions most palms cannot survive. For many years all of these palms were grown from seeds that came from their native home, Lord Howe Island near Australia. At one time, the commercial seed collection of these palms which supplied the American and European market was the chief industry of the island, and the keystone of its economy. Now the seeds are also produced in other parts of the world.

28. Rhapis humilis -- Broadleaf Lady Palm -- South China

The name of this genus comes from the Greek word *rhapis*--needle or rod, referring to the narrow leaf segments. The species name is Latin for lofty or highly elevated. These are durable, easy to grow, and highly decorative palms with a delicate appearance. In mild climates they are used

as hedges, evergreen shrubs, and foundation plantings. They are also popular plants for interior use.

29. Astrocaryum alatum -- Limon Astrocaryum -- Costa Rica

From the Greek words *astro*--star, and *karyon*--nut, the genus name alludes to the starlike patterns of radiating black lines that mark the seeds. They produce an oil used in cooking and as an illuminant. The fruits are edible but are covered with spines which make them difficult to work with. The leaf fibers, which are fine and soft, are used in weaving and for cordage. The wood is hard, strong, and durable--making it valuable for the construction of houses. (Illustration of the seed.)

30. Pritchardia hillebrandii -- none -- Pacific Islands

The genus name honors W. T. Pritchard, British Consul to Fiji in 1860. The species name honors a famous Hawaiian botanist of the 1800's named Hillebrand. This palm genus is the only one native to the Hawaiian Islands, and many of them occur naturally only in Hawaii. They are prized for their large handsome leaves which create a majestic display, and are used for weaving hats and other articles. The seeds can be eaten when they

are immature. In its native habitat, this species will grow 20 feet tall with leaves 4 feet wide.

31. Elaeis oleifera -- American Oil Palm -- Central America

This palm is related to the African oil palm (Elaeis guineensis) which is the source of commercial palm oil used in margarine, soaps, and lubricants. Other industrial uses for palm oil include the treatment of metals in the tin plating and iron fabricating industries. Although the American oil palm contains a similar oil, it is the African one that is presently cultivated for its oil even in the American tropics. However, the American species needs to be conserved because it is a valuable source of genetic material in breeding programs with the African species. The Institute of Economic Botany at The New York Botanic Garden is actively involved in research on genetic resources of the American Oil Palms as well as other plants. The Institute is seeking new plants or new genetic material of currently cultivated species in order to improve food and fuel plant cultivation in many areas of the tropics as well as the temperate zone. (Illustration of products such as margarine and soap.)

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PALM SURVIVAL IN A TOUGH WORLD

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The Palm Family--Royalty for Common Folk

Palms have been called the "Princes of the Plant Kingdom," and justifiably so. Perhaps this title is due to their regal appearance--an unbranched stem topped with a plume of graceful foliage--which is reflected in many of their common names, for example *Royal Palm* (*Roystonea*), King Palm (*Archontophoenix*), and Queen Palm (*Syagrus*). More importantly, palms have treated mankind royally by providing many products which we use daily. Only the grasses, which provide us with corn and sugar, as well as wheat, rice, barley, and other grains, surpass the palm family in economic importance. Palms supply us with oil for margarine, coconut for pies, dates for snacks, soap for washing, candles for illumination, rattan for furniture, carnauba wax for cars, rope for boats, fiber for brooms, charcoal for air purifiers, vegetable ivory for buttons, fodder for livestock, and leafy plants for homes and gardens. Palms also deserve recognition for the 'princely' ways they have adapted to many diverse and inhospitable environments.

To many of us, thoughts of these plants stimulate mental images of tropical beaches lined with coconut palms, or aerial views of thick rain forest canopies dominated by lofty palms. Other people may visualize a desert such as in the Middle East or southwestern United States, its sparse vegetation dotted with single-stemmed palms. While these images represent a wide variety of challenging habitats, all of them are realistic. From sandy beaches to stagnant swamps, from competitive rain forests to arid deserts, palms thrive sometimes to the exclusion of almost all other vegetation (Thomlinson, 1979). They also have the ability to survive, better than most plants, many natural disasters such as hurricanes, droughts, and floods.

What morphological and ecological adaptations have palms developed which enable them to survive in so many demanding environments? What mechanisms give palms, considered by many botanists to be one of the oldest forms of flowering plants (Corner, 1966), the capabilities to grow and reproduce in such diverse habitats? This article will discuss several unusual survival mechanisms, some of which are specific to the palm family.

Some palm seeds can actually float in the ocean for months and still maintain viability. Other palm seeds grow 'umbilical cords' which contain the germinating embryos and have the ability to burrow two feet into the ground--essentially, planting themselves. In some species, the flowers appear to change sex--from male to female--in order to attract pollinators at just

the right time for fertilization. Palms have developed a number of successful ways to disperse their seeds, thus spreading the domain of the species. In addition, they have extremely strong, yet flexible, trunks which allow them to bend without breaking in strong winds. Because of these adaptations, palms are able to flourish in many diverse, and often inhospitable, habitats.

Life Cycles--From Seed to Seed

The palm, like all plants, has a life cycle which involves several stages. To begin with, a seedling must grow to maturity and produce flowers that contain ovaries, which must undergo pollination--a process which can result in fertilization of the ovaries (figure 1). The ovules within fertilized ovaries develop into seeds that are generally contained within fruits. When the fruits mature, they must be dispersed to an environment suitable for the seed to germinate. After germination, the newly sprouted seedlings compete for growing space with surrounding plants. Eventually, they grow into adult palms, able to produce flowers, and the process repeats itself. At every stage--pollination, seed development, seed dispersal, germination, seedling competition, and plant maturation--palms have developed unusual mechanisms to insure survival.

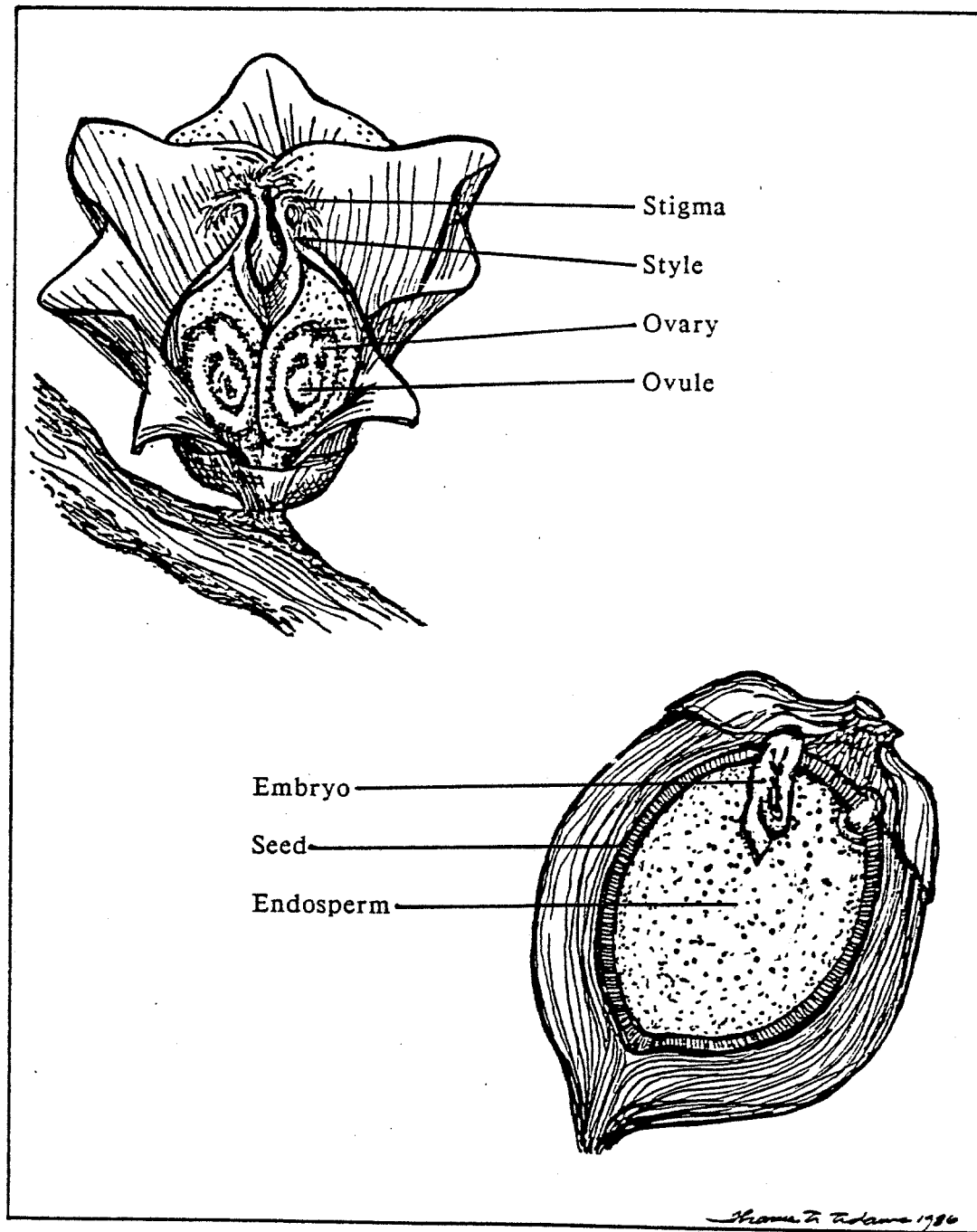


Figure 1. Left: Longitudinal section of a palm flower showing stigma, style, ovary and ovule. Right: Longitudinal section of a palm fruit (a mature ovary) showing seed, and embryo (which develop from the ovule).

Pollination--Sex Among Flowers

When palms produce flowers, they accomplish it with exuberance. Although the individual flowers are small and inconspicuous, they generally occur in incredible numbers. The Talipot Palm, *Corypha umbraculifera*, produces one of the largest clusters of flowers (inflorescences) in the plant kingdom--over 60,000 individual flowers make up an inflorescence that extends more than 20 feet above the leaf canopy! The average palm inflorescence has hundreds of blooms and measures from two to six feet long.

Many palms have developed a specialized method to promote pollination. The Palma Conga, *Welfia georgii* is one of them. The inflorescence is composed of many small flower clusters, each of which contains four flowers--three male and one female. The flowering process starts when the male flowers open, one cluster one day, another cluster the next day. This takes 10-15 days--long enough for insect pollinators to become accustomed to feeding on the plant's pollen. Then the female flowers open all at once and bloom for 2-4 days. They mimic the male flowers in both color and shape, thus attracting the same insects which have been feeding on pollen from the male flowers. While the insects search female flowers for food, they transfer pollen--recently collected from nearby male flowers--from their bodies to the receptive female flowers. Thus, pollination occurs (Jansen, 1983).

Seed Protection--Armored Guards

After a flower is pollinated, and the ovary has been fertilized, the flower petals fall off and the ovule develops into a seed. While the seed is maturing inside the fruit, it needs protection. Maturation takes from three months (in small-seeded fruits like the Macarthur Palm, *Ptychosperma macarthurii*) to six years (in the huge seeds of the famous Double Coconut, *Lodoicea*). Some palms, have evolved morphological protective mechanisms which inhibit animals from destroying the developing seed. Many palms like *Phoenix reclinata* or the Peach Palm, (*Bactris gasipaes*) have spines or thick fibers along the trunk. (In fact, some early botanists made the assumption that spiny trunks were an indication of edible fruit.) Others such as the coconut (*Cocos nucifera*) develop a tough, fibrous husk around the seed. *Bentinckia nicobarica* exemplifies those palms that have specialized cavities in the flower stalks which completely encase and protect the ovule (Uhl and Moore, 1973). Once the seeds mature, and these various protective mechanisms are no longer needed, the fruit naturally falls to the ground ready to sprout or to be dispersed to a similar environment.

Chemical deterrents are another type of seed protection. Certain immature seeds such as those in the genus *Chamaedorea* contain calcium oxalate crystals. When eaten, these crystals irritate the mouth and throat

causing swelling and possible asphyxiation (Uhl and Moore, 1973). After the seed has matured, the crystals break down and the fruit is edible.

Seed Dispersal--They Sure Get Around

Several palm fruits are a favorite food of a wide variety of birds and mammals. Since many palm seeds are contained in succulent, brightly-colored fruits, they attract a variety of "dispersing agents" that eat the pulp. As E. J. H. Corner indicates in The Natural History of Palms, "There are little fruits for little creatures, big fruits for big creatures, and more than enough to be rotted away by the organisms of the soil." Orioles, minahs, and woodpeckers feed on small fruits. Apes, bears, and toucans eat larger fruit. Deer, rhinoceros, and tapirs feast on fallen fruit of almost any size, while elephants savor the large, eight-inch diameter fruits of the palmyra palms. All these animals feast on the fleshy, outer portion of the fruit, but they cannot break through the hard seed coats which protect the fragile embryo. The seeds are either discarded immediately or swallowed whole, passing unharmed through the digestive tract. Later, they are expelled (with an initial source of fertilizer) at varying distances from the mother plant. Since the seeds contain all the genetic material necessary to produce a new plant, the discarding and expelling actions result in dispersal of the palm species throughout an area.

Another seed dispersal method involves animals and insects directly planting palm seeds. Squirrels and rodents bury fruits, perhaps with the intention of eating them later. If they do not return in time, the seeds sprout. Scarab beetles roll fleshy fruits of the Jelly Palm (*Butia capitata*) to moist, sandy areas where they bury the fruits and lay their eggs around them. Presumably, the young grubs feed on the flesh but do not harm the seeds.

Coconut palms have an unusual dispersal method. They often grow along the shore with their trunks leaning towards the ocean. When the fruits mature, they fall into the water ready to be swept away to a distant shore. According to a recent study, coconuts can float in salt water up to 214 days and still remain viable (Ward and Allen, 1980). Because of this, if the currents are strong, the coconuts can and do travel hundreds of miles.

Germination--The Next Generation

The next challenge once the seeds are dispersed, is to germinate and produce new plants. Palm seeds range from 1/4 inch to 12 inches in diameter. They generally contain a large amount of stored food (endosperm) which enables them to sprout huge seedlings. These seedlings can compete much better than smaller seedlings in areas such as forest floors and small rock crevices where growing space is restricted. The large

quantity of endosperm also provides the seedlings with nutrients until the root system is established.

Coconuts, along with their unusual dispersal method, have developed an interesting survival mechanism for the sprouting seed. Although the coconut can float in salt water for months and still germinate, the young seedling cannot survive in a pure salt water environment. What prevents the seed from germinating in salt water? Perhaps, it is a timing mechanism stimulated by the lack of wave motion. Although the embryo may begin sprouting a root while it is still floating in water, the root stays protected inside the thick, fibrous husk until the coconut stops rolling in the surf and is washed above the high water mark. Upon making contact with moist soil, the initial root sends out numerous anchor roots which secure the seed to the ground (Jansen, 1983). Once this occurs, the cotyledon emerges, and a new plant is on its way.

Self-Planting Mechanism--On Their Own

A mature palm seed consists of a seed coat and an embryo which contains the beginning of the new root, the new shoot, and one seed leaf (cotyledon) surrounded by endosperm. Normally, when the embryo germinates, the root emerges from the seed coat and grows downward, while the shoot emerges and grows upward. If the environment is not conducive

to growth, the new plant dies. Certain palm seeds such as those from the Palmyra, the Double Coconut, and the Wax Palm (*Copernicia*), have the ability to relocate their own embryo, thereby increasing chances for survival (figure 2). Remote germination, as this unique characteristic is called, seems to be an ecological adaptation to dry habitats (Thomlinson, 1966). The seed sprouts a structure similar to an umbilical cord (called an apocole) which contains the embryo. It burrows into the ground--as far as two feet down and as much as 12 feet horizontally from the seed--to a more hospitable environment for germination.

Another unusual survival mechanism of germinating seeds is the ability of the newly sprouted shoot to grow downward for several feet before turning upward (figure 3). Often, this results in a "trunkless" palm which appears to produce leaves directly out of the ground. This characteristic, common in Palmettos (*Sabal*) and the Coroza Palm (*Orbignya*), protects the growing tip of the palm and enables it to resprout after a fire--a common occurrence in Brazilian savannas.

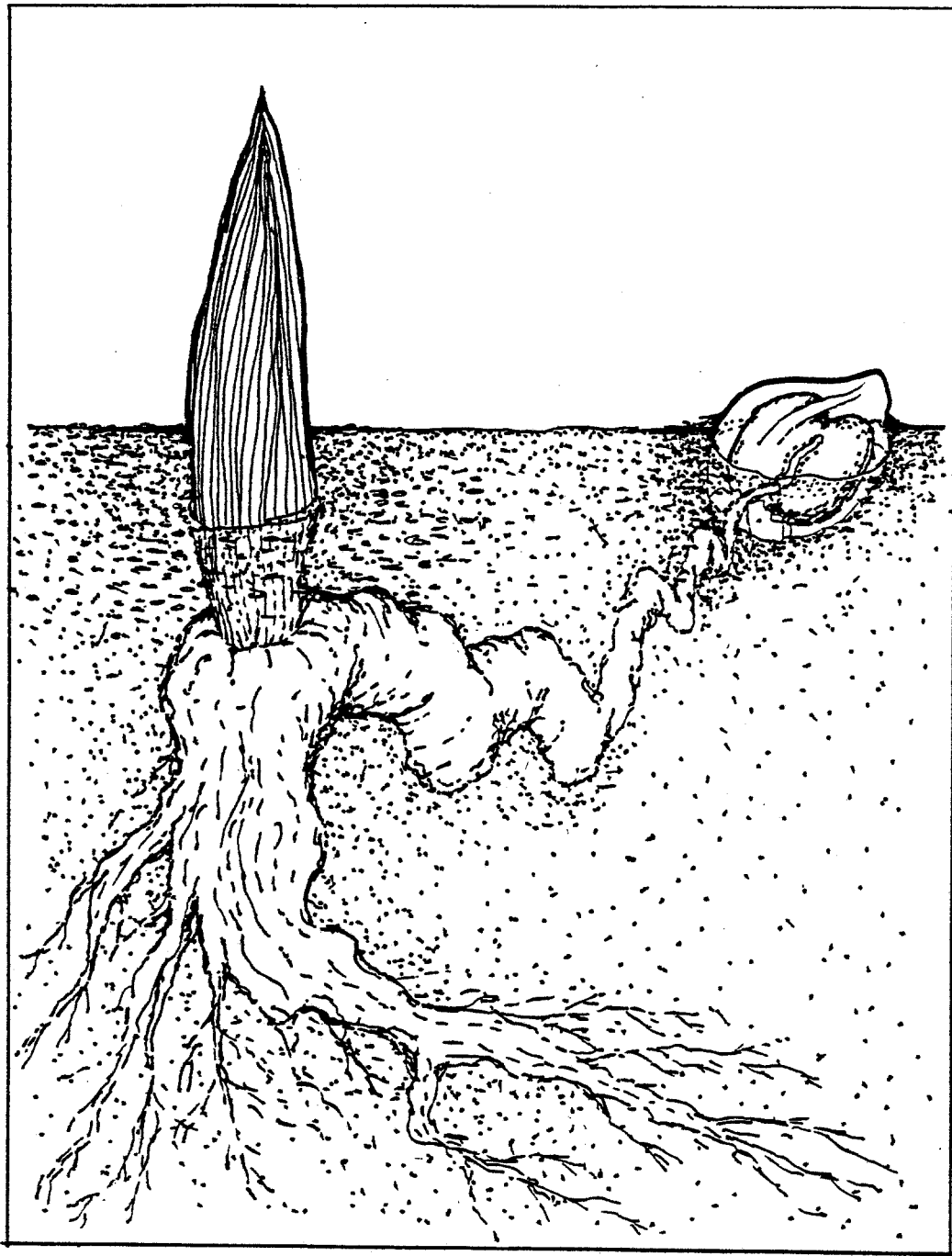


Figure 2. Remote germination in Double Coconut (*Lodoicea*) showing the embryo sprouting from a 12-foot 'umbilical cord' which grows out of the seed that is contained inside a protective husk.

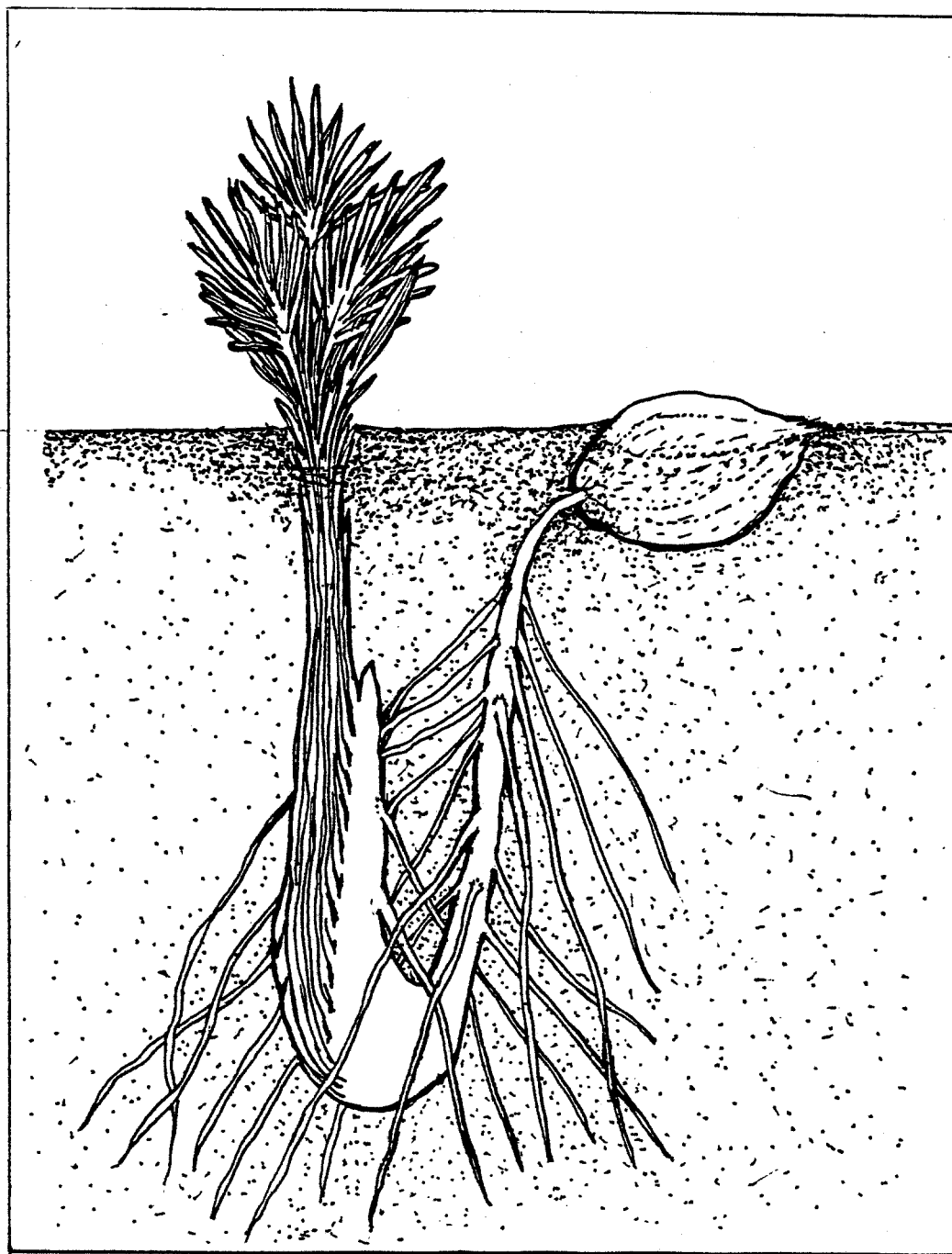


Figure 3. Seedling of Palmetto (*Sabal*) showing the stem sprouting from the seed and growing downward several feet before turning upward and breaking through the ground.

Surviving To Maturity--With Inside Help

Palm 'trees' differ from true trees in many respects. One major difference is their internal structure. They belong to the subclass "Monocotyledonae" which refers to the production of a single cotyledon, or seed leaf. Other woody trees and shrubs belong to the subclass "Dicotyledonae" which produces two cotyledons. The differences, represented by these two subclasses, affect the basic structure of the plants. In palms, these differences contribute to their strong, flexible trunks which enable them to survive tropical storms and hurricanes.

Dicots have a layer of actively growing cells (cambium) between the outer 'bark' and the inner heartwood (figure 4). This cambium layer makes it possible for dicots to increase in girth as well as height. Monocots do not have this cambium layer; as a result, palms, like other monocots, can only produce new cells from the tip of the stem. Their increase in girth is due to cells either enlarging or separating from each other. This separation creates air pockets which increase the palm's circumference and contribute to its flexibility.

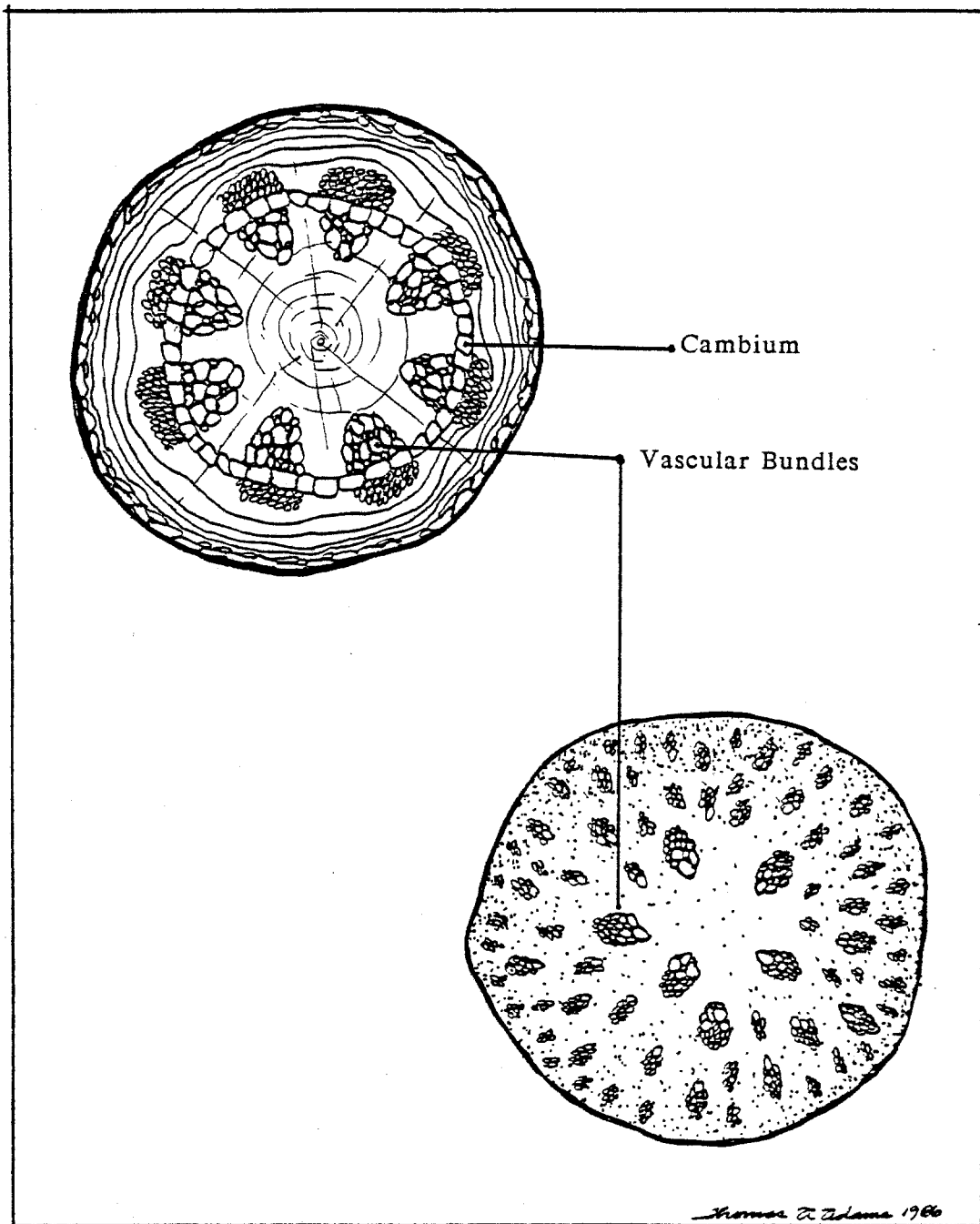


Figure 4. Left: Dicot stem showing cambium and vascular tissue encircling the heartwood. Right: Monocot stem showing scattered vascular bundles.

The trunks of both monocots and dicots house conducting tissue, called vascular bundles (figure 4). The function of these bundles is to move water and nutrients between the leaves and roots. However, the tissue in monocots differs from the tissue in dicots in both arrangement and morphology. In dicots, the vascular bundles encircle the heartwood next to the cambium layer. In monocots, they are scattered randomly throughout the soft, often spongy, tissue. Surrounding the vascular bundles are fibrous sheaths which provide mechanical strength to the trunks and leaf stems. In some cases, the bundles are concentrated around the periphery of the stem creating a trunk so hard it can repel the blade of an ax. These tough fibers, contained in spongy tissue, give palms their strong, flexible nature. By bending in the wind, they are able to withstand tropical storms and hurricanes. Under identical conditions, dicot trees often break like toothpicks.

Stilt Roots--Above it All

Stilt roots give palms the ability to survive in swampy areas, on steep slopes, and in flood plains. These roots form on the palm genera *Eugeissona*, *Iriartea*, *Socratea*, and *Prestoea*, all commonly referred to as Stilt-Root Palms. The roots appear to push the trunk right out of the ground. In reality, the roots develop on the stem just above older roots and then grow down into

the ground (figure 5). Simultaneously, the oldest roots die, creating an empty space under the trunk. In swampy areas or during floods, stilt roots prevent the stem from suffocating by elevating the palm above the water line. They also produce specialized rootlets which absorb oxygen from the air (Frangi and Ponce, 1985). On steep hillsides, stilt roots grow different lengths on each side of the plant to keep it vertical. They can reach heights of over eight feet; sometimes only three roots support a full-grown palm (Corner, 1966).

This unusual root formation benefits the palms in many others ways. Stilt roots increase the rooting area, thereby increasing the ability to take up water and nutrients. They also trap a tremendous amount of organic litter near the base of the trunk. As this debris decays, it becomes a nutrient source for the plant. As well, the litter provides shelter for certain rodents and birds whose droppings are another source of fertilizer (Holbrook, et al. 1985).

Practical Uses--From Food to Furniture

Many of the survival mechanisms developed by the palms which enable them to survive in diverse, often inhospitable conditions, are what make this family so valuable to mankind. A number of morphological adaptations which evolved to protect the developing seeds, such as the

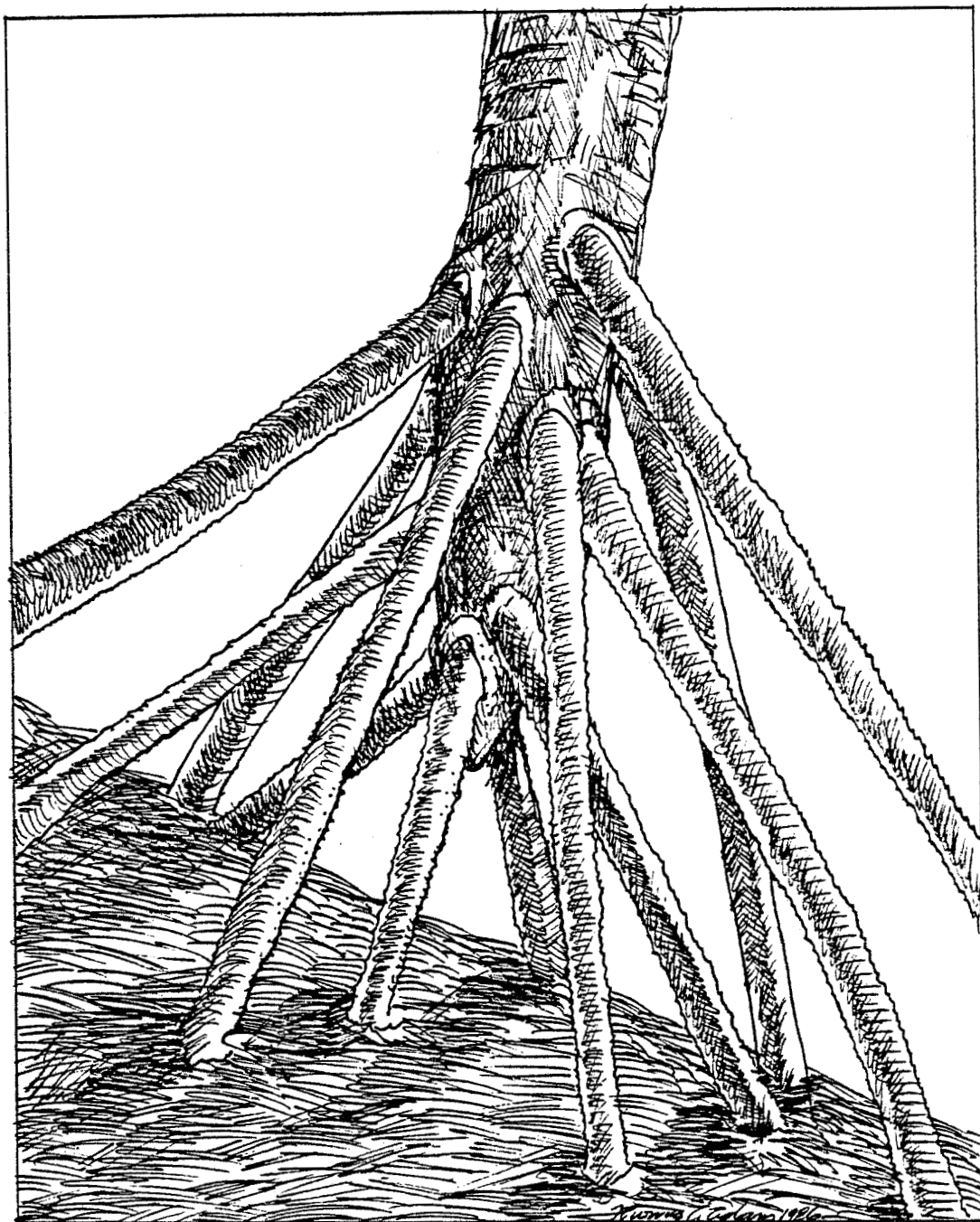


Figure 5. Stilt roots--developing from the above-ground stem--with specialized rootlets which absorb oxygen from the air.

Banquet Princes

coconut's fibrous husk, provide raw material for ropes and door mats, as well as stuffing material for furniture and pillows. The structural strength and flexibility of palms make them useful in constructing buildings and furniture. For example, rattan palms, *Calamus* and *Desmoncus*, have thin flexible stems that climb to the top of forest trees in search of light. These stems are used to make rattan furniture. In some monocotyledonous palm trunks, the air pockets--created by the separation of enlarging cells-- fill with stored energy resources (carbohydrates). People harvest this for a food called sago. Also harvested are many of the edible fruits--so attractive to birds and mammals--which are used in hundreds of ways, including foods, beverages, soaps, and candles.

Because of their morphological and ecological adaptations, it is not surprising that palms have survived for so long and so well. With all of their uses, and their royal appearance, it is no wonder they are considered the Princes of the Plant Kingdom.

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