Hunt Institute for Botanical Documentation
5th Floor, Hunt Library
Carnegie Mellon University
4909 Frew Street
Pittsburgh, PA 15213-3890
Telephone: 412-268-2434
Email: huntinst@andrew.cmu.edu
Web site: www.huntbotanical.org

The Hunt Institute is committed to making its collections accessible for research. We are pleased to offer this digitized item.

Usage guidelines
We have provided this low-resolution, digitized version for research purposes. To inquire about publishing any images from this item, please contact the Institute.

Statement on harmful and offensive content
The Hunt Institute Archives contains hundreds of thousands of pages of historical content, writing and images, created by thousands of individuals connected to the botanical sciences. Due to the wide range of time and social context in which these materials were created, some of the collections contain material that reflect outdated, biased, offensive and possibly violent views, opinions and actions. The Hunt Institute for Botanical Documentation does not endorse the views expressed in these materials, which are inconsistent with our dedication to creating an inclusive, accessible and anti-discriminatory research environment. Archival records are historical documents, and the Hunt Institute keeps such records unaltered to maintain their integrity and to foster accountability for the actions and views of the collections' creators.

Many of the historical collections in the Hunt Institute Archives contain personal correspondence, notes, recollections and opinions, which may contain language, ideas or stereotypes that are offensive or harmful to others. These collections are maintained as records of the individuals involved and do not reflect the views or values of the Hunt Institute for Botanical Documentation or those of Carnegie Mellon University.

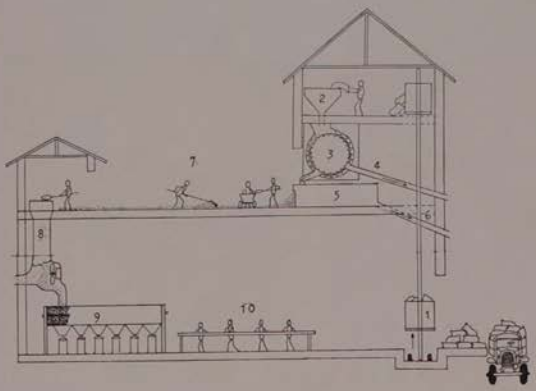
About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

PLANTS
HAWAII NATIONAL PARK

ILLUSTRATED

OTTO DEGENER



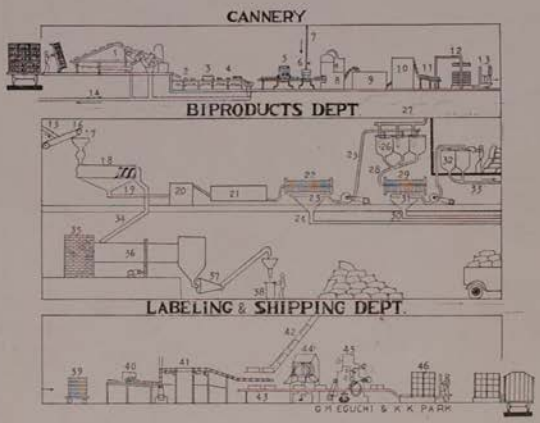
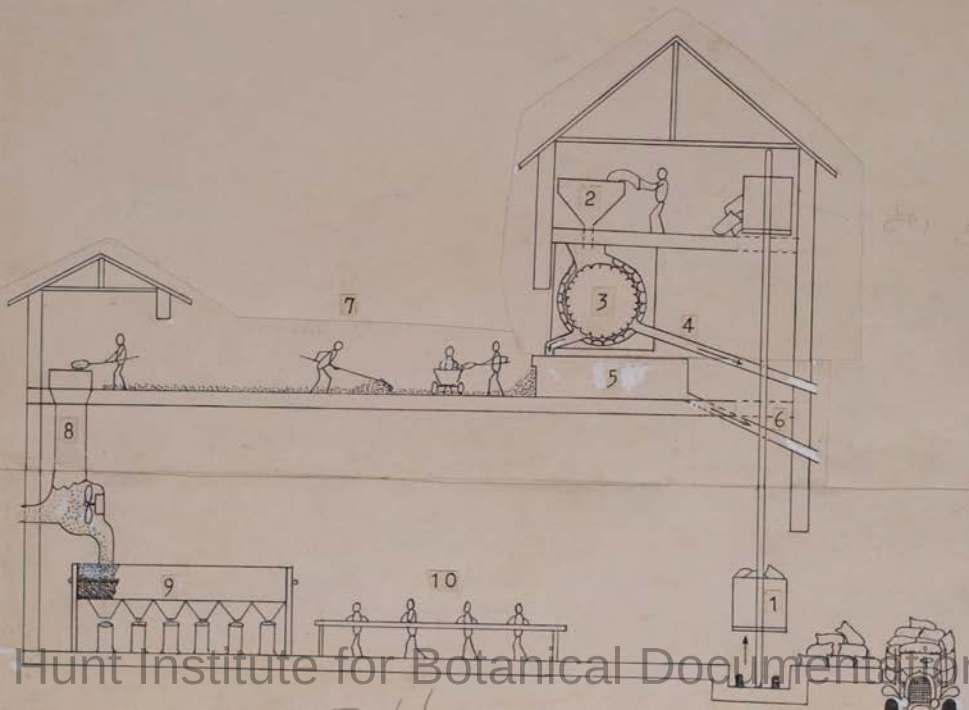
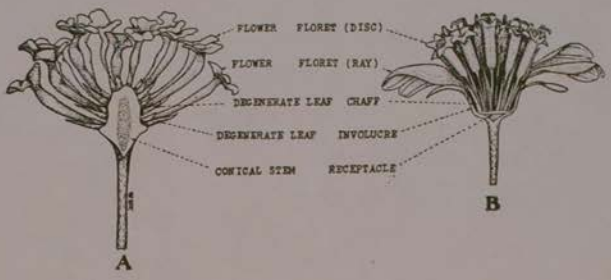
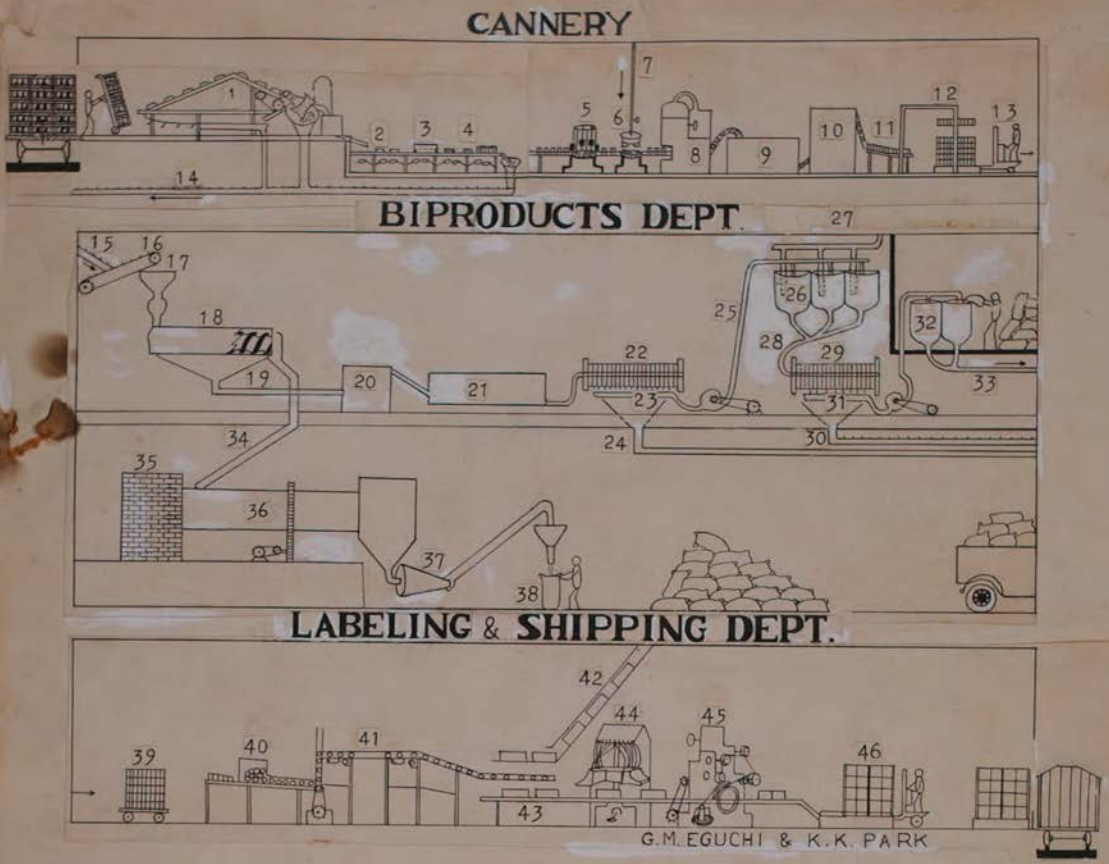


Fig. under Coffee







— 4 —

Figure under Pineapple

...own, were

...LUSION

... pages should have drawn attention to the unique ... of the Hawaiian Islands, particularly in respect to their flora; should have taught a few fundamental principles of Botany; and should have imparted a feeling of respect for the ancient Hawaiians and their customs, both perhaps recalling Homeric Greece to mind.

For the comprehensive flora, the writer is collecting additional information on native plants and their relationship to the Hawaiians as well as circumstances and the time of introduction of foreign plants into these islands. Such information, and the correction of facts in the present text, will be greatly appreciated.

GLOSSARY AND INDEX

Note 93

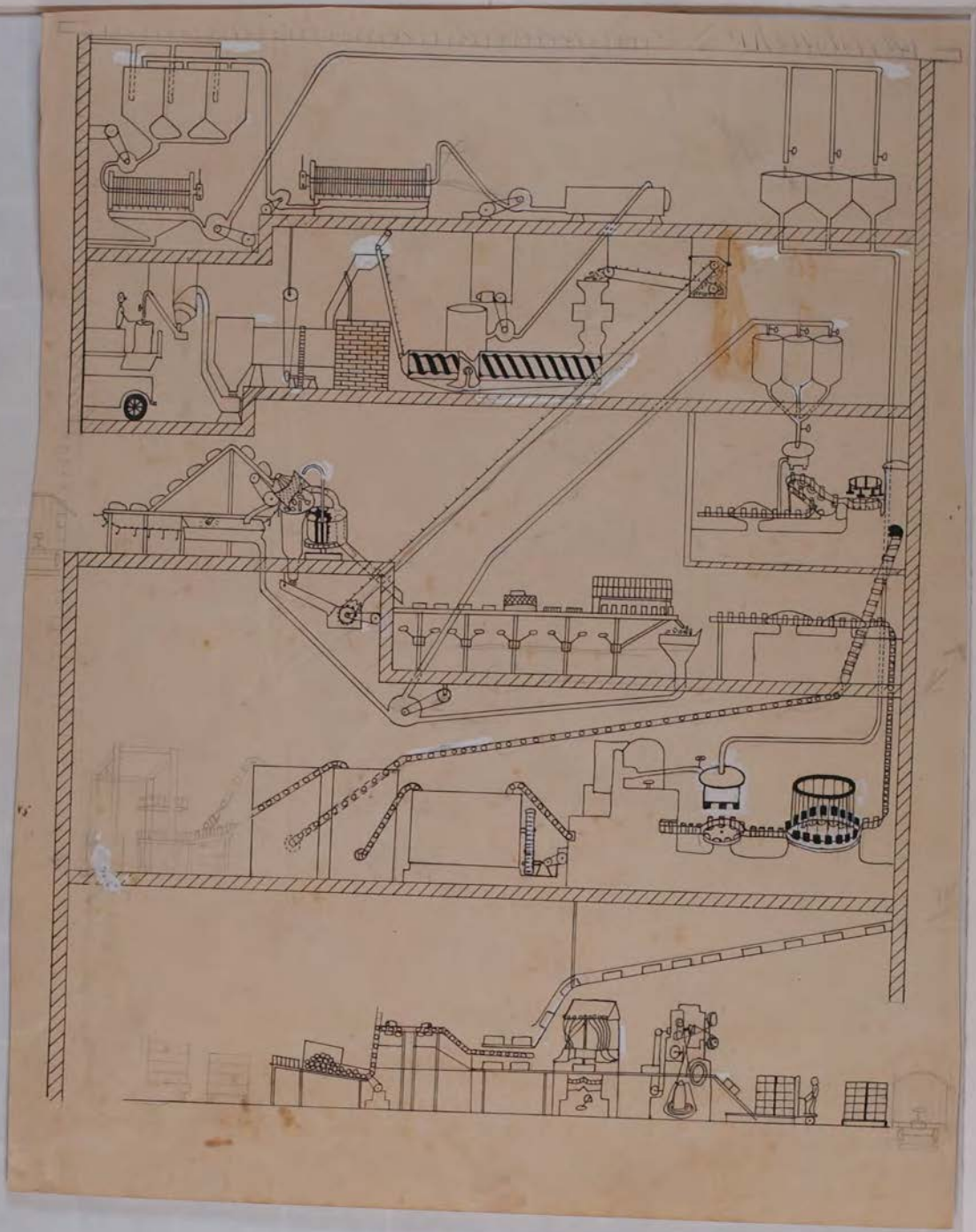
Degener [?] what about the

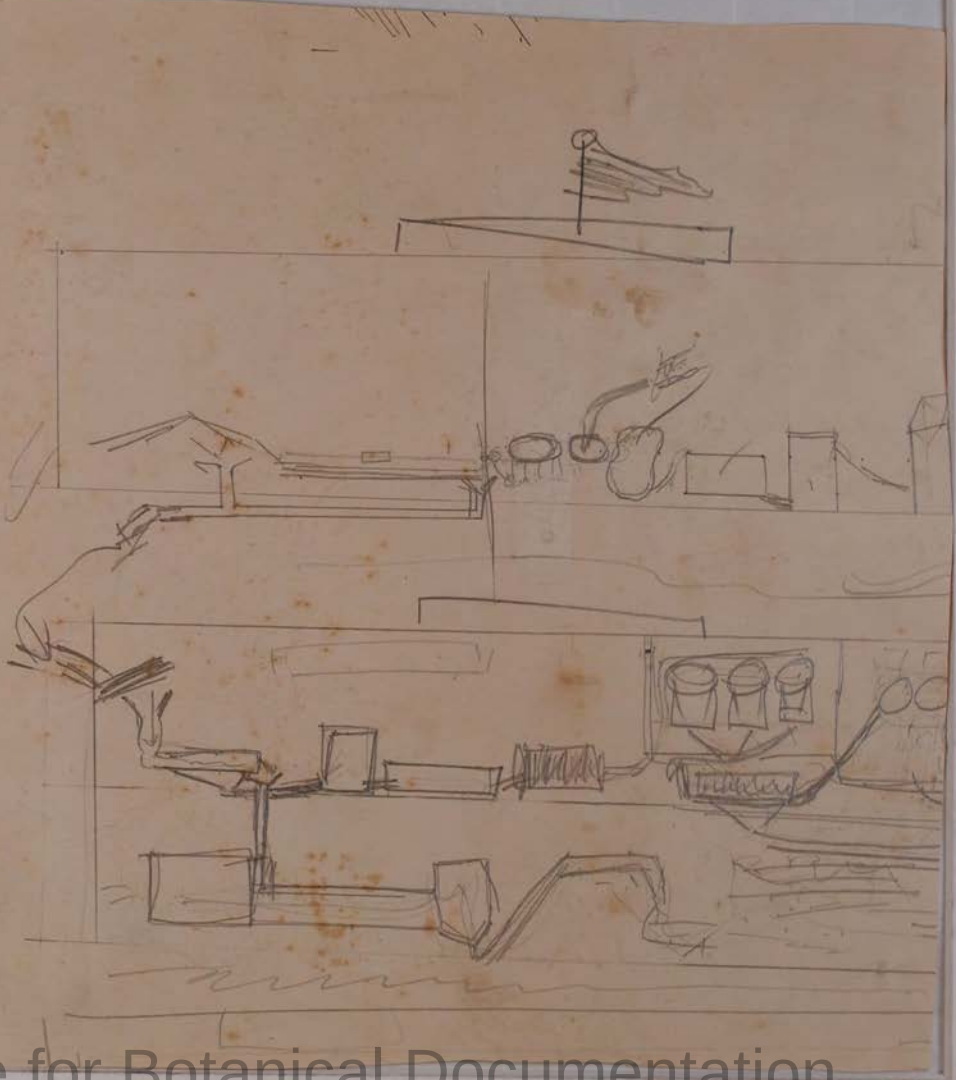
Papala Kepau - Pisonia inermis - (its importance to Hawaiians

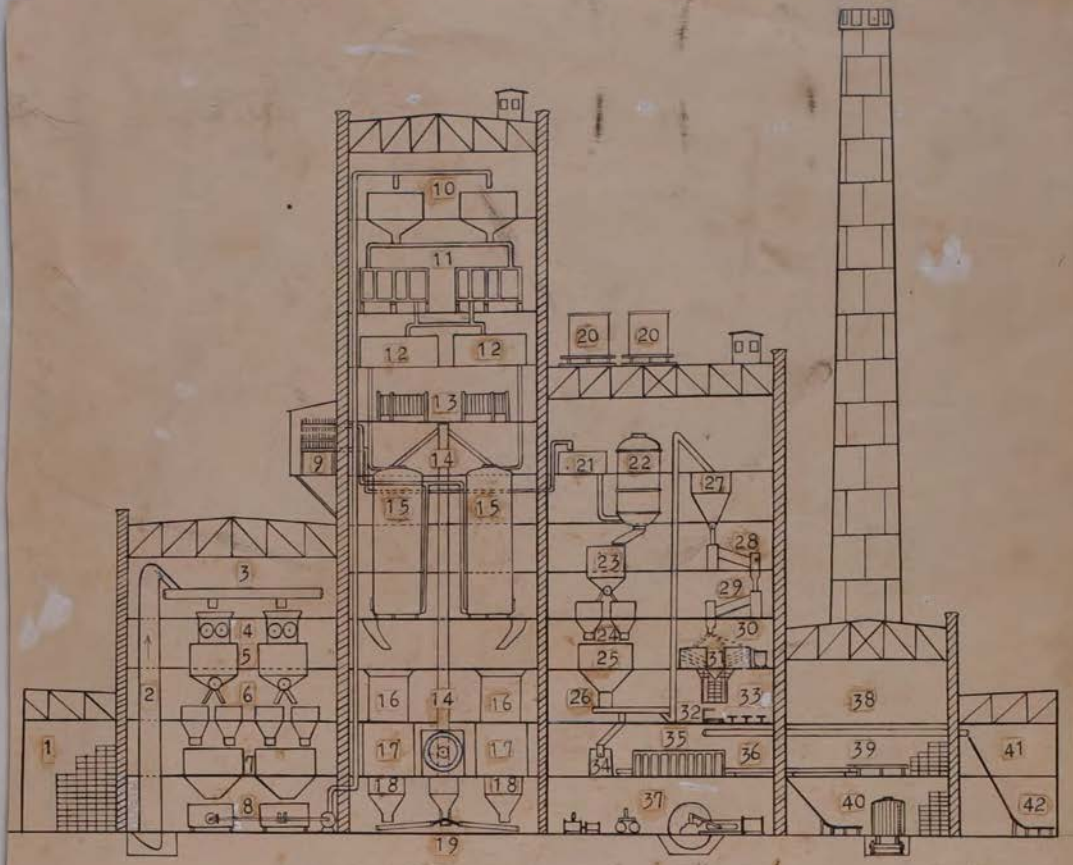
Oha Kepau - a tree, remember the plant I found near Aloala crater with a yellow fruit like a fig used by the Hawaiians as a bait for trapping the Mamo & Oo.

I thought I gave you notes on it if not I will send it to you and also the Olopua = Olea sandwicensis important notes on this also Keoua's prized chief Kaupali would only use the Olopua wood for his spears and he never failed in a close fight or spear [illegible] this from Kukaua & Olopua 93. If you want these notes I'll send it, I have it in Hawaiian, I'll put it in English for you 93.

Ver Yost [?]







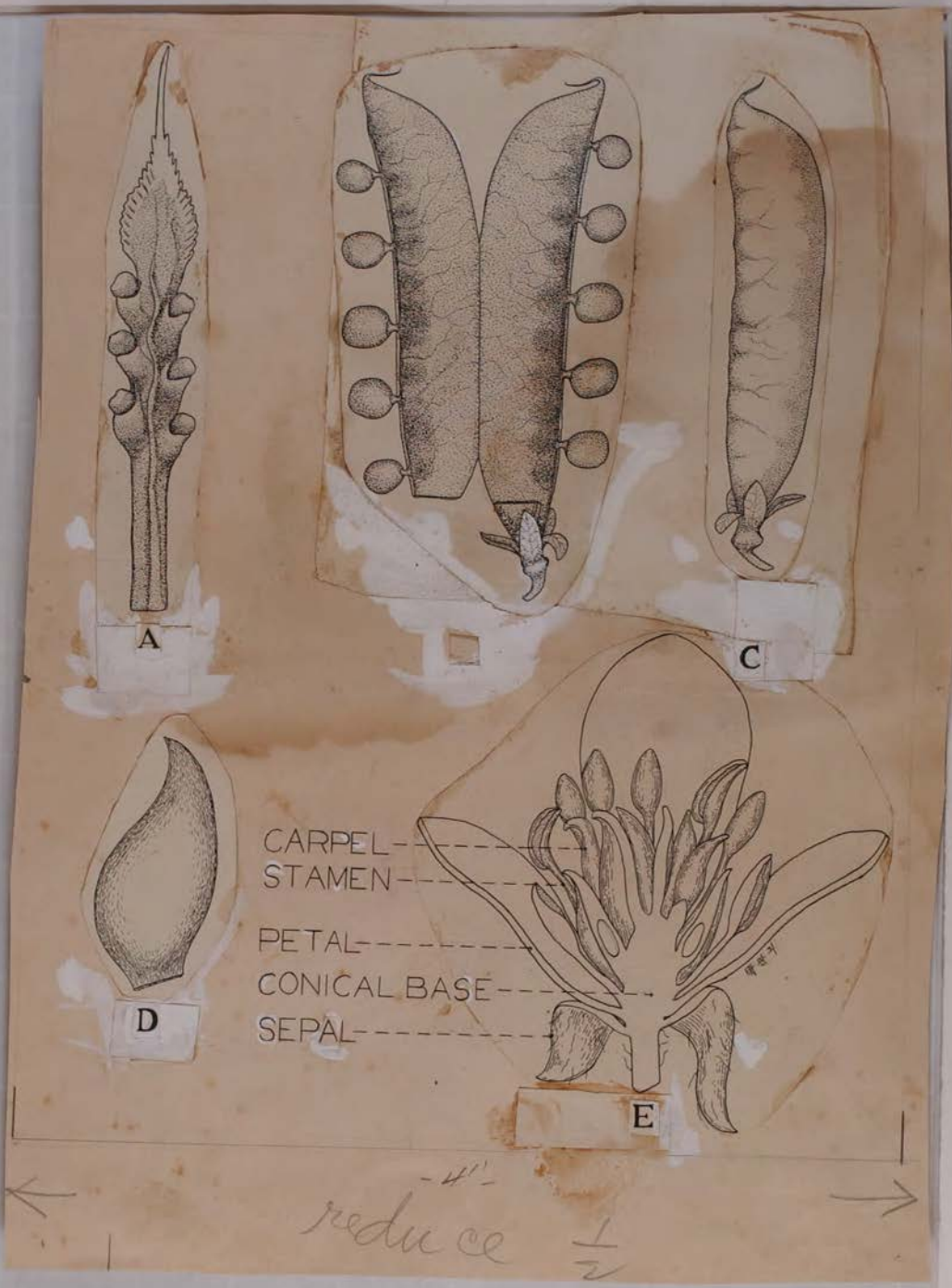
reduce to [illegible] in length
4 7/16 inches

Diagram of Process for Deriving Refined Sugar from Raw Sugar

Adapted from G. M. Rolfe

1 Raw sugar warehouse
2 Raw sugar elevator
3 Raw sugar conveyor
4 Raw sugar crushers
5 Mixers
6 Centrifugal washing machines
7 Storage bins
8 Melt tanks
9 Liquor troughs
10 Blow up tanks
11 Filters
12 Storage tanks
13 Filters
14 Bone char elevator
15 Bone char filters
16 Bone char driers
17 Bone char kilns
18 Bone char coolers
19 Bone char [illegible]rs
20 Water s[illegible]ks
21 Pans [illegible]

22 Vacuum pans
23 Mixer
24 White sugar centrifugals
25 Storage
26 White sugar conveyor
27 White sugar storage
28 Sweaters
29 Granulators
30 Powder mill
31 Screens
32 Automatic scales
33 Sewing machines
34 Cube machine
35 Cube drying ovens
36 Cube conveyor
37 Pump and engine room
38 Bag sewing room
39 Small package department
40 Shipping department
41 Refined sugar warehouse
42 Shipping department



Cretaceous period, variously estimated by geologists as 90 to 120 million years ago, some of these mountains attained such a great height that their summits rose above the surface of the sea to form islands of considerable size. In general, the most westerly ones arising from this volcanic rift, such as Ocean Island, were the first to lose volcanic activity. Those farther south-east, with exceptions perhaps, lost their volcanic fires successively later, while the last island of the entire series, the Island of Hawaii, is the only one possessing volcanoes that are still conspicuously active. A general account of the present condition of the islands along this rift is interesting.

The most westerly islands mentioned above exist today as dangerous reefs and shoals, as stretches of wind-blown sand or as almost barren rocks where sea-birds nest at certain seasons. Some are actually coral atolls raised but a few feet above sea level on a submerged volcanic base, while others are volcanic cone-remnants several hundred feet in height. Their small size in comparison to most of the islands to the east of them, which we know as the Hawaiian Islands proper, is thought to be due to two or possibly even three causes. First, they have long ceased to grow by the outflow of fresh lava. Second, they are so old that in many cases the rains, winds and waves have had time to erode much of their igneous rocks away. Third, they may have slowly subsided.

The Island of Kauai is east of these ~~subsiding and~~ extensively eroded bird islands. Though the greater part of its mass may be as old as the latter islands, Kauai is partly covered with a veneer of lava of more recent age. Nevertheless, even this comparatively thin layer is so old that the rain of the high mountains, continually collecting in streams and charged with silt, sand and boulders, has been able to cut huge, scenic canyons into its sides. Of these, the best known and most easily accessible are Olokele and Waimea Canyons. Then apparently long after this major period of volcanic activity, the very last outburst of vulcanism on Kauai produced Kilohana Crater, near the town of Lihue.

Oahu, the island east of Kauai, is composed of two distinct volcanic areas. The western, centering around the Waianae Range, may be more or less contemporaneous with Kauai. On the contrary, the eastern part, which is composed mainly of the Koolau Range, had its last great eruptive activity later. Its lava flows therefore overlap the ends of those extending from the Waianae Range. Then similarly as Kilohana Crater completed the eruptive stage of the Island of Kauai, Diamond Head ( ), Punchbowl and a number of less well-known craters of south-eastern Oahu completed the eruptive phase of that island. This fact becomes evident to every visitor who sails into Honolulu harbor and sees these well-preserved craters before him.

Molokai is similarly composed of two volcanic masses. The western range is nowhere more than 1400 feet high and consequently extremely arid. The eastern and larger range, on the other hand, rises to a height of almost 5000 feet, thus causing the trade winds to precipitate their moisture and making it possible for a dense rain forest to cover its upper slopes. Whether the last great volcanic activity in this island preceded or followed that of Oahu is not known with certainty.

There is rather conclusive evidence that the western end of the Island of Maui is composed of long-extinct volcanic mountains that are much eroded, Mt. Eke remaining the hard core of one of them. The eastern base of these worn mountains was later covered by the flows from the huge Crater of Haleakala ( ). Though this crater is now apparently extinct, we have two proofs of its activity within relatively recent times. First, its cinder cones are still well preserved. Second, a stone wall built by the Hawaiians on its flanks in prehistoric times has been partly destroyed by a lava flow. Moreover, one of the early white settlers was told by a native informant that this flow occurred the year his grandfather was just old enough to carry a coconut. By estimating the probable date of birth for his informer and that of the father and grandfather, the settler concluded that the last lava flow must have occurred about the year 1750.

The Island of Hawaii is the last island of the series on this rift. It apparently was built by the combined action of five distinct volcanic centers

that can be recognized today as Kohala Mountain, Mauna Kea, Hualalai, Mauna Loa and Kilauea. The north-western center, now comprising the District of Kohala, was undoubtedly the first to become extinct if not the first to be formed. It therefore gave the forces of erosion uninterrupted opportunity to wear canyons into its sides. The rest of the island, on the contrary, is little eroded. This is due to the fact that the four remaining volcanoes broke through the older land and covered it almost completely with their lava flows. Of these little-eroded volcanoes, Mauna Kea seems to be practically contemporary age with Haleakala so far as most of its surface lavas are concerned. Hualalai was still more recently active than these, having produced a lava flow as late as 1801. Mauna Loa and Kilauea, the two volcanoes at the extreme end of the rift, are more or less active to the present day. In 1790 and again in 1924, Kilauea erupted explosively as figure of its vent termed Halemaumau shows. Usually, however, its activity is relatively quiet. Views of Halemaumau during one of these phases is shown. Figure is from a photograph of Halemaumau taken at six o'clock in the afternoon of July 25, 1929, while the following figure shows the same view taken two hours later when night had fallen.

Relief map of Hawaii

Origin of the Hawaiian Flora

The plants that existed on the earth 100 million years or so ago differed from those that exist today. They were in general more primitive, not yet having had sufficient time to evolve to their present state. Probably about that time, the chain of islands of which the Hawaiian group is a part gradually arose from the sea, a mass of bare lava. It is interesting to speculate how these barren islands became clothed with vegetation.

Mosses and ferns produce spores or unicellular reproductive bodies of microscopic size that, like dust, can be borne for great distances by the wind. Orchids (p.) produce minute seeds that are extremely light. Plants like the railliardia (p.) bear spreading hairs on their small fruits to act as parachutes that enable them to be carried by the wind more readily. Such plants may have reached these islands during windstorms.

The hala (p.), nōni (p.), naupaka (p.) and others either have

corky material around their fruits or seeds, or air spaces within them. This enables them to float in sea water for months or even years. They, no doubt, were carried here by ocean currents.

The peperomia (p.) and mistletoe (p.) have sticky, seed-like fruits. The strange sedge uncinia (p.) and several of the native beggar-ticks or kokolau (p.) bear hooks or barbed hairs on their dry fruits. It seems reasonable the think that these plants reached this chain of islands attached to driftwood or more likely to the bodies of migratory birds.

Very many plants like the raspberry (p.) and the native lobelia relatives (Clermontia, p. , Cyanea, p. , Rollandia, Delissea) have adopted a very efficient method for the distribution of their seeds and the establishment in the soil of the seedlings arising from them. Their seeds are indigestible but are contained within edible and often conspicuous fruits that tempt some bird or other animal to eat them. Thus birds frequently carry them in their alimentary tracts for considerable distances and at length deposit them in their droppings on the ground. Seedlings developed from seeds carried in this way have the unique advantage of beginning their growth in fertilized, or manured, soil.

On our chain of volcanic islands the conditions as to soil, climate, competition with plants and animals, and isolation by mountain ranges or bodies of water were obviously not identical with those elsewhere. Consequently almost every plant immigrant that found refuge here hundreds of thousands of years ago either became locally extinct or gave rise to a race of offspring that gradually evolved along a different line from its relatives left behind on the continents or on the islands to the south. In general, the longer the race has lived in the Hawaiian Islands, the greater has been the opportunity for change. Today we notice that for this reason the offspring of the earlier immigrants for the most part have become more modified from the ancestral condition than have those of later arrivals. The offspring of comparatively recent immigrants, on the other hand, have become little if at all modified. As a result, we find that about 85 per cent of the present native Hawaiian flora consists of plants that have been so changed by local conditions from the ancestral structure that they are now recognized as being peculiar to these islands. Such plants are said to be "endemic," while the kinds found native in

these islands that have not yet perceptibly changed from their relatives growing elsewhere are termed "indigenous". Plants brought here purposely or accidentally by the Polynesian and other races, in contrast, are said to be "introduced."

Due to the relatively weak competition among plants living in isolation on the Hawaiian Islands, many of the archaic types formerly enjoying a more extended range have persisted here to the present time in a more or less modified form though exterminated elsewhere. Hence the endemic vegetation of these islands largely comprises a unique flora relicta, counting among its members strange arborescent plantains, composites, violets, geranium relatives and other wonders of plant life.

After the discovery of the islands by Captain Cook in 1778, the former balance of nature rapidly changed, working havoc with the endemic flora. Scores of plants that have taken hundreds of millions of years to evolve have been exterminated since that year, less than two centuries ago. Hundreds more are on the verge of extinction, and the rest, for the most part, are doomed to the same fate in a comparatively short time. Two factors are responsible for this rapid decline of the endemic flora, namely introduced animals and introduced plants.

Cattle were first brought here by Vancouver in 1793; sheep were first brought probably by Calmet and later by Vancouver in 1793; horses were first brought by R. J. Cleveland in 1803. As the number of these animals in the islands gradually increased, the Hawaiian plants inhabiting the more fertile regions became more and more exposed to injury by trampling and browsing, and in most cases succumbed. Goats were introduced by Captain Cook. Their feral descendants soon roamed the drier and rockier regions in small herds, particularly on the Island of Hawaii, taking a heavy toll of the plants peculiar to such localities. Pigs, introduced by the Hawaiians in prehistoric times, continue their depredations in the wetter jungles to the present day.

R

The choicest lands were cleared of their native plants to give place to suger cane, coffee, pineapple and other crop plants. Plants purposely introduced for food, such as the guava (p.), or as ornamentals, such as the lantana (p.) and melastome (p.), escaped from cultivation. Still others came in ballast, with fodder and merchandise, in impure garden seed and in countless other ways. Many of these vigorous plants accustomed to keen competition in their original homes on the continents found conditions for growth ideal in these islands. Many spread like wild-fire, crowding out the pampered native plants that stood in their way. Today the lowlands are almost destitute of Hawaiian vegetation, being covered with troublesome weeds that hail from almost every tropical and subtropical country in the world. It is only in the rain forests that the Hawaiian plants are still supreme. This is due to the fact that weeds inhabiting similar districts on the continents are rarely transported to these shores. As the number of plants introduced from all types of regions, however, is steadily increasing, the native rain forest flora will likewise eventually succumb.

Just as about 85 per cent of the native plants of the Hawaiian Islands differ markedly from those growing elsewhere so, in a general way, does a smaller percentage of plants of one island of the Hawaiian group differ to a lesser degree from those growing on another island. In fact, it is not infrequent to find a definite kind of plant which has no counterpart elsewhere growing only on a single mountain, ridge, valley, or kipuka or oasis. This condition in the native flora is due to many complex and interrelated factors. Within a relatively small area, these islands offer to land plants extremely diverse ecological conditions. They can find a foothold from sea level to an altitude of almost 14,000 feet, on Mauna Kea and Mauna Loa. They may have tropical heat throughout the year, as in the Kau District of the Island of Hawaii, or freezing temperatures for much of the time, as on the three highest mountains of these islands. They may grow under conditions of extreme aridity, as in many localities on the leeward side of the islands, or with almost perpetual rainfall as on the summit of the Island of Kauai.

Furthermore, they are offered opportunity to grow either in deep, mellow soils, found in the valleys; or on rough aa # (fig.   ) or glassy pahoehoe ## (fig.   ) lava flows, which cover vast areas on Hawaii and Maui; on salt-impregnated soils, such as may be found south-east of Kilauea that are actually poisonous to many plants; or on soils of great fertility. If a plant becomes isolated from its kind by being transported as seed or spore to a different geographical or ecological region on the same or on a different island, or even by being surrounded by extensive lava flows, it sooner or later begins to differ from its relatives. These differences may be actual, deep-seated and hence heritable from generation to generation in spite of external factors; or they may be merely apparent, superficially imposed by the environment on an impressionable organism and consequently exerting no influence on succeeding generations. Only in the case of the former are the resulting plants actually distinct from their relatives. In the latter case they are merely disguised representatives.

When plants become hybridized to a greater or lesser degree with one or more relatives, in the islands no doubt a comparatively frequent occurrence that usually escapes detection, a host of variable offspring may result. Some of these may become segregated, as previously mentioned, and give rise to yet other distinct kinds of plants which in turn may or may not hybridize. Such processes were doubtless largely responsible for the surprisingly large number of plants found in these islands that are apparently annectent, or intermediate, types between otherwise distinct kinds. This ability to hybridize has likewise, no doubt, been instrumental in the evolution of new kinds of plants locally. To distinguish between plants which 1) possess various degrees of actual differences which are transmissible by inheritance from 2) those that appear to be different from others but are actually the same and from 3) those that are more or less hybridized and do not as yet breed true but are still producing variable offspring is a problem still demanding intensive and long-continued study.

-.

add footnote – on following page   R

A pahoehoe flow is characterized, as the Hawaiian word signifies, by a velvety appearance. It is lava that has cooled when at rest or nearly so. It therefore resembles liquid lava in appearance. Tar oozing from a pavement on a hot day simulates pahoehoe on a small scale.

The surface of an aa flow is characterized by jagged, angular and rough masses of lava, extremely variable in size and shape. It forms by congealing while yet in motion, the front and surface of the flow solidifying into a crust in the cool air and the remainder probably cooling due to infiltration of steam generated from the water in the soil below. As the crust becomes engulfed in the flowing mass, fresh liquid lava takes its place and, likewise, solidifies. As this continues, the entire mass becomes a sluggishly advancing flow in which liquid lava is rarely seen. Solid lumps of lava from the upper part of the front of the stream tumble down its slope, advancing ahead of the lower part as this is retarded because of friction with the surface of the ground.

The plants described in the following pages are arranged, where possible, in the order of their complexity, the primitive in structure preceding those that are more advanced. For a book of this kind no key for the identification is necessary, a perusal of the illustrations serving in its stead.

(Acknowledgement)

The writer is greatly indebted to his former student Henry Wiebke, to Oliver Pohina and especially to Everett Brumaghim for knowledge of the native uses of plants; to Herbert Lau, to Yasuma Iwasaki and to others for executing the drawings; and to Herbert Gregory for stimulating him to devote his full time and resources to a study of the local flora. Without their aid and influence, this book might never have appeared. He also wishes to express his appreciation to Thomas Allen, Superintendent of Hawaii National Park; to Mrs. T. A. Jaggar; to Harold S. Palmer; and to many other friends for helpful criticism.

PSILOTUM or MOA

Two kinds of psilotum, the *moa* of the Hawaiians, may be found within the boundaries of the Park. Though rarely attaining one foot in length, both are unique plants because of their narrow, uniformly forking branches and inconspicuous leaves. In lieu of roots they have subterranean branches which are inhabited by strands of a microscopic fungus, or mold, called a mycorrhiza. This fungus in some way aids the plant in gaining part of its food.

The upright psilotum, *Psilotum nudum* (L.) Griseb., (Plate) of the botanist, is the more common of the two plants, growing on the ground or, rarely, on trees. It can be identified by its three-cornered stems and upright habit of growth. The flat-stemmed psilotum, *P. complanatum* Sw., (Plate), on the other hand, invariably grows on tree trunks, especially on those of the giant ferns. It has flattened stems that grow a short distance out from the trunk of the tree before drooping sharply like a mare's tail.

The two psilotums, which live throughout the tropics, and two plants called *Tmesipteris* which live in Australia and New Caledonia, form a remarkable group termed *Psilotales*. They are neither ferns, clubmosses nor flowering plants but seem to resemble more closely certain primitive, long extinct plants that are known only as fossils.

The leaves of psilotum are very small and scale-like. In the upper part of the plant they are deeply divided and bear three-chambered, yellow capsules called sporangia. When mature these split open to shed a cloud of dust-like reproductive bodies called spores. These spores germinate under favorable conditions into minute plants called gametophytes, or prothalli, which grow hidden entirely under ground, in the crevices of rocks or in the decaying trunks of trees. These were not known until around 1910 when a botanist took some spores and forced them into blocks of old pumice. After leaving these porous rocks in a moist place for about a year, he sliced them with a razor to reach the gametophyte for study. This, he discovered, is a minute, root-like structure which has a mycorrhiza living in its tissues. The lat-

ter aids it in gaining nourishment. At maturity, the gametophyte produces microscopic sex organs called antheridia and archegonia. Within the antheridium numerous motile sperm develop, while within each archegonium rests a single egg. The sperm are finally liberated in wet weather and then actually swim to the archegonia to unite with the eggs. From such a union arises the next generation, called sporophyte, which consists of the plants here illustrated. Thus the large generation producing asexual reproductive bodies, called spores, gives rise to the minute generation producing egg and sperm. Such an alternation of unlike generations occurs in all the plants described in this Guide. In the Flowering Plants, however, the gametophyte generation has become so obscured that only the botanist can recognize it.

The upright psilotum furnished the Hawaiians with two medicines. The tea, derived by boiling the plant, was given to babies suffering from the common disease called ea in Hawaiian and "thrush" in English. This is caused by a fungus (Oidium albicans) that produces white patches in the mouth or on the tongue, and finally covers the entire mucous membrane with an even, white coating. This tea was also drunk as a laxative or cathartic. The oily spores, on the other hand, were given to infants as a remedy against diarrhoea, and were also used like talcum powder in preventing chafing which occasionally occurred by wearing the malo, or loin cloth.

The upright psilotum was used in playing the Hawaiian game of fighting cocks. Two players each took a branch of the plant and removed all but a single side twig. Then holding the branch by the tip, this inverted twig would act as a hook. The two contestants would lock hooks and slowly pull until either the one or the other branch should break. The owner of the branch that remained intact thereupon declared his victory by crowing like a rooster.

(374) CLUBMOSSES or WAWAEIOLE 104c 12

Several kinds of clubmosses, the wawaeiole of the natives, grow in Hawaii National Park. These plants belong to the Lycopodiales, a group that may be considered somewhat equivalent to the Psilotales ( ) and the ferns in evolutionary development though by no means closely related to them.

The nodding clubmoss (Plate), botanically known as Lycopodium cernuum L., is the most common representative of this group of plants in the islands. It is found in the Kilauea Section of the Park in great numbers, forming dense thickets in the more open woods with the uluhe ( ) fern. It creeps along the ground for long distances, giving off at definite intervals stems one to three or more feet high. These, in turn, bear short, forking branches. The entire plant, with exception of the root, is beset with innumerable awl-shaped leaves.

At maturity, the smallest branches of the nodding clubmoss produce drooping, cone-shaped structures called strobili. As these ripen, the scale-like leaves turn back ( ) to expose axillary capsules, or sporangia. The sporangia, as in psilotum , liberate unicellular reproductive bodies known as spores. Upon germinating, these ~~spores~~ grow into minute sexual plants, or gametophytes, containing male and female reproductive organs. Upon the fertilization of an egg borne in the latter, a new generation of clubmoss arises similar to its sexless grandparent and very dissimilar to its parents.

The spores of all clubmosses germinate so rarely that the gametophytes, or sexual generations, of most kinds are still unknown. In 1848 Spring, the specialist on this entire group of plants, wrote that as he had never seen clubmosses produce seed, he suspected that all the female plants had been exterminated in the Deluge and that only the males had survived, these growing to the present day. He obviously mistook the clubmosses, with their asexual spores, for flowering plants bearing highly specialized, "unisexual" flowers that produce pollen grains only and no ovules to mature into seed. The mystery as to the life history of this strange group of plants was finally solved by Treub in 1886 in Java with the discovery of the sexual stage of the nodding

R

clubmoss. In recent years the sexual generation of this same plant was discovered in New Zealand, and in 1922 the third find was made at Kilauea. Here the greatest number of gametophytes of any kind were gathered. These, strange to say, were growing by the thousands almost exclusively in the volcanically heated crevices of the Sulphur Bank and its vicinity#. The rarity of the gametophyte under normal conditions and its phenomenal occurrence in fumaroles is due to the fact that the ideal environment for the growth of the one generation is harmful to that of the other. Such an explanation may, in part, account for the extinction of most of the clubmoss relatives which flourished during the Carboniferous Period and largely built up our coal deposits with their branches, leaves and inflammable spores.

Another clubmoss, which may be found east of Kilauea and in the Koolau Gap of Haleakala, is Lycopodium venustulum Gaud., a close relative of the continental L. clavatum L. This plant also creeps over the ground but, instead of producing nodding strobili, these structures are erect and exposed on a stalk. The plant is rather rare.

A few other clubmosses may, perhaps, be noticed by the visitor. For instance, L. polytrichoides Kaulf., and L. phyllanthum Hook. & Arn., grow along the trail between Makaopuhi and Napau Craters in the Kilauea Section. It is, however, useless to search on the ground for these rare plants as they grow on the moss-covered trunks of trees. L. polytrichoides, the smaller of the two, is shown on Plate . L. phyllanthum is two to six times as large and bears flattened leaves.

Degener, O., The Nodding Clubmoss; Popular and Technical Account of an Interesting plant of Hawaii. Pamphlet (1931). Based on Bot. Gaz. 80:26-47. 1925.

The Hawaiians used the nodding clubmoss, or wawaeiole, as a medicine for rheumatism. The patient bathed in cooled water in which the plants had been boiled for about three hours.

R

(5)

FALSE STAGHORN FERN or ULUHE

Four kinds of false staghorn fern, the uluhe of the Hawaiians, grow in these islands. The particular one botanically known as Dicranopteris emarginata (Brack.) W.J. Robinson is native to the islands of Hawaii and Oahu. It is especially abundant in the Kilauea Section of the National Park.

The uluhe ferns belong to a tropical family called Gleicheniaceae. Many of these plants have long, wiry, creeping stems which give rise at various intervals to upright fronds. These differ from the fronds of other ferns in possessing numerous dormant buds. When the plants grow in rather open country, these buds seldom develop further and hence the fronds rarely exceed a height of two or three feet. But in localities where shrubs and trees tend to shade the plants, these buds quickly awaken into growth to produce complicated frond systems that clamber over the obstruction to a height of ten or even fifteen feet.

In spite of the unusual structure of the fronds, the uluhe is one of the most primitive ferns in the Hawaiian Islands. This is at once apparent by inspecting the under side of some of the older fronds. Here one may often see small dots, termed sori, scattered with some irregularity. Each is composed of about a dozen spherical, stalked bodies called sporangia that only the keenest eye can discern. In the more highly evolved ferns, the sporangia are not openly exposed to danger in this way but, instead, are protected by an outgrowth from the margin of the frond, as in the tree fern (Plate) and maidenhair, or in some other way.

The sporangia of the uluhe fern, as well as those of practically all other ferns, enclose numerous microscopic spores which are finally shed into the air as a fine cloud of yellow dust. The spores that fall in some moist locality may germinate and develop into small, green, often heart-shaped, sheets of cells called gametophytes, or prothalli, each a fraction of an inch in length. These finally produce sperm and eggs. From their union, the asexual spore-producing generation that we commonly recognize as a fern then arises.

The uluhe ferns are almost the only native plants that are actually

troublesome to man. The thickets they ~~form are frequently~~ naturally so dense as to be practically impenetrable. Seeds of forest trees falling into such dark, tangled masses of living and dead fern fronds may germinate but the growing seedlings usually die before being able to force their way into the light. When such thickets become dry during periods of drought, a carelessly discarded cigaret or a neglected camp fire may ignite them and thus cause a devastating forest fire. Even shrubs and trees of medium size are not immune from their attack. If they stand in the way of a spreading uluhe patch, they may be covered by the climbing fronds and weakened or even killed.

It is extremely difficult to eradicate the uluhe. Where the fern is found in small patches, it can be controlled after the first general clearing of the ground only by the continual digging up of the growing, brittle rootstocks that have managed to remain in the soil. Where the plants cover extensive forest areas, they may be exterminated by planting introduced kinds of bamboo in artificial clearings. These giant grasses soon produce subterranean branches that spread in all directions whether uluhe grows over them or not. From these branches, sharp shoots soon arise which, instead of spreading, press straight up through all obstacles before producing a dense crown of blades, or leaves. Thus, in time, a forest of bamboo spreads over the tangle of fern and kills it with its dense shade. It is indeed doubtful whether the fern or the giant grass is the greater pest, for after the former has displaced a tangle of uluhe, it will encroach on the land still held by forest plants. A good example of such a dense bamboo forest may be seen below Kolau Gap, not many miles from the boundary of the Kalaeakala Section of Hawaii National Park.

The Hawaiians in former times occasionally drank an infusion of the uluhe as a laxative.

P

(6) 16

TREE FERNS

Three kinds of tree fern are native to these islands, where they flourish from almost sea level in the more rainy districts to an elevation of ten thousand feet or more. All belong to the family Dicksoniaceae. They can be readily recognized by their tall, upright trunks. The only plant that the visitor may possibly confuse with the true tree fern is the Sadleria illustrated on Plate . The trunk of the latter, however, rarely exceeds five feet in height while the frond is never as complicated in structure as that of the tree fern. In fact, an entire Sadleria frond resembles superficially merely one of the many large segments, or pinnae, composing a single frond of the other plant.

Menzies' tree fern, Cibotium Menziesii Hook., which is known to the Hawaiians as hapu iii, is the largest of our ferns. Its trunk may become 25 feet high while the spreading fronds arising from its top may add another 10 to 15 feet to the plant's height. The lower third of the stalks of these fronds is always covered with very dark brown, almost prickly hair. Chamisso's tree fern, C. Chamissoi Kaulf., (Plate), and its very close relative known as C. glaucum (Smith) Hook. & Arn., both called hapuu by the Hawaiians, are usually about 10 feet shorter and the stalks of their fronds are without such stiff hair (Plate)

On the under side of many of the fronds may be seen small marginal bead-like structures called sori (Plate , fig.). They are much more complicated than the simple sori of the uluhe fern previously described. In this case, A small part of the margin of the frond has bent down to meet a flap of tissue arising from the under side. The resulting sorus, upon ripening, opens up like a purse near the middle to expose the well-protected sporangia, enclosed. These, in turn, spring open to liberate into the air large numbers of microscopic reproductive bodies, or spores.

The buds of all three kinds of tree ferns are densely clothed with brown, silky hair called pulu by the Hawaiians. By 1859 this was extensively gathered, especially from the hapuu, and shipped to California and elsewhere as

This pulu or the flowers of the sugar cane ( ) in the early days was often used in embalming the dead. First the vital organs, thorax, tongue and brain were removed. The resulting cavities were then tightly stuffed with the pulu and sewed up with olona ( ) fiber. It was next wrapped in a black sheet of bark cloth or kapa ( ), in which state it would remain little changed for at least eight months. The corpse thereafter was usually either buried in the ground or secreted in some cave. At times these remains were thrown into the surging lava lake of Kilauea in honor of Pele, goddess of volcanoes, who was said to feed chiefly on human flesh.

material for stuffing mattresses and pillows. In 1868 alone, the amount of pulu derived from these ferns and from the Sadleria ( ) for export amounted to almost 343,000 pounds. Now that this industry has fortunately ended, these beautiful trees are no longer being cut down to facilitate gathering the small quantity of pulu that each can furnish. Around 1920 the tree ferns were again threatened with destruction by the beginning of a fern-starch industry near Hilo. The trees were cut for the starch contained in their trunks. This was of very good quality, ~~being used for~~ laundry as ~~well as~~ cooking purposes. After a short time, the concern that manufactured the starch ~~went out of business.~~

Although an old tree fern may measure two or more feet in diameter at the base, only a very small proportion of this is actually taken up by the trunk itself. The greater part consists of intertwining aerial roots that arise from the trunk and gradually work their way toward the ground. These not only absorb nourishment for the plant but also aid in supporting it in an upright position and in protecting the true trunk from injury. Because of this ability to produce abundant adventitious roots, the upper part of the tree fern will continue to thrive even after a considerable part of the trunk has been cut away below. Plants are therefore occasionally seen by visitors in Hilo and Honolulu planted in gardens or ornamental tubs. In the vicinity of Kilauea, for example, they are commonly set in the ground in upright rows to form a delicate, living hedge as the new fronds uncurl. The bases of the trunks, ~~on the other hand,~~ are used to pave rustic walks.

In cross-section, a young tree fern stem ~~exhibits~~ has a light-colored central pith surrounded by several hard bands of wood. Enclosing all is a dark matrix filled with lighter circles and loops. These are the cut ends of aerial roots. In strata of the Carboniferous or Coal Period, stones have been found which upon polishing show similar designs but in various brilliant hues. These are cut and made into brooches and sold by German jewelers as Staar-Steine. A translation of this term is Starling-Stones, an appropriate name, because the fossil with its petrified rootlets somewhat resembles the

speckled plumage of the European starling, a relative of the introduced mynah bird. The botanist recognizes the jewel as the remains of the trunk of an extinct tree fern, called Psaronius, of questionable relationship to the Hawaiian plant.

The pith of the tree fern trunk, being rich in starch, was freed of the surrounding fibrous roots and wood, and then cooked for food by the Hawaiians in the early days during times of famine. Not many years before the Kilauea region was created a National Park by Congress, large tree fern trunks, as well as the trunks of the Sadleria, were dumped into certain steam crevices in the neighborhood of the Volcano House. After they had been cooked by this volcanic heat, they were fed to hogs to fatten them.

Two important animal enemies of the tree fern exist. The wild pigs, introduced by the Hawaiians centuries ago, uproot the plants and feed upon their starchy trunks. The other pest is a very small foreign weevil that now inhabits certain districts and bores into the stalks of many kinds of ferns. As this insect has no wings to enable it rapidly to extend its range of activity, the danger of introducing it into new regions would be greatly lessened if well-intentioned people refrained from transporting ferns from place to place, no matter how small the fragment. One of the few plants, on the other hand, that sometimes destroys the tree fern is the ohia lehua tree, as described on page 3.

Export of Hulu in pounds from 1867 to the present time:

1867	203,958
1868	342,882
1869	622,998
1870	233,803
1871	292,720
1872	421,227
1873	412,823
1874	418,320
1875	379,003
1876	314,432
1877	150,586
1878	212,740
1879	137,001
1880	44,946
1881	53,415
1882	-
1883	-
1884	465 practically none since that date.

HAWAIIAN POLYPODIES

(Plate) the ... of the Hawaiians,

The pellucid polypody, belonging to the fern family Polypodiaceae, is very common in the open woods near Kilauea Crater. Here its pinnae, or frond segments, have a tendency to be folded one against the other and to bear at the base an auricle or prolongation. In certain other regions, however, the plants have fronds that are flat and have pinnae that lack auricles, or that vary in other respects. Botanists are not yet decided as to whether all these plants comprise one single kind of polypody that varies considerably under different conditions of soil, temperature and moisture, or whether there are half a dozen distinct kinds in these islands difficult to tell apart. Until further study has definitely settled this question, the plants may be provisionally known as Polypodium pellucidum Kaulf.

This plant has thick rootstocks, densely covered with brown scales, that creep over the ground. The fronds, about one foot long, are attached to the upper side of rootstock by a basal joint and this is where they become detached when old and of no more value to the plant. Each frond bears numerous tongue-shaped pinnae. Upon holding one of these against the light, one will discern many transparent branching veins, to which the definitive name of this fern refers. At the ends of these veins on the upper surface of the older fronds, a white spot may be frequently found. This consists of salts that are useless to the plant and therefore expelled through a microscopic aperture, termed hydathode, in the frond surface. The under side of the mature fronds usually bear large, brown sori containing spores, or asexual reproductive bodies.

(Plate)

Safford's polypody, known scientifically as Polypodium Saffordii Maxon, is one of the smallest ferns peculiar to the islands. It is partial to the moss-covered trunks and branches of trees in the damper forests above 3000 feet elevation. Within the Kilauea Section of the Park, this plant is not uncommon. Because of its small size and peculiar habitat, however, it usually escapes the attention of the visitor or is mistaken for one of the mosses among which it grows.

R

Safford's polypody has a very short rootstock from which numerous thread-like roots ramify throughout the surrounding moss and bark. The linear fronds arising in a cluster from the upper part of the rootstock are one to five inches long and but a fraction of an inch in width. They are notched into bluntly triangular lobes for all but their upper third where the sori containing the reproductive bodies are located. These are borne on the under surface of the frond without any special protection. In this respect the plant resembles the pellucid polypody, indicating that both forms belong to the same plant group.

B

(9)

In 1922 *Pteris vittata* L., (Plate) was first collected in these islands. It was found in the vicinity of steam crevices near Kilauea. Eight years later, in company with the introduced silver fern called *Pityrogramma calomelanos* (L.) Link, it had become one of the common plants wherever the warm, moist volcanic vapors reach the surface of the ground. This plant is native to the tropics of the Old World and quite different from *Pteris longifolia* L., of America for which formerly it had been mistaken. The latter was not found growing near steam crevices (as reported by others) but on the wet cliffs at the Thurston Lava Tube.

Pteris vittata has bright green fronds. Its sori, as in all other kinds of *Pteris* of which about 250 are known, are protected by a flap of tissue, called the indusium, formed by the revolute margin of the frond. The various kinds of *Pteridium* or bracken, of which an evidence ... grows commonly in grassy localities in both sections of the Park, differ in having an obscure secondary indusium facing the marginal one. All these plants belong to the *Polypodiaceae* or Fern Family.

Hawaiian ... kilau or pai...

P

(10)

CLIFFBRAKE

The cliffbrake is known botanically as *Pellaea ternifolia* (Cav.) Link., and, like most ferns, belongs to the family *Polypodiaceae*. Our plant is native not only ~~native~~ to the Hawaiian Islands but ~~is found in~~ to warm and tropical America as well. This ~~it~~ is not a true cliff plant as its name would indicate but rather prefers to grow in very dry soil among ledges or embankments exposed to the full heat of the sun. It grows within the boundaries of both sections of the National Park and ~~it~~ has been found, though rarely, on the inner slopes of Haleakala Crater. Along the trail that leads from Kilauea to the summit of Mauna Loa, ~~on the other hand,~~ it is rather ~~quite~~ abundant in spite of the ~~presence of~~ livestock that is pastured where it grows.

This fern is characterized by a short, thick rootstock from which stiff, upright fronds arise which are usually less than one foot high. The stalks of these fronds are shiny and dark. ~~while~~ The pinnae, or frond segments, have a bluish-green tinge. Each of the latter is divided in such a way as to resemble a leaf of three blades, thus giving the entire plant the appearance of some strange clover. The margins of the segments are rolled under and hide the sori or clusters of reproductive structures from view. Although the fronds die with age and are replaced by younger ones, they long remain attached to the plant.

(11)

SADLERIA

Sadleria is the name of a group of ferns peculiar to the Hawaiian Islands. All have fronds of the character shown on Plate and all belong to the family Polypodiaceae. The plants live under many different conditions: some near the sea, while others live on the summits of all but the highest mountains; some in dense rain forests, while others manage to survive on the newest and driest lava or on the rocky faces of canyons. Whether four or more kinds of Sadleria exist in the Islands and live under one or more of these conditions is a problem that the botanist has not yet definitely solved.

The fern known as Sadleria may be collected along the Olinda Pipe-Line Trail on Maui a few miles below the north-west boundary of the Haleakala Section of the Park. Here it grows only on the moss-covered perpendicular rocks and embankments forming the sides of the canyons. During rainy weather the plants are abundantly supplied with water trickling down the thin layer of moss but during fair days they are fully exposed to the blazing sun that dries them and their substratum. They are evidently very tenacious of life to withstand such periods of drought and such seemingly unfavorable situations for growth. On some of the cliffs down which water seeps rarely, dwarfed specimens that have almost no rootstock and fronds barely three inches long may be found in full reproductive vigor. Normal plants have a rootstock about three inches long and fronds two feet long. At least two Sadleria may be found in the vicinity of Kilauea, both having an upright trunk six inches to five or, very rarely, even nine feet high. Hillebrand's sadleria, Sadleria Hillebrandii W. J. Robinson, called amau by the Hawaiians, is the less common. It can be seen growing in numbers, however, in the crevices between the Sulphur Banks and the Military Camp as well as near the Thurston Lava Tube. Its fronds are usually about one and a half to two and a half feet long. Their stalks as well as the midribs are practically always covered with brown scales and the smallest veins may be distinctly seen on the under side of the segments.

R

The common sadleria, S. cyatheoides Kaulf., is called amaumau by the Hawaiians. It usually becomes more than twice as large as the amau. It may be easily differentiated from the latter by the lack of permanent scales above the base of the frond and by the obscurity of all but the midrib in the smallest division of the frond. Between Kilauea and Glenwood several hybrid plants were collected that show features intermediate between those of S. Hillebrandii and S. cyatheoides. One of these unusual specimens was chosen for the illustration of Plate .

The common sadleria is practically the first plant to grow on fresh lava flows as the late, unfortunate C. N. Forbes, botanist of the Bishop Museum, has shown. Its old decaying fronds and living trunk soon furnish a suitable bed for the wind-blown seeds of the ohia lehua (page) to germinate. The seedlings finally develop into the trees so characteristic of the islands. This fern may be found also in the Kau Desert near Kilauea where not even the desert Silene (Plate) can survive the heat, dryness, and high concentration of salts in the soil. To be sure, the plants bear only two or three depauperate fronds in the midst of a dozen dead ones that have accumulated over a period of many years.

A generation or two ago, the soft scales protecting the buds of the common sadleria were gathered, as were those of the Cibotium (page), and shipped to California as pulu amaumau. There they were used as stuffing for pillows and mattresses. Before the white people came with their manufactured cloth, the Hawaiians macerated the stalks of fronds of this fern and beat them together as a sizing with the bark of various plants in the making of their kapa, or bark cloth (page).

The amaumau also furnished a red dye for their kapa. The outer part of the trunk was mashed and then its juice was squeezed into a calabash, or vessel. To this, salt was added to produce coagulation. Since the Hawaiians, however, had no metal or earthenware dishes to enable them to boil liquids, hot stones were placed in the calabash to boil and to evaporate some of the water in order to concentrate the dye which was then ready for use.

The early name of the fire pit within Kilauea Crater, according to the Hawaiians, is Lua Pele, or the Pit of Pélé, the goddess of volcanoes. A later name, and one less often used, was Hale-ma'u-ma'u, meaning "the house of amaumau fern". This name was given to it either because of the presence of a lava cone, now gone, that somewhat resembled the temporary shelter built of amaumau by the Hawaiians on their visit to the region or, less likely, because of the former abundance of this fern on the floor of the Crater of Kilauea. Though the word for "everlasting" is also spelled mau, the two Hawaiian words are pronounced in an entirely different way. "The House of Everlasting Fire", the English name for the center of activity in Kilauea, though very appropriate and worthy of retention, is consequently not a translation of the Hawaiian one as popularly supposed.

The starchy pith of Hillebrand's sadleria, the amau, was cooked in the ground and eaten by the Hawaiians, though not as commonly as was that of the hapuu (page). In early times for planting vegetables, the Hawaiians covered the ground in the drier regions with amau, and probably also amaumau, fronds. Then when they noticed that it would rain, they removed the fronds and planted their seed. After the rain, the leaves were replaced as a mulch to hinder evaporation. This custom was so prevalent that it has given rise to the saying: "While rain clouds are still in the sky, remove the covering of amau fronds." Amau fronds, according to some Hawaiians and amaumau fronds according to others, were used for thatching the native houses (page) when the more preferable pili grass (Heteropogon contortus (L.) Roem) was scarce, and were even used to cover the walls of the houses. The ground which the king and his attendants were to pass over or remain on at the dedication of a heiau, or temple, was likewise covered with amau fronds.

Because of the difficulty of making the ridge of the roof and the corners where two surfaces joined rain-proof no matter what thatch was employed, a row of sadleria fronds were commonly tied lengthwise over it. The midrib, or rhachis, of each frond was first slit on the upper side so that the fern could be made to lie flat on each surface of the roof.

R

(12)

SWORD FERNS

Two kinds of sword fern, members of the Polypodiaceae or Fern Family, may be found growing wild in the Hawaiian Islands. They are characterized by having an upright, scaly, short rootstock from which arise long, pinnate fronds. These, if mature, produce sori consisting of a circular area of sporangia, or asexual reproductive organs, protected by an overlying kidney-shaped tissue called an indusium. This structure is so typical of these plants that they have been placed in a common group named Nephrolepis, meaning kidney-scale. In addition to reproducing by spores, these plants produce long, slender runners which develop young plants at their ends which in time become detached from the parent by decay of the intervening connection.

Nephrolepis exaltata (L.) Schott, is native to tropical and subtropical countries of both the Old and New Worlds. It is also native to the Hawaiian Islands where it is one of the commonest ferns, especially at lower elevations. The plants growing on the continents have long been favorites among horticulturists who have produced from them many different ornamental forms of which the Boston fern is the best known. This, in turn, has been modified still further into more than fifty kinds of named crested and much-divided mutants or sports of considerable beauty, many of which have been introduced into the islands as garden and potted plants. These occasionally escape and may be found growing with their wild relatives.

The typical native N. exaltata may be found in the Kilauea Section of the Park in great numbers along the Chain-of-Craters Road and near Napau Crater. It grows commonly on the ground and occasionally on moss-covered trunks of trees.

Nephrolepis cordifolia (L.) Presl, also of wide distribution, is not native to the Hawaiian Islands but was probably introduced as an ornamental from Japan previous to 1875. It also has escaped from cultivation and is definitely known as a naturalized plant from Oahu where it was first collected by a Rev. Mr. Lyons and by J. F. Rock, from Mt. Eke of Western Maui where it was first collected by Degener & Wiebke in 1927, and from Hawaii where it

was first collected by the same botanists in 1929. On the latter island it is rather common on the trunks of trees and on the ground in the open forest near Makaopuhi Crater not far from Kilauea as well as on the slopes of Mauna Loa, Hualalai and elsewhere.

The two sword ferns resemble one another so closely that few notice that more than one kind exists in the islands. It is, however, not difficult to distinguish the two. N. exaltata has broader and flatter fronds than N. cordifolia. Moreover, the former has runners that are filiform throughout, while those of N. cordifolia frequently produce ovoid, scaly tubers as the bottom of the plate shows.

The native sword fern was known to the Hawaiians as pamoho, or even as nianiau okupukupu. ~~The preferred name, however, should be pala mahina~~. The plant was apparently of no special use to them.

R

(13) Screwpine or HALA) 10/42

The pandanus or screwpine, known in the Hawaiian Islands by the native name of hala or lauhala, is botanically Pandanus tectorius Sol. This is a typical coastal plant found native throughout Polynesia and Malaya in several different varieties and forms. It and its close relatives as well as two other groups of plants, constitute the Pandanaceae or Screwpine Family.

The hala is a peculiar tree ten to twenty feet high, having a short, erect, pale trunk bearing thick, forking branches. As the enlarging crown of the plant soon becomes too heavy to be supported by the original trunk and root during wind storms, thick prop roots arise from above the base of the trunk and not infrequently from the lower branches. These slowly grow toward the ground, adding strength to the plant. Their delicate ends, where active growth takes place, is protected by a very conspicuous, papery root-cap. Other parts are armed with conical prickles arranged roughly in longitudinal rows. These structures are actually side roots that have become arrested in growth and modified into weapons of defense.

The leaves of the hala are spirally arranged in tufts at the ends of the branches. On falling from their place of attachment they leave a permanent circular scar. The leaves are linear, three to five feet long, and quite hard and firm. Their margins and the under side of their keeled midrib are beset with very sharp, forward-pointing spines.

In cutting the stems or branches of various hala trees one will observe that in some trees they are very hard and firm throughout, while in others, on the contrary, they are hard near the outside and rather juicy and soft within. Around February when the hala flower, the reason for this difference in stem structure is clear. The trees are of two distinct sexes. Those possessing hard wood are staminate and produce staminate, or "male", flowers. Those possessing softer wood are pistillate plants and produce pistillate, or "female", flowers.

The staminate trees, called halapia, produce from the ends of their bran-

ches a pendant series of large flower clusters, called hinano by the Hawaiians, which are protected and made conspicuous by subtending, pale yellow bracts. Each cluster is composed of hundreds of pale yellow staminate flowers in which all floral structures have aborted excepting the stamens. A variable number of these are united by the lower part of their stalks into the oblong flowers (fig.). All, together, shed an enormous amount of pollen which is sought after by bees and various other insects as food. These pollen-filled flower clusters were sometimes gathered in former times by Hawaiian maidens for the purpose of playfully belaboring the youths of their choice on the supposition that the pollen would act as a love charm. The pollen was also at times seriously collected and used as an aphrodisiac.

The pistillate trees, ~~called ???puahala???~~, produce from the ends of their branches a single compact flower cluster, ~~called puahala~~, surrounded by bracts. This greenish structure gradually increases in size until it becomes about as large as a child's head. ~~How~~ In studying it, at this stage one can see how complex it really is. It is not a single fruit at all but is built up of 250 to 800 fruits that are firmly grown together into oblong and somewhat angular units, termed phalanges, composed of one central fruit surrounded by four to ten others. Fifty to a hundred of these phalanges in turn form the sphere which is consequently a collective fruit.

The hala is remarkably well adapted for dissemination. Each phalange when ripe is bright orange toward the basal end, fragrant and quite fibrous-fleshy on the outside. Within, it is so extremely hard and woody that the centrally located seeds on germinating could never force their way to freedom. Consequently a channel of less resistent and more spongy material leads from them to the surface through which the seedling can grow. In addition to these spongy channels, similar areas are scattered in the phalange.

The color and especially the fragrance of the phalange attracts rodents and other animals which ~~then~~ feed on the sweetish pulp. The woody tissue within, on the contrary, sometimes prevents them from eating the seed. In this way the plant may be disseminated by animals on land. In case the pha-

lange, especially when old and dry, should be borne into the sea, then the spongy areas function as a ~~flotation device~~ float. Thus the phalange, after being buffeted around by waves and currents, may at length be thrown on some distant shore where ~~its contained~~ the seeds contained may germinate.

The ripe phalanges, after the pulp has decayed or been purposely removed, were used by the Hawaiians as brushes, called hulumanai, in staining their kapa ( ), or bark cloth, with dyes. The seeds ~~within~~ were also occasionally eaten though hardly worth the labor of freeing them of the surrounding wood. The orange flesh was only rarely eaten, as, for instance, during times of famine, because it contains a considerable number of raphides, or crystals, that cause irritation as ~~in the case of~~ raw taro ( ). Other kinds of hala native to the South Seas contain so few raphides in their phalanges that their pulp is ~~used as~~ a staple food of the natives. In the making of garlands, or lei, the Hawaiians with a shark's tooth cut the basal third of the orange phalange into fragrant discs often serrate at the upper edge. It was considered ill luck to wear one of these.

known as lauhala, a name often given to the entire plant.

The greatest value of the hala was in ~~the use of~~ its leaves. Houses ( ) were frequently thatched with them, the ridge and corners usually being capped with dry amau ( ) fronds or with la'i ( ) leaves. The leaves of the hala were plaited ~~woven~~ into baskets and into mats, the commonest of floor-coverings. (Plate) Ordinarily the dead leaves were gathered from the ground. With a knife consisting of the sharp-edged panaua, or pahiaku, shell ~~[illegible]~~ to which a wooden handle had been tied, the flaring bases, the pointed ends and the teeth were cut away. If the entire width of the leaf was desired, then the midrib was scraped with the shell instrument until no thicker than the rest of the leaf. If the full width was not wanted, the leaf was torn in half lengthwise and the midrib discarded. The leaves, whether of the full width or half width, were then rolled lengthwise to prevent wrinkling and set aside to dry. If the

leaves were to be of a dark color, this drying was accomplished in the shade of the house; if light, then in the sun, ~~in the open~~. When ready to begin plaiting ~~weaving~~, the leaves were brought forth from storage and torn into strips an eighth of an inch to one and one half inches wide, according to the grade ~~type~~ of mat desired.

This procedure was often modified ~~when some special type of mat was desired.~~ For example, to produce a superior quality of mat, living leaves were gathered instead of dead ones, and these might first be passed through a flame to wilt them. At times the Hawaiians combined in their mats for the purpose of ornamentation not only leaves cured in one or more ways but the leaves of the *hala ulaula*, also known as *hala polapola*. These, ~~XXXX~~ on drying turned to a rich reddish-brown. This kind of *hala*, according to tradition, was brought at the same time as the pig from [redacted] the Society Islands by Hawaii Loa, the legendary navigator who sailed at least as far as China according to unpublished Hawaiian *mele*, or epics. For *hala* mats of especially fine texture and almost white color, living leaves were gathered and boiled until they had swollen and softened. These were next flattened with a stick until of uniform thinness, and hung up to dry. To produce mats, on the other hand, of a peculiar reddish hue, fallen leaves were used that had been dipped in a dye made of burnt coral boiled with the bark of the *noni* (   ) root.

~~XXXXXXXX;XXXX~~ Settees, called *koki*, for sleeping were also woven of *hala* leaves. The *maa* (   ), or sling, used in warfare was sometimes made of the leaves though more commonly of human hair or of coconut fiber. The most delicate of the white flowering bracts of the plant were woven into garments called *ahuhinano* of marvellous flexibility and fineness. The coarser bracts, and the young leaves, ~~on the other hand~~, were woven into canoe sails called *pea* or *la*. ~~(lau?)~~

(14)

CLIMBING SCREWPINE or IEIE

The climbing screwpine, or ieie of the Hawaiians, is botanically known as Freycinetia arborea Gaud. It is common throughout the Hawaiian Islands in the forest, especially at lower elevations. It is not known elsewhere, but thirty or more related kinds are found in the islands to the south-west of us and in the Orient. All belong to the Pandanaceae or Screwpine Family.

The ieie is very conspicuous along the highway from Hilo to Kilauea Crater during the summer when it is in bloom. Some plants may be seen climbing the trees and reaching to their very tops, the main stem clasping the trunks with their slender aerial roots while the branches curve out into the sun. Other plants trail on the ground in great masses, forming impenetrable jungles.

The woody, yellow stems of the ieie are about one inch in diameter and ringed with the scars of fallen leaves. They produce numerous, long, adventitious air-roots of almost uniform thickness throughout, which not only gain nourishment for the plant but enable it to hold on to its support. The stems branch every few feet to produce terminal clusters of slender, shiny, green leaves. These are pointed at their ends and spiny along their edges and on the lower side of the midrib.

All plants mentioned in this Guide, excepting the psilotums, lycopodiums and ferns, must have pollen, contained in their stamens, conveyed to their pistils in order to mature seed. But to produce seed that will develop into especially vigorous offspring, the pollen of one plant, in most cases, should fall on the pistil of another of the same kind. Plants have therefore gradually evolved various, often fascinating, methods for insuring such cross- pollination. Some plants, like the grasses, sedges, coprosma ( ) and plantain ( ), employ the wind for this transference and hence have inconspicuous, odorless and nectar-free flowers. Others, most of the kinds here illustrated, use insects instead to effect this transfer. They therefore bear flowers that contain nectar as a bait to lure the insect and are fragrant and conspicuously colored to enable the insect to find this bait with greater

ase. The special method that the ieie has devised to insure cross-pollination is so unusual as to be worthy of more detailed discussion.

At flowering time the ends of certain branches develop about a dozen bright, orange-red leaves called bracts. These are fleshy and slightly sweet near the base. Within them stand three brilliant cones (Plate , fig.), or inflorescences. Each is composed of hundreds of flower clusters, a cluster consisting of about six united flowers of which nothing remains excepting their pistils firmly grown together (fig.). On entirely different individuals similar showy bracts occur, also containing cones. But these, instead of bearing pistils, bear only stamens that shed pollen. The ieie has thus prevented all possibility of self-pollination by bearing its two sexes on two separate kinds of plants namely, "female" or pistillate, and "male" or staminate. How the ieie solved the problem of having the pollen transferred from the "male" plant to the stigmatic end of the pistil of the "female" plant can be learned by studying the plants near Hilo and similar ones along the Chain-of-Craters Road near Makaopuhi Crater.

In viewing the matured flowering branches growing there, one will invariably find them mutilated — most of the fragrant, colored, fleshy bracts have disappeared. They have been eagerly eaten by rats which, in their quest for abundant food, climb from flowering branch to flowering branch. In eating the fleshy bracts, the whiskers and fur of the rodent are covered with pollen, some of which undoubtedly rubs off on the stigmas of "female" plants visited later. The ieie is the only plant in the Hawaiian Islands and one of the very few in the entire world that uses mammals to effect pollination. Some of its relatives are pollinated by the flying fox, a kind of fruit-eating bat, that enjoys the bracts. The New Zealand plant, F. Banksii A. Cunn., bears such palatable bracts that even the natives eat them as a delicacy.

The Hawaiians in the early days made considerable use of the ieie. The fibers of the trunk, after pounding and scraping, were extensively used as cordage to bind the rafters of their grass huts and the outriggers to their canoes (page). They wove the strong, slender roots of the ieie, either whole or split in half lengthwise, into very durable baskets and into funnel-shaped traps of very fine mesh suitable for catching shrimp and small fresh water fish. They were also plaited into helmets, walled

[illegible] fibers of the trunk, after pounding and scraping, were extensively used as cordage to bind the rafters of their grass huts and the outriggers to their canoes; they were also plaited into helmets, called mahiole ( ), which were worn by the chiefs only in battle. Tightly fitted over the helmet was a net of olona (Touchardia latifolia Gaud.), to which both red and yellow feathers were attached to form definite designs. The red were derived from the iiwi (Vestiaria coccinea Forster) while the yellow usually came from the oo (Moho sps.). Idols (Plate) were fashioned in a similar way as helmets. These consisted of plaited heads covered usually with the red feathers of the iiwi to which the yellow and black of the oo were added to emphasize the features. The eyes were of mother-of-pearl with spheres of the dark wood of the kauila ( ) to represent pupils. The teeth were those of dogs. These horribly gorgeous heads were carried into battle on poles of kauila wood. Even the branches of the ieie were much used as decorations, particularly where the dancing of the hula took place.

The ancient hula had a religious significance and was therefore connected with definite kapu*, or "taboos". It was performed by professional dancers who had been obliged to undergo rigorous training. But because of the renunciation of the old gods, the breaking of the kapu and the coming of the foreigners, the hula gradually degenerated until today it is often little better than a vulgar spectacle. We owe to N. B. Emerson the valuable recording, translating and annotating of the various songs and customs connected with the real hula in his "Unwritten Literature of Hawaii".

In the early days a definite site would be chosen and then purified by being sprinkled with sea water mixed with turmeric or with red earth usually brought from Kauai. Here would be constructed the halau or place where the girls were taught the dances. This was strewn with rushes. It was considered a sacred structure. Within stood three huts or shelters, in one of which was a raised altar, or kuahu, dedicated to Laka, the goddess of the hula. While the kumu, or teacher, was chanting one of several appropriate prayers to Laka, the initiates would decorate the altar with the flowering branches of

* Our unfamiliarity with Hawaiian speech, the early voyagers misspelled the word "taboo", and thus it has become incorporated into the English language.

the ieie, as well as with certain ferns, maila ( ), and possibly with ohia lehua ( ), hau ( ), breadfruit ( ), banana ( ), ti ( ), aalii ( ), and ilima ( ). An uncarved block of hard, white wood from the sacred lama tree (Maba sps.,) was wrapped in yellow kapa, scented with turmeric, and conspicuously placed upon the altar to symbolize the goddess. Beside the teacher, or kumu, connected with the hula school, there were two types of pupils and several special officers. The olapa were the young initiates who were best fitted because of their youth and grace to move actively in the dance and to pose and gesture. The hoopaa, on the contrary, were the older men and women who handled the heavier instruments and acted their parts usually while sitting or kneeling. In case the kumu were absent, his assistant, called kumu kokua, took charge. The poopuaa was an officer chosen by the pupils. He executed the kumu's commands, collected fines and exacted penalties. He carried presents such as garlands and awa ( ) to the kuahu. The poopuaa had an assistant, paepae. During the construction of the altar, the poopuaa stood on the right while the paepae stood at his left. The hooulu, ~~on the other hand~~, was a guard stationed at the entrance of the halau who sprinkled everyone with sea water and turmeric who desired to enter. He also kept order and daily placed a fresh bowl of awa on the altar.

As the time arrived for graduation from the hula school, the discipline was tightened and no pupil was allowed to leave the halau except for the most urgent reason and then only if his head was muffled as a disguise. The day before the ailolo ceremony, special songs and dances were held. Then some time after midnight, the entire company except the teacher marched to the ocean to bathe and purge themselves of any possible ceremonial impurity. This procession was made in complete nudity for religious reasons. Upon entering the halaua they were sprinkled with holy water. This was followed by another period of dance and song when the kumu went into the sea alone to bathe. During his absence, the kumu kokua, or assistant, was in charge of the halau. Before being allowed to reenter the halau, the kumu recited the pass-word.

More songs and dances followed before the company retired for sleep.

At daybreak the dancers recited a prayer before the altar and then reclined to their breakfast to which friends, relatives and hula experts had been invited. The ailolo offering, consisting of a black suckling pig without a blemish, was then brought in and held down by the kumu. The hands of the pupils were laid on their teacher's hands while they consecrated themselves to their work. The pig was then taken out of the halau and prepared for the imu, or underground oven ( ). The halau was strewn with fresh rushes and the kuahu, or altar, was dismantled, another being built in its place and decorated with fresh material. The kumu now granted special dispensation to the pupils who retired to groom themselves, for which they had had little opportunity during their strict confinement to their studies for weeks or even months. Anointed and bedecked with wreaths, the pupils entered the halau at the appointed time, being sprinkled as usual with consecrated water at the entrance.

The cooked ailolo pig was then brought in and placed on the kuahu while the school sang songs of praise to the goddess Laka. At the conclusion of this service, the novitiates removed their wreaths and heaped them on the altar. Now the ceremony of ailolo began. Each novitiate received an equal share of the pig's snout, ears, feet, tail, portions of the vital organs, and especially the brain. This last, called lolo in Hawaiian, gave the name to this ceremony. These were eaten as a sacrament while the visitors sang praise to Laka. Thereafter the kumu lifted the kapu with a prayer and the entire assembly indulged in the feast that was spread in the halau for them. On this occasion, men and women were permitted to eat in common. A few more songs and prayers followed, and the students graduated from the school. Soon after, these new hula dancers passed out of the halau and performed their debut before the assembled multitude. From now on, they could dance wherever they desired, free from all restrictions.

(15) SUGAR CANE or KO 36.1

Sugar cane, Saccharum officinarum L., and its relatives, are members of the Grass Family, termed Poaceae by some botanists and Gramineae by others. To the Hawaiians, sugar cane is known as Ko. This giant grass has stems of rather uniform thickness filled with a sweet pith and marked off into prominent joints called nodes. These bear linear leaves and axillary buds in alternate arrangement. Like maize, or Indian corn, sugar cane at maturity produces tassels that are hairy and silver-gray with a reddish tinge. But unlike maize with its terminal tassel of "male" flowers and its axillary fused tassel or "ear" of "female" flowers that develop into grains of corn, the sugar cane bears terminal tassels only. These normally develop bisexual flowers, namely flowers having both stamens, or "male" reproductive organs, and pistils, or "female" reproductive organs.

Sugar cane probably originated in southern Asia though exactly where is not known. Chinese writers of the eighth century B. C., however, record its importation into their country from India. The plant, in many different varieties and forms, grew in most of the South Sea Islands previous to the coming of the white race, undoubtedly purposely transported by the Polynesians during their migrations. Even a hundred years ago the Hawaiians usually carried pieces of cane as a convenient portable and concentrated provision during their travels on land and water just as the American Indian was accustomed to carry maple sugar for the same reason. Before Captain Cook's coming, the natives in the Hawaiian Islands cultivated the cane in a crude way, even within the boundaries of the Kilauea Section of the Park, like the taro ( ) and the banana ( ). As with many cultivated plants, they distinguished more than a score of kinds by special names. This classification was based largely on the color of the stem but also to a lesser extent on its texture. Thus the kokea, lahi, oliana and uala have pale-yellow to greenish stems; the honuaula, koeleele and papaa have dark-red to purple stems; the ainakea, akilolo, laukono and manulele have variegated stems; and the puaole, a cane that was the most vigorous and contained the sweetest juice but which seldom if ever

R

The dried tassel with its basal stalk, in all about two feet long, was used for darts by children and adults in playing the game of kea pua. The lower end of the dart was tightly bound with string, wetted in the mouth and then thrust into the earth to become coated with clay. The players in turn ran forward in a stooping position from a slight mound and, with a downward and forward swing of the arm, threw the arrow at such an angle that it just grazed the surface of the ground. From here it occasionally glanced gracefully like a flat stone thrown to skip over the surface of a body of water.

flowered, was intermediate in stem color between the purplish and the variegated types. The laukono and the manulele ware used as aphrodisiacs by the kahuna, or sorcerer; the koelesele as a medicine in childbirth; and the kokea preferably for munching out of hand because of its thin rind. Many of these horticultural forms have become extinct.

Besides its use as food and medicine to the early Hawaiians, the cane plant was important to them in several other ways. Its leaves were occasionally used to thatch their houses ( ). ~~The dried tassel with its basal stalk was used for darts by children in playing the game of holoi and ka kua.~~ Sometimes the dead were embalmed by wrapping in kapa ( ) with the flowers of the koelesele sugar cane or with the pulu of the hapuu ( ) fern. As a sign that the plants in a field were kapu, or not to be taken by the common people, it was sufficient for a chief to place a stick of sugar cane in its corner.

The sugar industry in the islands had a very modest and desultory beginning in which many races of man have had a part. A Chinaman, on one of the Chinese vessels coming to the islands in 1802 to trade for sandalwood ( ), brought with him a stone mill for crushing cane and a boiler for concentrating the expressed juice. This primitive sugar mill, after grinding one small crop on the Island of Lanai, was abandoned when the owner returned to his native land. Don Francisco de Paula Marin ( ), the Spaniard who probably first recorded the growth of coffee ( ) in the islands, made sugar for the king in Honolulu seventeen years later. Lavinia, an Italian, made sugar in 1823 by pounding the cane like poi ( ) with a stone beater on a wooden trough and boiling the juice in a small, copper kettle. John Wilkinson, an English gardener whom Governor Boki ( ) of Oahu brought to the islands to stimulate agriculture, set out 100 acres of cane and coffee in the summer of 1825. This was planted on the governor's land in Manoa Valley, now part of Honolulu, by the natives with their oo, or primitive wooden diggers, at a cost of 25 cents per day. Though the plantings grew vigorously they were abandoned on Wilkin-

Saccharum officinarum introduced from Tahiti 1854 by G. Washington

R

son's death in 1827. The following year Antonia Silva, a Portuguese, made sugar at Waikapu, Maui, where he had erected a crude mill. In 1835 Ladd & Co., a firm which on its failure involved the Hawaiian Government in considerable difficulties, received a grant of land at Koloa, Kauai, from the king for the planting of cane. This was the first successful sugar enterprise on the islands on a large scale. Two years later the first sugar and molasses was exported. Around 1840 about a score of sugar mills were in operation, two run by water power and the rest by bullocks.

With the Gold Rush in California in '49, agriculture in the islands was greatly stimulated. Not only sugar produced in the lowlands but even wheat and potatoes grown on the slopes of Haleakala were exported to the miners. Due to the decline of the native population and the large number away from the islands on whaling vessels as well as the exodus of many white men to California in search of gold, the shortage of laborers for the local plantations became acute. This inaugurated the importation of men from many foreign countries. The first to come were 195 coolies from China. They arrived in 1852 and proved so industrious that more were desired by the planters with the result that by the time of the annexation of Hawaii in 1898 to the United States, 37,000 Chinese had come to the islands. Fearing that the native population of the Hawaiian Islands would be supplanted by an alien race of Caucasians and Orientals, the king tried to recruit Polynesian laborers. Consequently in 1859 ten South Sea Islanders were brought here and during the following twenty-five years more were imported from various islands to a total of about 2,000 men. As some of the Polynesians did not prove very satisfactory as laborers other peoples were tried. In 1868 the first Japanese laborers came as a little band of 148 men. They, however, were not the first men of that race to reach these islands in historical times, some shipwrecked fishermen finding asylum here as early as 1832. Then with the signing of the reciprocity treaty in 1876 which admitted all unrefined sugars from the islands into the United States free of duty, the industry enjoyed a period of unprecedented prosperity. This still further increased the demand for labor.

In 1878 the Portuguese began to come in large numbers. Many of them hailed 36 4
from Madeira and the Azores where, in many cases, they are more or less mixed in blood with continental and other stocks. In 1881, about 600 immigrants came from Norway and about 125 men, women and children from Germany. Most of these Germans settled on the Island of Kauai. The next group of Japanese that arrived in the islands after those of 1868 were about 2,000 who came in 1885. From that time on to 1907 Japanese immigration was continuous, the largest number of immigrants of that nationality for one year being almost 20,000. In 1903 the first Koreans came expressly as plantation laborers, in 1907 the first Spaniards to the number of 2,246, and two years later the first Russians. Porto Ricans, many of diverse racial stocks, also added their quota to the population. In 1906 the first Filipinos came and from that time on immigration from those islands has been continuous. By 1926 about 25,000 Filipinos were working in Hawaii, emigrants chiefly from the agricultural districts of Ilocano and Visayan. Thus the sugar industry is largely responsible for having prepared a unique field for the study of interracial relations and Eugenics, involving the peaceful amalgamation of four great races of mankind and many subsidiary races. It is amazing that this most important science has long since been not represented in the islands by an institution of trained specialists to concentrate solely on all phases of this one subject.

While the races of man inhabiting the islands were thus changing, the different races of sugar cane here likewise changed. During the latter part of the nineteenth century, if not before, many of the old native canes were gradually being displaced by more productive kinds. Their origin failed to be recorded in many cases. One of these early commercial canes, popularly called by the Hawaiians ko pake, was most likely imported by the Chinese, probably during the time of the sandalwood trade ( ). Another, called Lahaina cane because it was first extensively grown in that vicinity on Maui, was imported from Tahiti on the ship "George Washington" in 1854. This cane soon became very popular because of its high sugar content, hard rind resistant to many insect injuries, and rapid growth. It displaced most of the earlier types grown on the plantations. Then, about 1905, a root disease began to attack the plants,

R

thus threatening the entire industry with failure. Cane comparatively immune to this malady, such as the kinds known as Yellow Caledonia and H-109, were then planted in its stead. The latter is one of 5,000 seedlings ~~of Lahaina parentage~~ developed by the ~~local~~ experiment station of the Hawaiian Sugar Planters' Association. It proved to be far superior to other forms of cane in many respects and, consequently, is widely ~~planted~~ grown. As the experiment station succeeds in breeding still better forms, the older canes, in turn, will be abandoned. By breeding, by the control of insect and fungus diseases, by improved methods of culture and of application of fertilizer, as well as by improved processes of sugar manufacture, the average local production of sugar per acre ~~has steadily increased~~ from less than one ton for the crop of 1850 to 4.75 tons for the crop of 1900 and to 6.50 tons for that of 1925. The amount of sugar obtained per acre of cane in the latter year ranged, however, from 2.50 to as much as 18 tons.

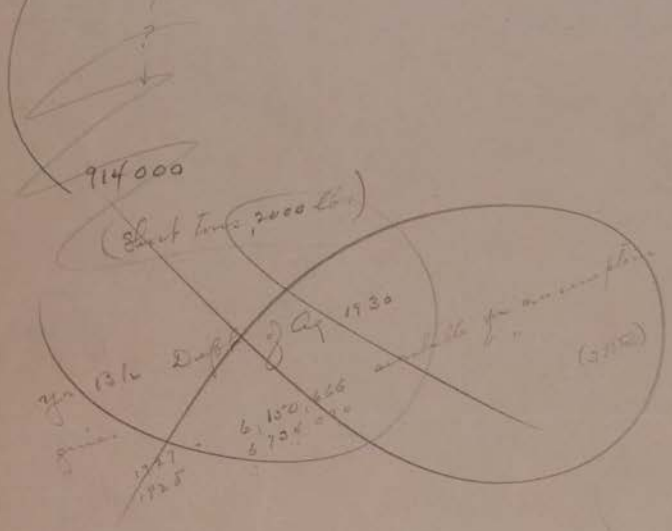
Today sugar cane is planted in the islands from near sea level to an elevation of about 2,000 feet. It is the usual practice to plow the land to a depth of one and a half to two feet. This is done with a tractor or more commonly with two steam engines spaced 1,000 to 1,500 feet apart in the field. These drag a plow ~~attached to~~ by means of a steel cable back and forth between them. For planting, furrows 18 inches deep and spaced five feet apart are opened and into them a continuous line of so-called "seed pieces", better known by the Hawaiian name pulapula, is laid. Each piece, preferably taken from near the top of the harvested stalk of cane, is about one foot long and carries at least two nodes with their attached buds. The pulapula is then lightly covered with soil and, ~~under~~ on irrigated ~~conditions~~ lands, a stream of water is run over the top. In about a week a continuous stand of buds break through the surface of the soil. This cane is fertilized, irrigated and cultivated from time to time. While it is young, the weeds are killed by hoeing or by spraying them with a poison made of arsenic and caustic soda. This latter practice necessitates the posting of warnings along adjoining roadsides such as "poison grass". As the cane increases in size and shades the ground, weeds become less troublesome. Several months before the time of harvesting, irrigation

and fertilizing are reduced or entirely discontinued to concentrate the juice in the plant. Then in fifteen months to two years after the initial planting, the cane may begin to flower and may be ready to harvest. This usually occurs in November and December. The fields are usually burned over to rid them of as many dead leaves as possible and thus lighten the labor of handling the crop. Thereupon the blackened stalks of cane are cut as near the ground as possible and, after the top has been removed, are ready for delivery to the mill. Transferring the rod-like canes to the mill is accomplished in several ways, depending upon local conditions. They may be placed in portable, board flumes and floated to the mill; or they may be piled into railroad cars on temporary tracks laid in the field and hauled to the mill; or, along the Hamakua coast of the Island of Hawaii, they may be tied into 175 pound bundles and sent by gravity over cables to the mill.

At the mill, the cane passes through crushers that express the juice. The refuse, called bagasse, then falls into the furnaces to be used as fuel or is saved for the manufacture of wall-board and mulching paper ( ). The expressed juice, on the other hand, is subjected to various processes to extract from it the "raw sugar" it contains. The latter is then usually shipped to California to be refined for the consumer's use. The simplified diagrams of mill ( ) and of refinery ( ) give a general idea of the manufacture of sugar from cane.

The plantations usually arrange their work in such a way that while one crop is being harvested, another is being planted, and a third is actively growing. After the first harvest, the old cane plants are usually left in the ground to produce a second crop termed the "first ratoon" crop. Thereafter a second, a third, or even a fourth ratoon crop may be grown after which the field is plowed under and replanted to fresh segments of cane. The visitor, consequently, will fail to see idle sugar land, since it is never lying fallow or being planted to other plants in rotation. The scientific application of fertilizer and of irrigation has made this intensive culture possible, the fields being more productive now than ever before. An average of 1650 pounds

of fertilizer was applied to each acre of cane in 1929. Thus for each ton of sugar produced, ~~about ten~~ seven to eight dollars' worth of fertilizer was used. And for the same amount of sugar, about 4,000 tons of irrigation water was applied to the land. In this way about 150,000 acres of cane were growing in 1929, involving the employment of over 50,000 people. The crop harvested that year amounted to ~~over~~ 900,000 tons and ~~was valued in excess of~~ approached $75,000,000 in value. In terms of sugar this amounts to a little over ~~3~~ 7% of the world supply. The United States consumes about ~~ten~~ 7 times that amount.



R

(16) GAUDICHAUD'S GAHNIA

Gaudichaud's Gahnia, Gahnia Gaudichaudii Steud., is one of the strange members of the Cyperaceae or Sedge Family. It is found only on the islands of Hawaii, Maui and Lanai, but about thirty related kinds exist in tropical Polynesia, Australia and Southern China. Our plant is particularly common in the dry, open woods adjoining the Chain-of-Craters Road in the Kilauea Section of the Park, and on the upper slopes of Haleakala.

Though not brightly colored, this plant is ornamental because of its intensely black, shiny, seed-like fruits. These hang suspended and dangling often for more than a year from the upper part of the brown, fruiting stalk. The threads that hold them in this inverted position are the wilted stamens. These are firmly attached by their bases to the base of the fruit, while their free ends are curiously held to the plant by the twisting of its drying scale-like floral envelope.

R

(17)

HAWAIIAN UNCINIA

38

The Hawaiian uncinia, Uncinia Lindleyana Kunth, belongs to the Cyperaceae or Sedge Family. It grows usually in the rain forest and may be found on Kauai, Molokai, Maui, Lanai and Hawaii but not elsewhere. It is ~~quite~~ common in the tree fern forest and in the vicinity of the Thurston Lava Tube in the Kilauea Section of the Park on Hawaii, and along the Olinda Pipeline Trail not far from the boundary of the Haleakala Section on Maui. Though superficially resembling a grass, it is an entirely different kind of plant.

Uncinia is related to the many sedges of the continents called Carex. Unlike these, however, each of its numerous minute dry fruits (fig.)bears a sharply curved hook at the top. This readily catches in the fur or the feathers of animals who scatter the contained seed, thus aiding the plant to become established in regions where it has not grown before.

The ability of the fruit to catch on hair is so annoying that hunting dogs who know the plant from experience try to avoid it. An idea of what the dogs must feel and of the efficacy of this method of plant dissemination may be had by drawing the back of one's hand or arm across the ripening fruiting stalk (fig.) and observing the number of fruits that attach themselves.

(18) COCONUT or NIU 1946 39

The coconut palm, the niu of the Hawaiians, belongs to the Palm Family, technically termed Arecaceae by some students and Palmae by others. The tree itself is known botanically as Cocos nucifera L. It is the only member in existence belonging to the ~~genus~~ group Cocos, notwithstanding the fact that other palms cultivated in the islands as ornamentals are locally still known by the same group name.

The question of the origin of the coconut palm has been the cause of much controversy. Some maintain that it is native to tropical America; others, that it is native to the Orient. The belief in the American origin of the coconut ~~seems~~ was based primarily on two misconceptions. The first consisted in the belief that its closest relatives were growing in the New World and that therefore it likewise came from there. The latest investigations, however, disclose that the coconut is not as closely related to American plants ~~but~~ as it is to Jubaeopsis caffra , a palm growing originally in southern Africa. The second error consisted in ascribing a statement made by Cieza de Leon, apparently a soldier in Pizarro's army in 1534, to the coconut. De Leon, however, had referred to a South American palm allied to Attalea. Actually, in addition to de Leon, not a single early writer on America can be found who considered the coconut native to the New World.

The belief in the coconut's origin in the Orient, founded on several kinds of evidence, is ~~rather~~ more convincing. Its closest relative, as mentioned above, grows wild in Africa. Furthermore, a temple relief (fig.) at Bara Boedoer on Java, dating from the eighth century, depicts a coconut tree in full fruit. Marco Polo, whose travels in the Orient occurred ~~just~~ two centuries before the discovery of America by Columbus, definitely refers to "Indian nuts" growing in northern Sumatra, in the Nicobar Islands about 200 miles north-west of ~~this region~~ Sumatra, and along both the eastern and western coasts of southern India. That these were clearly coconuts we know from his following description: "The Indian nuts also grow here, of the size of a man's head, containing an edible substance that is sweet and pleasant to the

P

taste, and white as milk. The cavity of this pulp is filled with a liquor clear as water, cool, and better flavored and more delicate than wine or any other kind of drink whatever." The word copra, the name of the dried meat of the coconut, is derived from the Sanskrit khorpara given to the same substance. This also shows that the coconut must have been known in India from very early times.

The best proof of the coconut's original home is given by the robber crab, Birgus latro. This crustacean, a highly specialised relative of the hermit crab, becomes about as large as a lobster, has a symmetrical abdomen covered with a series of horny plates, has one huge claw and one very small one, and has forsaken the sea as its permanent abode but goes there periodically to wet its gills and to reproduce. It spends the greater part of the day in deep burrows, carpeted with fibers stripped from the husks of coconuts, hollowed out beneath rocks or the roots of trees. At night it comes forth in search of fallen coconuts or, for want of these, actually climbs the trees to pluck the growing ones. To reach the contents of the nut, which is its principal food, the crab first tears away the fiber of the husk covering the three "eyes". At this end it then hammers away with its ponderous claw until a hole is made in the shell, when it extracts the contents by means of its slender one. In the Marshall Islands, after most of the walking legs of this crab are amputated to prevent escape, the natives fatten it on coconuts until its abdomen attains the size of a child's head. This is then roasted and the huge liver, which consists of a delicious, thick, oily liquid, eaten with a spoon.

The fact that this crab is dependent for its normal existence on the coconut and can subsist entirely upon it virtually precludes the possibility that it evolved to its high degree of specialization where its food plant did not exist. By determining the range of the robber crab one therefore arrives at a fairly reliable idea of the area covered by the coconut in early times. The crab is not found in America nor in the Hawaiian Islands but in such widely scattered regions as the Paumotu and Fanning Islands south of Hawaii, the

Liu Kiu Islands between Formosa and Japan, ~~in~~ many islands of the Indian Ocean, and even Madagascar. The coconut, before the discovery of the New World, was not only found wherever the crab existed but also in northern Australia and in isolated regions in Africa. This extensive range of the coconut palm is due probably ~~in part~~ to the fibrous ~~husk~~ husk that can float the fruit for months in the ocean, and more ~~likely~~ generally to the Polynesians, or ~~to~~ some closely related people who in prehistoric times carried the fruit both as food and drink on their long voyages to many lands. This might explain why the coconut is known practically throughout its range as niu or a variant of this name. Even as far west as Madagascar the vernacular name wua-niu for the coconut shows this influence. Wua, meaning "new", was obviously a Malagasy word prefixed to that of the invaders who may have brought the coconut with them.

According to tradition, at least the large-fruited type of coconut known as niu polapola was brought to ~~these~~ the Hawaiian Islands by the early Polynesian navigators from Bolabola, an island not far from Tahiti. Before Captain Cook's coming, the Hawaiians also knew a few other kinds such as the niuhiwa with dark colored fruit and the niulelo with yellowish fruit. Elsewhere in its range the coconut is known in many other varieties and forms which the natives not only call by distinct names but use for different purposes.

As these islands are almost too cold for the coconut, it grows ~~locally~~ best on the warmer, leeward side of the Island of Hawaii, the most southerly of the entire group. Here its trunk may be seen standing actually within reach of the ocean spray as well as at higher elevations. In Hawaii National Park it is found only near the shore south of Kilauea Crater. It is a graceful palm usually becoming sixty to seventy years old though, occasionally, individual trees live a hundred years or longer. The slender trunk rises as much as a hundred feet from a swollen, inclined base. ~~This~~ The trunk is surmounted by the massive crown of leaves of which the lower ~~have a pendency to droop~~ have the tendency to droop. These leaves are ten to twenty feet long and bear approximately one hundred leaflets on each side. The strength and elasticity of the trunk bearing such heavy leaves and usually a crop of huge fruits, possibly fifty per year, is

remarkable. During the so-called Kona storms that occasionally strike the islands, the slender trunks lean far toward the ground before the heaviest gusts of wind only to spring back to their original position after each gust has passed.

From the time the tree is about ten years old it produces clusters of flowers one after another in continuous succession until its death. These ~~clusters~~ are axillary and dependent for most of their nourishment on the leaf immediately below them. If this leaf be cut away, the cluster ~~therefore~~ dies. To protect the flowers from injury ~~while in the process of~~ during their development, the entire cluster is enclosed by a massive, green structure termed the spathe ( ) This finally bursts apart due to the pressure exerted by the enlarging flowers, and liberates the ~~entire cluster~~ entire cluster. The ~~latter~~ consists of about thirty-five spreading branches, each thickly beset with several hundred closely pressed staminate, or "male", flowers. Toward the base of the lower branches, only a few pistillate, or "female", flowers develop.

Each "male" flower blooms but for a single day, those toward the top of the cluster opening first. As about ten thousand of these flowers are found in a single cluster, it takes almost a month until all have opened to expose their pollen. Some of this is doubtless carried away by insects which have been attracted to the flowers by nectar that exudes from three centrally located glands. Usually several days after all the pollen-bearing flowers of a cluster have bloomed and fallen, the large, globular pistillate, or "female", flowers bloom. This process is obscure, consisting mainly in the secretion of nectar toward their apex and the exposure of tissues receptive to pollen which the wind or some insect may perchance carry to it. Only then can the flower develop into a fruit. ~~By the blooming of~~ Since "female" flowers bloom only after the "males" have decayed, it is utterly impossible for the former to become pollinated with pollen borne in the same cluster. This may be a distinct advantage as cross-pollination in contrast to self-pollination usually insures the development of more vigorous offspring.

About ten months after the bursting of the spathe, the pistillate flowers

R

have developed into fully grown fruits known as coconuts which are completely ripe about five months later. Technically, these are not nuts at all but rather drupes, being characterized by an outer fibrous layer or "husk" that surrounds an inner stony layer or "shell". In the Malayan nawasi variety, curiously enough, this husk is actually edible. The shell of all coconuts is marked with three "eyes" near the stem end. These are germinal pores of softer tissue. Through one, which has a plug that lifts out with comparatively little pressure from within, the single seedling forces its way to freedom. The two remaining pores are useless to the plant. They are vestigial structures suggesting that the ancestral coconut palm bore fruit containing three seeds instead of just one.

Within the shell of the coconut lies the white "meat" or solid endosperm which is not part of the embryonic plant but merely food for its development stored up by the parent. The embryo, itself, is a minute structure imbedded in the endosperm near the "eye". The liquid, commonly termed "milk", which fills the cavity of the young coconut is likewise food. It is the liquid endosperm.

In falling from the tree, the ponderous seed is well protected from cracking by the thick husk. If it falls in a favorable locality, germination begins with the enlargement of the embryo and the growth of its first leaf or cotyledon into the cavity surrounded by the solid endosperm. Instead of being a foliar structure, this cotyledon is a white, spongy sphere, termed haustorium. As this enlarges and presses against the endosperm, the latter disappears. This is because the haustorium first secretes a chemical substance, or enzyme, which dissolves the solid endosperm whereupon it is readily absorbed and used as food. While this is going on, the stem of the seedling grows through the "eye" by pushing aside the plug. It then proceeds to bore through the husk to freedom. Meanwhile, roots have grown from the stem, just beyond the "eye", which ramify throughout the husk for nourishment and moisture. Finally the haustorium decays as the parental nourishment is exhausted, the roots penetrate the soil for mineral salts, and the stem unfolds its leaves in the sunshine where the

can synthesize food to maintain life. Thus about ten months after the fruit began to germinate, the young coconut has become established in the soil.

The coconut was one of the most valuable plants to the Hawaiians. Occasionally the trunk was hollowed out and made into a canoe termed lolonīu. The pahu ( ), a large drum, was made preferably from the hollowed trunk of the coconut palm or breadfruit tree. If made of palm wood, it had an unusually beautiful grain due to the woody strands, or fibro-vascular bundles, that ramify through the tree.

Though the leaf of the hala ( ) was chiefly used in plaiting, ~~it was not made into fans because of~~ made it unsuitable for fans its flexibility. Coconut leaflets being stiffer, were used instead. A broom, or - - - , was made of the stiff midribs, termed niau, of the leaflets. These were usually tied together at their base. The midribs were also used to stir the kernels of kukui nuts in the making of torches ( ). Because of their stiffness, the midribs were likewise used in the game panapananiau. This consisted of bending them in the shape of bows in the hands. Upon releasing them suddenly, they sprang elastically away. The midrib of the coconut or a piece of bamboo was made into a musical instrument, the niaukani, which resembled a jew's-harp, one end being placed between the teeth of the player. The entire leaf, with the branch of the la i ( ) ~~also~~ symbolized high rank. In more recent times, the Hawaiians wove hats of such fine texture from the coconut as to be impervious to rain. The leaflets were first slit in half lengthwise to expose the filiform veins on each side. These were then removed from the green tissue ~~XXXXXXXXXX~~ by drawing a needle-shaped piece of bamboo through the tissue of the leaflets on each side of them. After the fibers had been scraped, washed and dried, they were suitable for weaving into the hats. These were just a single fiber in thickness.

The old flower cluster, after it had dried, served as a garden rake.

Every part of the coconut fruit had its uses. The strands of fiber composing the thick husk, after being separated, were used as a strainer. These strands ~~are~~ were also braided or twisted into cord called kaaha or aha, and ~~also~~ made into rope called lanalana. These were used generally in tying, as for example, the handle, or au, to the stone adz, or koi. Outrigger canoes were also tied together with this material. Such cord ~~They were~~ also made into nets ( ) for carrying calabashes and

other utensels. Lukea, a similar cordage, was highly valued for tying the outrigger to the canoe ( ) because of the belief that it was more durable in sea water than most other fibers. In spite of this quality, however, it was rarely employed in the making of fish nets. The fibers of the olona (Touchardia latifolia Gaud.) were usually preferred, being stronger and more pliable. Thick strands of coconut fiber served as a cable for the stone anchors of canoes. Slings, maa, were even made from these fibers or braided from human hair to be used in warfare to hurl smooth pieces of compact lava with considerable force at the enemy. These missils were oblong, about two inches long, and slightly conical at each end to enable them to be thrown with greater accuracy.

When pigs were offered alive in the haiau or temple, the small ones were carried in the arms of the priest before the idol and the large ones were lead before it. In its presence the priest pinched the ears or tail of the animal until it squealed. At the same time he stated which of the devotees had made the offering. Thereafter he made a hole in the ear of the pig through which he tied a strand of coconut husk. The offering now sacred to the god, was liberated until the priest had occasion to make use of it. No matter into what fields it might later break to feed, the farmer could do no more than gently drive it away.

Burial ceremonies differed markedly according to the rank or profession of the deceased. If a commoner, the upper part of the corpse was raised and the face bent forward to the knees. The hands were then put under the thighs and passed up between the knees. Head, hands and knees were next bound together with rope made of coconut fiber. The corpse was afterwards wrapped in a coarse mat or black sheet of kapa ( ) or bark cloth and disposed of within one or two days. It was either buried in a shallow grave in a sitting posture in the garden or even in the house, or secreted at night in a cave. Calabashes of water and poi ( ), sugar cane ( ) and other food were left at the place of interment. The following morning all who had come in contact with the corpse bathed, sat in a row before the door of the house, and were sprinkled with holy water by the priest. After a few prayers had been offered, the ceremony had ended. Sometimes the corpse was embalmed as described previously ( ).

It was not uncommon for the devoted husband, wife or friend, as the case might be, to secretely exhume the corpse in order to remove the four leg bones and the skull. These were then washed until clean, wrapped up and enclosed within the pillow to be slept on every night. Instead of the bones, perhaps the palm of the hand would be cut off, salted and dried in the sun and then taken to bed. The palms of Captain Cook were thus prepared after his death which was sincerely lamented by the good natured Hawaiians. These relics of the dead were preserved by the devoted until such a time as their love came to an end.

~~had ended, [illegible] was [illegible] as described previously ( ).~~

Coconut shells, puniu, were made into drinking cups of two distinct kinds. Those cut in half lengthwise were termed oló and reserved for the priests; those cut at right angles to their length were called apu niu and used by the others. Parts of small coconuts, ~~on the other hand,~~ often tied to a wooden handle served as spoons for ladling out food. Shells served as receptacles for fish-lines and ~~The shells~~ were even used as musical instruments. The puniu ( ) was a small drum made from the shell which gave it its name. The end containing the "eyes" was removed and the remainder carefully smoothed and polished. The opening was then tightly covered with the skin of some scaleless fish as, for example, the kala (Acanthurus unicornis (Forskal) Shaw). This skin was placed in position while moist and flexible, and fastened to a ring-shaped cushion of kapa, the poaha, that encircled the opposite end. The natives sometimes used the gum, pilali, of the kukui tree ( ) to fix the drum heads more securely in place. In using the puniu, it was fastened to the right thigh of the performer. This he then beat with a thong of fiber held in his right hand. In this way his left would be free to manipulate the large drum, pahu, that might be standing on his left side. The puili was yet another musical instrument. It was made either from a small coconut or a small gourd. ~~Curiously~~ Strangely enough, coconuts were forbidden as food to women. This custom was connected with the kapu system ( ).

The coconut at a certain stage, is completely filled with the "milk". This, being slightly sweet and delicately flavored, forms a wholesome, germ-free drink. As the nut matures, the milk loses some of its sweeetness and becomes somewhat cloudy. At the same time, the solid endosperm, or "meat", develops. This at first has the consistency of custard and can be eaten with a spoon. With further development, the meat becomes cheese-like and finally ~~horny~~ firm in texture, in which state it is ~~universally known~~ shipped throughout the world. The Hawaiians not only used the milk and meat of the coconut raw as food but also as an ingredient in many cooked dishes of which some are worthy of trial in Caucasian and Oriental homes.

Kulolo was a pudding ~~consisting~~ of coconut and taro. This was made by scraping the meat of a ripe coconut against a rough stone. The juice squeezed from it into a calabash was then mixed with raw, scraped taro. This mixture was ~~then~~ next cooked in the imu ( ), or native oven. A similar pudding, the paipaiee, was made by substituting breadfruit ( ) for the taro. In the case of poipalau, on the other hand, sweet potatoes were used in place of the taro.

The meat of the coconut as well as that of the <u>kukui</u> nut (   ), both rich in oil, were sometimes chewed and spat over the sea to quiet its ripples. To oil the hair pieces of coconut meat were drawn through it or chewed meat rubbed into it. ~~In the latter case, as soon as the Hawaiian went swimming, the hair was clean and also oiled.~~ Then the Hawaiian would go swimming to free his hair of the small particles of coconut meat.

Today the coconut industry of the Hawaiian Islands is unimportant ~~[illegible]~~ ~~local~~. But to the south and west where the temperature is higher and the labor cheaper, it is of great magnitude. ~~The fiber, termed coir,~~ Coir, the fiber, of the husk, is ~~utilized for the making of~~ made into door mats, brushes and similar articles, and copra, the dried meat, ~~termed copra,~~ is used as food or as a source of oil for soaps and margarines. Unfortunately, to gain the best quality of coir the nuts must be harvested when young , at a time when their meat would dry into the poorest quality of copra. If, on the other hand, a good quality of copra is desired, the nuts must not be harvested until fully ripe. At that time the husk is so old that the coir derived from it is too hard and brittle to be of much value.

In the case of copra, ~~an industry which began in Europe with the first shipment from the South Seas in 1868,~~ the fully ripe coconuts are preferably gathered once every two months from the trees in the plantations. This is laborious work that cannot well be avoided. In Sumatra, to be sure, monkeys have been taught to climb the trees, twist the nuts from the stem, and throw them to the ground. But this ingenious method is far from commercially practicable. The shelled nuts are cracked open and preferably washed to remove the film of sweet milk which forms a good bed for the growth of injurious bacteria and molds. The pieces are then laid with the inner side to the sun. After the first day, the drying meat has partly curled from the shell and is readily removed for further drying. After about five days, weather permitting, the copra is usually placed in artificial driers for a time. Thereafter it ~~a little longer. It now~~ contains little water and 64 to 69% oil, and is ready for shipment to the factory, ~~often located~~ probably thousands of miles away. There it is grated and freed of the desired oil.

OUT — See Proof Galley 15

~~In the making of candy~~

over

OVER

In preparing coconut suitable for the making of candy and cakes, the fresh meat is carefully cleaned and then shredded or grated. Next it is almost instantaneously dried in a vacuum under heat. In this way it retains its flavor. About three nuts thus prepared produce one pound of dried, shredded coconut.

In some countries, the juice from the injured flower clusters is collected. While fresh it contains about 15% sugar. Then it is known as toddy. Upon fermentation, it becomes palm wine, while if this wine is distilled, the product becomes arrak.

~~#~~ (19) TARO or KALO 1064c 48

The taro is native to the East Indies but has been carried by the Polynesians in their migrations throughout the Pacific. Thus this plant reached these islands with the early progenitors of the Hawaiian race to whom it has long been the most important food plant. By the Hawaiians it is called kalo while technically, according to the most recent research in nomenclature, it must be known as Caladium colocasia (L.) W. F. Wright. The plant belongs to the Araceae or Arum Family and hence is a relative of the calla lily and the elephants ear, both grown as ~~or~~ ornamentals on the mainland Continent, and of the Jack-in-the-pulpit which grows wild in the woods of the eastern part of the United States.

The taro is a typical marsh plant bearing a short, underground stem, or rootstock, which is used as a storage organ for the starch produced by the leaves. Due to the accumulation of this starch it swells ~~enormously~~ to a great size. The original root decays early in the life of the plant and is replaced by so-called adventitious roots that arise near old leaf scars on the swollen stem. The leaves, borne in an upright cluster, are more or less ~~arrow-~~shaped like an arrow head. Their stalks are grooved on the inner side and here the young leaves, longitudinally rolled together, lie for protection until it is time for them to expand. When the plant has attained maturity it produces a flower stalk called peduncle which is somewhat shorter than the leaf stalks. Near the apex of the peduncle is a greatly modified leaf, ~~called~~ the spathe, which protects the actual flower cluster within. This consists of an erect stem, the spadix, which bears three ~~different~~ kinds of flowers. Toward the base lie the pistillate, or "female", flowers while on the upper part of the spadix lie the staminate, or "male", flowers. Separating the two kinds of functioning flowers, is an area of staminate flowers which have degenerated and therefore never produce pollen.

The taro is conspicuously free from injury by insects and herbivorous animals. This immunity is largely due to the presence of innumerable, minute cells scattered throughout the tissues, each one filled with scores of needle-shaped crystals, termed raphides, of calcium oxalate. As soon as the cells are wetted by the

saliva or body juices of an insect or grazing animal attempting to eat the plant, they forcibly expel their crystals. How effective these cells are in preventing the plant from being eaten may be tested by touching the tongue ever so gently to the cut end of the stem. In chewing part of the plant while raw, the lining of mouth and throat would be very painfully irritated. These minute crystals are dissolved in cooking and the plant thus rendered perfectly harmless. The only taro now in the islands which has so few stinging cells that its ~~XXXXXX~~ rootstock can be eaten raw without pain is not a native plant, but one introduced from Japan in recent years.

Since the base of the taro is usually completely buried under water in foul mud, it is deprived of oxygen. As access to this element is necessary for the life of all cells, the oxygen must be conducted to the subterranean part of the plant in some way. This is accomplished by means of large canals which pass from the leaf-blade down the stalk to the swollen rootstock through which the air, rich in oxygen, can rapdily pass. The leaf-stalks owe, obviously their spongy character to these abundant air canals.

The taro, like the banana, has been cultivated by the Polynesians for such an incredibly long time that an untold number of horticultural varieties have originated. In the Hawaiian Islands alone, more than thirty kinds, possessing various noticeable characteristics, were known to the natives by name. They were propagated from crowns cut from the old plants or from those cut from one year old rootstocks arising from the old plants. Most of these kinds of taro require marshy soil for growth. Where this was not available, artificial marshes, or loi, were made with the aid of irrigation and the taro planted on mounds built up within a few inches of the water surface. A few kinds would grow in the dry earth of the uplands without special protection, though to gain a better harvest, it was customary to cover the ground and the stem of the plants with the fronds of ferns like the sadleria ( ).

As the entire taro plant furnishes food for man, it has been estimated that from one square mile planted to this crop and diligently cultivated, over 15,000 people could subsist for an entire year. The starchy rootstocks, popularly called "taro root", are thoroughly baked in the imu ( ). Then they are ~~XXXXX~~ peeled, washed, and pounded ( ) with a little water into a hard,

dough-like paste on a wooden trough called papakuiai (fig.) with a stone pestle known as pohaku kuiai (fig.). In this state, called aipaa, the taro will keep for several months if properly wrapped in la i ( ) leaves. If it was to be sold, aipaa was ~~usually~~ commonly put up in twenty or forty pound bundles. This material was usually carried on journeys and then sometimes eaten in that state. ~~Usually~~ More often, however, aipaa was allowed to ferment for a few days before being it is diluted with more water. The resulting gray, gruel-like paste, called poi, was then eaten cold and unseasoned. The Hawaiians sometimes sipped it from the rim of the calabash in which it was contained. Most commonly, however, they dipped their index and middle finger into the poi, moved them around in small circles and then with appropriate manipulations stuck them into their mouths. The adhering poi was then sucked off with the lips. Now poi is often ~~usually~~ made by machinery in a more hygienic way and commonly eaten with a spoon. Today a plate of poi can be had ~~ordered~~ at most restaurants.

The rootstocks of the taro were also baked whole upon hot stones and in recent times ~~or~~ sliced and fried like potatoes. To guard against a possible famine taro was occasionally baked and dried for keeping over long periods of time. In this state it was called ao. Kulolo was a pudding made of grated raw taro and the juice expressed from grated coconut ~~milk~~ meat. This was cooked in a calabash in the imu.

The Hawaiians in the early days were epicures in the eating of dog meat, the neck of the animal being especially esteemed. To eat such a dish is not revolting when one realizes that certain small dogs were especially raised for this purpose. ~~They were not similar to the mongey curs that sometimes roam the streets today in search of offal.~~ These were sometimes kept in special kennels and were fed only on vegetables, particularly the taro, to make their flesh more tender and delicately flavored. For this reason they were commonly called poi dogs.

The young leaf blades of taro are gathered while yet tightly rolled together and enclosed in the groove of the old leaf stalk. Before cooking ~~them~~, the lower epidermis of their midrib is stripped off and discarded. This dish, known as luau, which name is also applied to a native feast, is eaten like spinach.

The entire flower cluster of the taro and its stalk was called puakalo by the Hawaiians. After the epidermis had been stripped from this stalk and from the lower surface of the midrib of the spathe, the puakalo was cooked and eaten. The petioles or leaf-stalks, called aihaha, of the taro were likewise freed of their epidermis, cooked and eaten ~~like spinach~~.

Laulau is a special combination of taro and pork. The blades of fresh la i leaves are first flattened out to form a plate or container. Upon this are laid several unrolled luau. Pieces of pork are put on next. Then usually on top of all comes the puakalo or the aihaha, or a combination of the two. Thereupon the plate of la i leaves is drawn up around the food and securely tied at the top with the rope-like old leaves of the same plant. This bag of leaves (shown on plate - - -) is then trimmed of superfluous material at the top before it is placed in the imu, usually next to the pig. Such packages of laulau are usually only large enough to serve a single person. Cooked in this way, it has a delicious flavor. Haha was the term given to the entire taro tops with their tough, old leaves. This material was often steamed and fed to pigs.

Besides being a food, taro had other uses. The cut rootstock in the raw state was touched to bleeding wounds as a styptic. The cut petiole was sucked on wounds made by the sting of insects. Aipaa was used as a poultice on infected sores. Diluted poi was used as a paste to glue strips of kapa ( ) together or to glue patches of kapa to torn sheets of the same material. Raw taro grated and then cooked was used, as described elsewhere ( ), as bait in catching the opelu. William Ellis, who keenly observed the Hawaiians over a century ago, describes how taro was used in ornamenting their gourd calabashes, some of which had a capacity of four or five gallons. "When the calabash has grown to its full size, they empty it in the usual manner, by placing it in the sun till the inside is decayed, and may be shaken out. The shell, which remains entire, except the small perforation made at the stalk, for the purpose of discharging its contents, and serving as a mouth to the vessel, is, when the calabash is large, sometimes half an inch thick. In oder to stain it, they mix several bruised herbs, principally the

As a febrifuge raw taro juice was given to the patient to drink. Because of its irritating qualities it was mixed with sugar cane juice, and with the milk of the coconut and the juice expressed from its meat

stalks and leaves of the arum [taro], and a quantity of dark ferruginous earth, with water, and fill the vessel with it. They then draw with a piece of hard wood or stone on the outside of the calabash, whatever figures they wish to ornament it with. These are various, being either rhomboids, stars, circles, or wave and straight lines, in separate sections, or crossing each other at right angles, generally marked with a great degree of accuracy and taste. After the colouring matter has remained three or four days in the calabashes, they are put into a native oven and baked. When they are taken out, all the parts previously marked appear beautifully dark brown or black, while those places, where the outer skin has not been broken, retain their natural bright yellow colour. The dye is now emptied out, and the calabash dried in the sun; the whole of the outside appears perfectly smooth and shining, while the colours imparted by the above process remain indelible."

~~The primary use of the~~ Taro was ~~as~~ the staple food of the Polynesian just as bread is the staple of the Caucasian, and rice of the Oriental. An idea of the importance of taro in the diet of the Hawaiian until relatively recent times is shown by the objection many gave a century ago ~~against~~ visiting England - that taro could not be obtained there!

(20) PINEAPPLE 1048 53 5

The pineapple is best known scientifically as Ananas ananas (L.) Cockerell. It is such a well-known and important member of the Bromeliaceae that it has imparted to this entire group the common name of Pineapple Family. The wild Hawaiian plant itself, unlike most of its relatives, is a large, terrestrial, rather variable herb having a short, massive stem. This bears stiff, linear leaves, sometimes a yard long, in dense spiral arrangement. These are grooved in the center, and armed along their margins with hooked prickles, in that respect resembling the leaves of the hala ( ). In the axil of the clasping base of these leaves are dormant buds and so-called adventitious roots. The latter, shown near the bottom of the illustration (Plate -- fig.) after the removal of the lower leaves, are of great value to the plant. Dust and dirt may be blown by the wind upon the leaves to be utterly useless to the plant. But when it rains, such material washes down the central groove to be retained by the clasping base. Here the adventitious roots are enabled to absorb the water and the soluble constituents of the wind-blown particles, thereby adding raw food to the plant's usual supply ~~additional to that~~ coming from the ground.

At flowering time the shortened stem elongates to become several feet high. The upper part enlarges and develops into a variable number of purplish flowers, each borne in the axil of a single degenerate leaf, termed a bract. The remarkable fact about this flower cluster is the firm union of its main stem with the lower part of its axillating bracts and the lower part of its flowers. This is plainly shown in the longitudinal section of the maturing cluster figured ( ), the wilted part of the flowers showing above the free part of each bract. Surmounting all, is the continuation of the stem bearing a crown of small leaves.

With maturity, not only the individual ovaries of the pineapple plant ripen into fruit, bearing hard seeds, but the bracts and the main stem likewise become fragrant and filled with a sweet, acid juice. The latter is the "core" of the pineapple, familiar to everyone. The entire complex structure, known commonly as the pineapple proper, is botanically termed a collective fruit.

In the wild state, no doubt, this was an attractive food for various animals. In eating it they must break off the terminal crown of stem and leaves. This crown, practically no matter where it falls, will strike root. Thus, if conditions are favorable, both sexual and asexual reproductive parts of the plant may be disseminated by the same agent at the same time. In this plant is probably deprived in the Hawaiian Islands of the visit of a suitable insect to effect pollination. It seldom matures seed (fig.). Nevertheless, abortive ones (fig.) may always be seen by slicing the fruit.

The pineapple is a native of Brazil whence it has been widely disseminated. It is grown extensively in the open throughout the tropics and subtropics. It was first brought to Europe about 1650 and grown under glass in France and England as early as the latter part of the eighteenth century. As with the sugar cane ( ), the coffee ( ) and the pigeon pea ( ), it is not known when nor from where the plant was first introduced into these islands. That it was introduced by the Hawaiians is inconceivable as that would presuppose considerable Polynesian intercourse with America. The plant was brought here either directly from the tropics of the New World by the white race or from Tahiti or some other region to which it had been previously imported from America by the same people. It is even possible that the pineapple, carried as an antiscorbutic, was brought here on a shipwrecked Spanish vessel before Captain Cook's discovery of the islands. It is known from Spanish records that three vessels sailed from Mexico in 1527 for the Moluccas under the command of Don Pedro Alvarado de Saavadra and that two of these never reached their destination. Moreover, in the reign of Keliiokaloa who was born about 1500 a strange vessel, so Hawaiian tradition relates, was wrecked at Keei in the District of Kona. This might readily have been one of Saavadra's small squadron.

Hala kahiki, the Hawaiian name of the pineapple, though it proves its exotic character is rather an ambiguous phrase. It means either the "Tahiti hala" or much more likely the "foreign hala". Kahiki (k and t in the Hawaiian language being often interchangeable), to be sure, originally meant Tahiti,

the island last visited by the Hawaiians around the twelfth century. But as time went on, knowledge of that country became more and more vague so that by the eighteenth century kahiki meant any foreign country whatever. Whether this foreign country happened to be Tahiti or not may never be solved. According to written records the first white man to plant the pineapple in the islands was Don Marin ( ). This was done in 1813, though the Hawaiians had been growing the plant in a semi-wild state long before. From William Ellis, who toured the Island of Hawaii in 1824, we know that "oranges, limes, citrons, grapes, pinapples, papaw-apples, cucumbers, and water melons, have been introduced, and, except-ing the pine-apples, thrive well." A year later Andrew Bloxam, Naturalist on the Frigate "Blonde" reported that in Honolulu ------"pineapples and some other fruits are to be had, but not in abundance." Elsewhere he mentions the pineapple as one of the introduced plants. These plants, of which a typical one is pictured on Plate , produce rather small but very fragrant, sweet fruits. They may be found near sea level usually as escapes from early cultivation by the Hawaiians. They grow in numbers in rocky places on the Island of Hawaii in Puna, not far from the Park boundary, as well as in Kona where they to this day receive considerable care from the Hawaiians; they are known from a wet but well-drained forest in Wailau Valley, Island of Molokai; on the Island of Kauai; and probably elsewhere. From these Kona plants Capt. John Kidwell, an English horticulturist, established in 1885 the first real pineapple plantation. This consisted of about five acres located in Manoa Valley, Island of Oahu. The type of pineapple, however, is not the one so extensively planted today for export.

The pineapple for which these islands are well known, is a highly improved product by the gardener. One of its ancestors came from the vicinity of Cayenne, French Guiana, and from there was introduced into France in the early days to be grown as a hot-house luxury and curiosity. Some of these French plants were brought to Kew Gardens, England, where they were probably crossed with other South American strains. The greatly improved offspring were later shipped to Queensland, Australia, and to Jamaica for planting on a large scale. In 1886 plants were brought to these islands from Jamaica by

R

Kidwell, and the same kind a few years later from Queensland by E. V. Jordan. These plants, known as the Smooth Cayenne because of the absence of spines on the leaves and the country of origin, were first grown to a rather limited extent. They were sold locally and in San Francisco as fresh fruit only. Due to losses from decay in shipping them Kidwell and John Emmeluth, a plumber, conceived the idea of canning them. The cans for this purpose were first laboriously made by hand in the islands. Later ~~they~~ cans were imported from the coast though the expense was considerable because of their bulk. Now, however, their cost has been greatly reducing by importing the flat sheets of metal and rolling these into the shape of cans in the islands. Since 1905, the Smooth Cayenne has risen to be second only to sugar cane in importance as a crop for the Hawaiian Islands. This pineapple has been so improved by man that it is difficult to believe that its ancestor was very similar to the naturalized plant of these islands.

Though thriving in well-drained soil from sea level to an elevation of 1,500 feet, the pineapple in the Hawaiian Islands is grown chiefly above the cane belt, or within it on land naturally too dry for cane and impracticable to irrigate. The plants are propagated asexually in single, double, triple or even quadruple rows by means of cuttings of several kinds (fig.). Suckers, the young shoots arising from buds in the axils of the lower leaves, are gathered shortly after the fruit from the old plant has been harvested. When planted they may develop ripe pineapples within 15 to 20 months, the quickest possible time. ~~The crown, the tufts of leaves and stems of which are surmounts each aggregate fruit, are gathered at the time of canning.~~ The crown of the pineapple plant, consisting of the stem and cluster of leaves that surmount the collective fruit, are saved at the time of canning. After planting they develop their crop rather uniformly, nearly all the plants fruiting at about the same time. Slips, arising from degenerate flower stalks axillary to the main one, are not very different from suckers but mature fruit a little later. Stumps, as the name implies, are the basal parts of the old plants. These were formerly much used to produce an additional supply of plants for setting out in the field. When the suckers, crowns and slips are ready for planting, the rows are covered with a special strip of strong paper having

holes cut into it at regular intervals. A plant is then inserted in each hole, the paper not only acting as a mulch to retain the moisture in the soil but also to prevent the growth of weeds in the rows and to raise the soil temperature. This paper is allowed to remain in the field, where it finally decays.

After the first crop has been harvested, the old plants are deprived of all but two suckers which are left to produce the following harvest. This is spoken of as a ratoon crop. A good field may even yield a second and third profitable ratoon crop. Finally, about five years from the time of the original planting, the tangled mass of plants is plowed under and the field possibly planted to some rotation crop, such as pigeon peas ( ).

In spite of abundant iron in Hawaiian soils, as their rich red color indicates, pineapple roots cannot absorb a sufficient amount of this element for the healthy growth of the plant. Consequently, the plants often sicken as shown by their yellowing leaves. To avoid this condition, it is a common practice to spray such ailing plants with a solution of iron-sulphate. Wherever drops of this liquid fall upon a leaf, the area covered often turns to a healthy green. Then when the rain washes the chemical into the leaf axils, the adventitious roots are enabled to absorb the fertilizer and to transmit it throughout the plant. The iron-sulphate is often made locally by dumping discarded automobiles and scrap iron into vats containing concentrated sulphuric acid. Thus it is not far wrong to state that the iron of cars may be coursing in our veins.

Pineapples were formerly shipped fresh to the mainland, but today nearly all are canned. The diagram ( ) shows the essential procedure. In 1929 the area planted to pineapple in the Hawaiian Islands comprised 50,000 acres of non-irrigable land. During that year nine million cases, each containing two dozen cans, were packed. These were valued at approximately $38,000,000.

(21) DIANELLA or UKIUKI#) 1. 4c

About fifteen kinds of dianella are found in Asia, Australia and Polynesia. All are perennial herbs with short, branching rootstocks, narrow leaves, and usually bluish flowers borne in open clusters. From the character of the individual flower which invariably has its various parts arranged in multiples of three, we can tell that it, ~~just like the astelia ( )~~, belongs to the Liliaceae or Lily Family.

Two kinds of dianella, called ukiuki by the Hawaiians, are native to these islands. Only one has been recorded from here before and that has commonly masqueraded under the names of related but foreign kinds. In studying the excellent collections of Hawaiian herbarium specimens at the New York Botanical Garden in 1925, the writer became convinced that the dianella growing in the Hawaiian Islands are not the same as those found elsewhere. The one having a flower cluster usually longer than its leaves and dark, ink-blue berries that are commonly juicy and somewhat oblong is not found within the boundaries of the National Park but on Oahu, West Maui and probably Kauai. This plant is the true Dianella sandwicensis correctly described by Hooker and Arnott about one hundred years ago. The other kind (Plate) has its flower cluster always shorter than its leaves and sky-blue berries. These are depressed-globose in shape. This plant is found growing typically in clumps of bushes on the ash ejected in explosive eruptions in the vicinity of Kilauea, particularly in the Kau Desert, and to a lesser extent in Kaupo Gap within Haleakala Crater. It is interesting that both kinds with their hybrid offspring grow together on a high mountain near Lahaina, West Maui. The lava-inhabiting dianella will be found in the Illustrated Flora Hawaiiensis properly described, and named after the type of locality in which it habitually grows.

The juice expressed from the berries of the ukiuki was formerly used by the Hawaiians as a pale blue dye of considerable permanency for their kapa ( ) cloth. Whether only one kind of ukiuki furnished this dye or both has not been definitely ascertained. The berries of the plant growing near

(OVER)

Kilauea crushed on linen leave a permanent brownish-yellow stain.

---for---

#The collective Hawaiian name ~~XX~~ many plants having sedge-like leaves was ukiuki or uki. The uki usually employed as an inner lining for the walls of the ancient Hawaiian grass house was the tall sedge Vincentia angustifolia Gaud., which is quite common in the open forest near Kilauea.

The la i of the Hawaiians is botanically known as Taetsia fruticosa (L.) Merrill, formerly called by the incorrect name of Cordyline terminalis (L.) Kunth. Now it is commonly called ti or ki, a corruption of the Hawaiian word applied to its root. The plant is a member of the Liliaceae or Lily Family as the structure of its flower shows. It is found widely scattered throughout the warmer parts of the Orient and the islands of the Pacific, but its original home is not definitely known. It grows throughout the Hawaiian Islands in great abundance, especially in the wetter, open forests at lower elevations. It is not unlikely that it was introduced here in prehistoric times by the Polynesian progenitors of the Hawaiian Race. Because of its ease of cultivation and its variability, it has been one of the favorite plants of the horticulturist, who has produced many ornamental forms bearing leaves of distinctive shape and color. Some have purple, pink, yellowish or white-spotted leaves, while others exhibit various beautiful metallic hues. Such plants are commonly planted in gardens throughout warm and tropical countries or within doors in colder regions. They are usually called dracena by the layman in spite of the fact that the plants do not belong to the botanical group Dracaena. To be sure, of the latter at least two kinds are native to the islands, the one growing on West Oahu being first described in the Flora Hawaiiensis. These plants were ~~named~~ called halapepe by the Hawaiians, meaning "baby hala", a name appropriate because of their resemblance to the screwpine (   ).

The la i is a simple or sparingly branched plant 3 to 10 or more feet high arising from a swollen root. Its yellowish stem bears a terminal cluster of spirally arranged leaves. As each of these falls to be replaced by younger ones, its former place of attachment to the stem remains as a circular scar. Each leaf consists of a grooved petiole or stalk, and a shiny, oblong blade. When the plant flowers in spring, it produces a drooping, branched flower-cluster at least one foot long. This bears numerous, closely-set, white buds tinged with pale purple. Each is about half an inch in length. As the flower blooms, its six perianth lobes curl back to expose six spreading, yellow stamens and a single, white, erect pistil. Only very rarely does a flower mature into a spherical berry a quarter of an inch in diameter. This is yellow at first but changes to bright red when fully ripe.

The la i was of great value to the Hawaiians up to a few generations ago. 60
Its leaves, which go by the same Hawaiian name as the entire plant, were sometimes used in thatching their houses ( ), or shredded up to form a cool, serviceable pa'i, or skirt, reaching from the waist half way to the knees. The main disadvantage in wearing this garment, however, was that it lacked permanence. Upon wilting and shrinking, it had to be replaced. The leaves were also used extensively for wrapping ainaa or hard poi ( ), fish, fruits, limu or edible seaweed and, in fact, almost anything that required a paper-like support. The leaves of the plant were extensively used in cooking in the imu ( ), the food often being wrapped in them so that it should retain most of its flavor and remain clean. They were used in place of plates and sometimes folded into convenient drinking cups. By rolling up a strip of the fresh leaf about one inch wide and six inches long, a rude musical instrument called pu or pulai resulted. This, when held compressed between the lip and blown into, produced a flute-like tone. In former times this was occasionally used to accompany ~~informal~~ impromptu hula dances ( ).

The la i was considered sacred to Lono, the god for whom Captain Cook was mistaken by the Hawaiians. Enclosures ~~sacred~~ dedicated to that god were therefore thatched with this plant. As a flag of truce in war times a branch of the la i or a young banana plant were sent to the enemy. The la i, as well as the coconut, was a symbol of high rank or divine power. It was therefore often worn by the kahuna, or priest, around his neck. It was considered a charm against evil spirits. Because of the superstition that those partaking of cooked opelu would otherwise suffer from a rash, some la i leaves were customarily tied around the ~~tale~~ tail of that fish.

The surplus amount of food which the la i plant manufactures in its leaves is stored in its thickened root, correctly called ki, not in the form of starch but as sugar. This amount being considerable, the root was often baked and then eaten. It has a taste not unlike that of molasses candy.

Before the coming of the white man, the Hawaiians brewed ~~comparatively harmless~~ beverages of low alcoholic content from the ki, ~~root~~, sweet potato, or sugar cane. Before 1800, however, they were taught by some ~~visitors~~ convicts from Botany Bay, Australia, to distill a strong intoxicant from the ki. The root was first baked in the ground and then macerated in a canoe. After standing for five or six days, in spite of the abundance of insects, it was distilled in the iron caldrons of the whalers in which whale oil had been tried from the blubber. A gun barrel was attached to this to conduct the

vapor and to reduce it to a smoky whiskey. As the bottom of a calabash was known as ʻōlole to the Hawaiians and iron as hao, the crude still and its products were named ʻōlelehao. The use of this strong liquor and the introduction of diseases foreign to these islands before their discovery by the white man have been potent factors in reducing the native population. When Kamehameha forsook drinking ʻawa ( ) for alcoholic liquors, many of the Hawaiians followed suit. Kamehameha, noticing the ill effects of this habit, later wisely abstained.

Women before marriage wore the hair long. After marriage and the birth of their first child, it was customary for them to have their hair cut short over the back of the head. Over the forehead it was cut so as to enable them to dress it into a tuft by smearing it with the juice of the root of the la i mixed with pilali, the gum gained from the kukui ( ). This same juice was also mixed with lime and then ~~XXXXX~~ by some fashionable natives rubbed into the hair. This dressing, called hawena, gave it a shiny luster and bleached it gray or even white.

La i leaves were used by the Hawaiians when suffering from headache. The midrib and stalk were removed and the remaining part of the leaf placed in cold water. These were then dried and tied around the head to cool it. As soon as this bandage became heated, freshly cooled leaves were substituted. Such leaves were also spread under the backs of bedridden invalids to relieve soreness.

Where smooth, grass-covered slopes abounded, the Hawaiian children often amused themselves by sliding down hill sitting on a few leafy la i, holding the stems between their legs.

(23)

ASTELIA or PAINIU

The astelia, or painiu of the Hawaiians, belongs to the Liliaceae or Lily Family. ~~It occurs in~~ There are several different kinds and varieties. These are so perplexingly variable that botanists neither agree as to the number existing in these islands nor as to the scientific name by which the more common ones should pass. The plant growing in the vicinity of Kilauea may be called provisionally Astelia veratroides Gaud., while a different one growing on Haleakala and here illustrated should go by another name.

Astelia grow at higher elevations where rainfall is abundant, either on the ground or more commonly on the moss-covered trunks of trees. Plants of this type that merely perch on others but do not rob them of food are termed epiphytes, while plants like the mistletoe ( ) that actually live upon the juices of their host are called parasites.

The requirements for epiphytic existence are more severe than for existence on the ground. A plant growing upon a tree trunk lacks the constant supply of moisture that a terrestrial plant receives from the soil. It must therefore either become dormant during dry seasons or store up as much moisture as possible in its tissues during rainy days to be used for its life processes during periods of drought. The astelia is particularly well fitted to survive these dry periods. Its leaves are covered with a white, silky layer of wax. This greatly restricts the amount of water given off by evaporation during sunny days and thus conserves the hard-won water supply within the plant. As an additional precaution, the leaves are so closely pressed together at the base that they catch and retain rain water as in a cup. In the rain forest on Molokai and presumably also within the boundaries of the native Park, the water supply in the leaf axils is so constant that the [redacted] damsel fly, a relative of the dragon fly, lays its eggs in them as a convenient home for its aquatic larvae.

The small greenish flowers of the painiu are not in themselves beautiful, but the entire plant with its silvery leaves and white, hairy flower stalk produces a very ornamental effect. It is exceedingly attractive in late

OVER R

summer when bearing clusters of bright orange berries. These are easily seen and then eaten by birds which deposit theyswallowed seeds on branches of trees in their droppings. Without their aid, this plant would always be terrestrial.

The Hawaiians occasionallyd stripped the silvery epidermis, or skin, from the leaves of the painiu. This material, alternating with some fern, was then interwoven with various kinds of flowers into a garland or wreath called lei painiu. The silky epidermis, sparkling in the sun like glass, would give a beautiful effect to the whole.

(24) 1866 HAWAIIAN SISYRINCHIUM or MAUULAILI

The Hawaiian Sisyrinchium, the mauulaili of the natives, is botanically known as Sisyrinchium acre Mann. It is peculiar to the Island of Hawaii and to East Maui. It may be found in boggy ground near the Hilo entrance to the Kilauea Section of the Park and along the trail leading up the slope of Haleakala Crater to the Rest House on the rim.

About one hundred fifty kinds of Sisyrinchium are known, almost all native to America. Because of their short rootstocks and their linear leaves, they are often mistaken for one of the grasses among which they commonly grow. So when they produce their ephemeral flowers which are usually blue in color, the layman calls these plants Blue-Eyed Grasses. A study of their flower, however, will at once prove that these plants are not grasses but belong to the Iridaceae or Iris Family. As the Hawaiian plant bears yellow flowers, it cannot very well be given the vernacular name used on the continent. It had better be known as the Hawaiian Sisyrinchium or by the native name which, when separated into syllables to aid in its pronunciation, reads mau-ula-ili.

The earliest Polynesians that populated the Hawaiian Islands, ~~according to Fornander's researches,~~ possessed a comparatively primitive native civilization. But around the Twelfth Century a considerable wave of migrations from Tahiti to the Hawaiian Islands occurred, the voyagers navigating the ocean ~~probably~~ in double canoes of enormous size carrying upward of a hundred men and women with provisions, water, and objects deemed worthy of introduction into a new country. The intermarriage of these newcomers with the older stock already living in the islands was the beginning of a Hawaiian Renaissance - heiaus or elaborate temples were built, ~~accompanied by revised~~ religious ideas, the hula was taught, the kapu or "taboo" system with ~~many of~~ its objectionable features was instituted, a more rigid caste system was evolved in which the invaders ultimately became the nobles and priests, and tattooing was practiced. The Hawaiian Sisyrinchium was one of the plants employed in this way.

Tattoo marks were usually made with an instrument called moli. This consisted usually of a flattened piece of kauila ( ) wood about a quarter of an inch wide in which either sharks' teeth, sharp shells or fish bones had been partially imbedded in a definite design. The moli, first dipped in a dye, was placed upon the body surface that was to be ornamented, or on the tongue in case of mourning, and then quickly struck with a small rod, the sharp points piercing the flesh and at the same time carrying the coloring matter under the skin. The wounds, upon healing, then showed a permanent stain. One of these dyes was made from the juice of the mauulaili mixed with that of the purple fruit of the Hawaiian pokeberry (Phytolacca brachystachys Moq.). This method of gaining a tattoo was very painful but its advantage was that the marks were permanent.

The mauulaili was also used in painless tattooing, especially by women. The marks in this case lasted only for about a year. The leaves were split lengthwise and the torn surface laid upon the skin in the desired pattern. A tight bandage was then applied and within an hour a reddish brown mark appeared which could neither be washed nor rubbed off. The hula dancers, for example, would tie the leaves against their wrists and ankels so as to form certain patterns. If these were later considered sufficiently ornamental, a permanent tattoo with the moli would be cut into the skin.

In the early days, travelers would often prove to their friends at home that they had visited the Crater of Kilauea by tattooing each side of their mouth with the mauulaili. As this plant was known to grow in the vicinity of the crater, such a mark would attest the truth of their story.

Although with the coming of the white man members of the Hawaiian Race gave up this custom of marking their skin, some "tattoo artists" supplied with electrically propelled needles and synthetic inks still drive a brisk trade here in depicting mermaids and compasses on the fair arms and chests of numerous haoles, or strangers

R

(25)

TRITONIA

In driving from Hilo to Kilauea, the visitor may see long, slender wands of brilliant orange flowers giving color to the roadside. This is the Tritonia, often incorrectly called Montbretia, introduced into these islands as an ornamental probably before 1900. It has unfortunately escaped from cultivation and now grows naturalized in moist meadows and similar places in various districts on the Island of Hawaii as well as at the head of Waimea Canyon on the Island of Kauai. This plant has already become ~~such a costly~~ a bad weed in pastures and cane fields that it should be eradicated, in spite of its beauty, whenever possible.

The Tritonia is not a product of Nature but of Man. It is the result of crossing two African plants belonging to the Iridaceae or Iris Family. The one is botanically known as Tritonia Pottsii Benth. & Hook., while the other is Crocosmia aurea Planch. The resultant hybrid, first blooming in 1880 in France where it was named X Tritonia crocosmaeflora Lemoine, is almost invariably sterile and unable to produce seed. This inability for hybrids to reproduce when their parents are very distantly related is a common ~~case~~ in both plants and animals. Among the latter, is the mule, a sterile cross between the donkey and the mare, is a well known example.

The Tritonia, as the illustration shows, bears long, slender, upright leaves. These are attached to an extremely short, swollen stem, called a corm, that somewhat resembles an onion bulb in shape. From this, subterranean branches arise to radiate in all directions and to give rise at their ends to a second series of corms and upright leaves. This type of growth continues indefinitely, the slender underground branches between the corms finally dying and isolating the newer growth into separate plants distinct from the old. Thus a colony of Tritonia can rapidly spread over a field even though no seed are produced.

(26)

BANANA or MAIA

The banana, ~~the~~ maia of the Hawaiians, is the best known member of the Musaceae or Banana Family. It is strictly native to the tropics of the Old World where it has been cultivated from prehistoric times. The army of Alexander the Great found it planted on a large scale in the Indus Valley as early as 327 B.C. It was undoubtedly spread throughout the Pacific by the Polynesian and related races. Probably influenced by primitive cultivation and selection, a few distinct kinds of banana have developed into hundreds of varieties and forms, most of which have lost the ability to produce seed.

The banana is really a remarkable plant. It is not a tree but a giant herb which has no aerial stem for the greater part of its life. The true stem is so contracted that it consists of a massive subterranean structure not unlike that found in the taro plant ( ). From here leaves arise in concentric arrangement, the youngest developing in the center as in the onion. With the formation of such central leaves, the older ones are forced apart to form, in transverse view, a series of crescents ( ).

The ensheathing stalks of the leaves of the banana ~~actually~~ form the stem-like structure commonly mistaken for a true tree trunk. The upper part of each stalk does not clasp the others but diverges somewhat to expose the enormous, oblong, terminal blade to sunlight and air. It must take considerable force to enable the young leaf to force its way from near the surface of the ground through the older encircling leaves. In order to do so, its blade is tightly coiled into a compact cylinder which lies in a groove found in the midrib of the leaf next in age.

To facilitate the passage of the young leaf into the air and to prevent its premature uncoiling and possibly the entrance of rain water, its apex consists of a long, filiform point. This seems to have no other function, tearing and dying as soon as the blade unfolds. Mucilage cells and possibly a bloom consisting of a wax-like powder act as lubricants to enable the young leaf to slip beyond the old.

The blade of the leaf has prominent veins running at right angles to it

length but lacks veins running ~~in the opposite direction~~ lengthwise. For this reason it easily tears into segments with the wind. When not excessive, this apparent mutilation seems to be harmless to the plant. Another feature of interest in the leaf blade is the presence of a pulvinus, or cushion, along each side of the midrib. This acts as a hinge. In dry or hot weather, it enables the two halves of the blade to collapse, and even to touch each other. Their under side, being covered with countless microscopic pores from which moisture escapes, is thus protected from ~~losing~~ undue loss of water by evaporation. On the contrary, if the water supply for the plant is sufficient and the heat moderate, the blade is exposed in a flat sheet to the sun and the under surface to the breeze.

As the plant approaches maturity, the contracted basal stem begins to lengthen and to push its way through the center of the column made by the sheathing leaf stalks. It terminates in an oblong flower cluster. This stands erect and matures fruit in that position in a few kinds of banana, for example in the <u>fei</u> (<u>Musa</u> <u>fehi</u> Vieill.) which was introduced into these islands from the South Seas early in the nineteenth century. Ordinarily, however, this flower cluster bends over as Plate shows.

Preparatory to flowering, a shallow, cup-shaped structure, usually of a brownish red, curls back. This originated in generations past by the union of several leaves, one standing under each flower. Situated before one of these structures, which might be called a collective bract, one will observe two horizontal rows of flowers. These have well-developed pistils or "female" organs and degenerated stamens or "male" organs. They secrete an abundance of nectar which in some kinds of banana is jelly-like and considered a delicacy by the Hawaiians. Such nectar attracts insects and birds which may, in their visits from flower to flower, cause pollination and insure the setting of seed. Due, however, to long continued cultivation as previously mentioned, fruit mostly develops without pollination and usually fail to mature seed.

Below the first two rows of pistillate flowers a second foliar structure is found, protecting a second pair of rows of pistillate flowers. This arrange-

VR

ment continues without interruption to the apex, the only change being in the character of the flowers. Those toward the middle of the cluster become perfect, namely bear both pistils or "female" organs and stamens or "male" organs. The very apex, on the contrary, bear staminate flowers (Plate) which, of course, lack functioning pistils.

The pistillate and often the perfect flowers develop into bananas, the crop maturing about a year after the plant has first appeared above the soil. The entire fruiting cluster forms the bunch of bananas while each pair of rows of bananas, that had been protected by a single collective bract, is commercially termed a hand. After the fruit has ripened, the plant dies. Suckers, however, arise from its base to become isolated into new individual plants later on.

The Banana plants vary in height from about eight feet, in the Chinese banana (Musa Cavendishii Lamb.) here shown, to thirty-five feet, in the fei or bolabola banana. In most cases the collective bracts covering the staminate flowers fall, but in the Chinese kind the terminal are persistent. The bunches commonly bear 5 to 9 hands, totaling about 250 fruits. In the "king of thousands", a Malayan banana, the bunch has been known to grow to a length of seven feet and to bear 2000 fruits. On the other extreme comes the lubang, (Musa cornicul[illegible]ata Lour.) of Cochin China, in which the entire bunch commonly consists of just a single banana not unlike a large cucumber in appearance. The skin of the fruit in the different kinds varies from yellow to red or even green when ripe, while the pulp varies from yellow, pink, salmon to almost white. In consistency the pulp ranges from soft to firm. In many cases the fruits can be eaten out of hand and such plants are called bananas in Hawaii and in the West Indies. Those that are best suited for cooking, like most of the feral Hawaiian fruits, are known as plantains in the same regions. In the eastern tropics, on the contrary, both types of plant are known as plantain. All bananas show dark spots, the abortive seeds, in the pulp; or, in very rare cases, have viable seed. These are hard, more or less round and often angular. (How big? Color?)

R

The banana grows best in sunny mountain gorges and swampy yet well-drained areas below an elevation of about 4000 feet. It is found throughout the Hawaiian Islands, being especially numerous on the slopes of Haleakala. Its occurrence in such isolated places is explained by the fact that the Hawaiians purposely planted them in the mountains and that suckers from these plants were occasionally washed to lower elevations by freshets and there produced new clumps of plants. In the Kona District of the Island of Hawaii, 20 kinds of bananas were known to the Hawaiians living there. When one considers that bananas were grown on the other islands of the group as well, it is quite possible that several hundred forms were known to the natives in the early days. Since the introduction of the Chinese banana by way of Tahiti in 1855, many of these interesting though less productive Hawaiian plants have become extinct.

Besides the value of its fruit as food, either raw or cooked, the banana plant was used by the Hawaiians in other ways. The false trunks, being about 80% water, were mashed and commonly placed in the imu ( ), or native oven, to generate steam for the cooking of food. A young plant was used as a flag of truce in war.

The banana was often used in sacrifice, daily offerings being made to the spirits of the dead of the fruit as well as of certain kinds of fish and of awa ( ). The banana, and in fact almost anything appropriate to give to the gods, was kapu for women to eat. Among these objects may be listed pork, turtle, coconut, breadfruit when coming from trees growing in plantations, and certain fish like the ulua, shark, humu and hihimanu or sting-ray.

The kapu system, characteristic of the Polynesians and probably most fully developed by the Hawaiians, was a religious rather than a civil regulation to which even the king was subject. It influenced the daily life of the people with complicated and often useless restrictions whose violation was usually punished with death. Some kapu were permanent and well understood by all, while others were temporary and erratic. Permanent kapu were usually those relating to idols, temples, chiefs, and customs in eating and in house keeping ( ). The special or temporary kapu were imposed by the king or the kahuna for

R

some definite reason, such as conserving food that was getting scarce, or merely for a whim.

Women were prohibited from eating with the men excepting under special dispensation as at the hula school feast ( ). They were forbidden to eat food cooked in the same oven as was that of the men unless the oven were of special construction. To save labor, men of the lower classes often formed what might be considered eating clubs from which their wives were excluded. The regulation about eating was so extreme that a daughter from the time of birth could not be fed with any particle of food that had been kept in the father's dish or cooked at his fire; and the son, after weaning, was fed with his father's food, and, as soon as he was able, sat down to meals with his father. His mother, at the same time, was not only obliged to eat in an outbuilding, but was interdicted from even tasting the kind of food that he ate. Infringement of these regulations was a capital offence.

Death was the penalty for the slightest breach of etiquette established by kapu in the neighborhood of the king or high chief. It meant death for a common man to remain standing at the mention of the king's name in song, or when his food, drinking water or clothing was carried past; to put on any article of clothing belonging to him; to enter his enclosure without permission; or even to cross his shadow or that of his house. If he entered the presence of the king, he crawled to him prone on the ground and left him in the same manner. The king's head was considered especially sacred. For anyone to touch it or to occupy a position above it was regarded treason. So even after the coming of Captain Cook, no subject dared appear on the deck of a vessel when the king was in the cabin below.

There were times during the kapu period when no one could sail a canoe, nor be seen abroad, nor bathe. No domestic animals could cry for fear of breaking the kapu and rendering it worthless. Chickens, brought by the Polynesians were then usually confined in a covered calabash to keep them quiet. If a disturbance occurred while such a kapu was in effect, the offender was killed by strangulation or by being beaten with a club or stone and usually offered as a sacrifice

R

in the heiau ( ). So oppressive and rigorous was this system that the otherwise comparatively happy existence of the people often suddenly changed to a life of fear and misery.

In 1819 the last capital punishment for the breaking of a kapu was inflicted, this occurring at the City of Refuge, or puuhonua, at Honaunau, Island of Hawaii. At that time one person was killed for putting on a chief's loin cloth; another, for eating something which had been kapu; and a third, for leaving a house under kapu and entering one which was free. Some years previous to this infliction of punishment at Honaunau, at the same place two young girls of the highest rank, Keoua and Kapiolani, the latter being the chiefess after whom a Honolulu park has been named and who defied the goddess Pele ( ), stole into the sea with a banana and there ate it in the belief that ~~their act~~ they would escape observation. A kahuna, however, detected them in the act of committing this crime. Due to their high rank, the girls were absolved of the offence. Instead, their tutor was held to blame and drowned to appease the insulted deities.

Of this entire complex system the only relic that has survived to the present day may be seen in wayside warnings. Instead of reading "No Trespassing", they usually read "Kapu".

HAWAIIAN GINGER or AWAPUHI

The Hawaiian ginger, or awapuhi of the natives, is botanically known as Zingiber zerumbet (L.) Rosc. It is a member of the Alpiniaceae or Ginger Family. The plant is native to the Hawaiian Islands as well as to most tropical regions between here and India. It may be seen growing at lower elevations in the woods adjoining the road that leads from Hilo to Kilauea.

The awapuhi has a thick, prostrate rootstock, called rhizome, from which two distinct kinds of upright stems arise. The one reaches a height of one to rarely three feet and bears about a dozen leaves arranged in two vertical rows. Exposed to light and air, these manufacture various substances, necessary for the existence of the plant, aided by the roots that have absorbed water and minerals from the soil. The surplus supply is then translocated, or carried, to the swelling rhizome where it is stored for future use. Toward late summer, the second type of stem develops. This is very different. It is much shorter and appears club-shaped because of a terminal cluster of modified, often reddish leaves termed bracts. These are scale-like, concave, and so closely arranged on the stem that their margins overlap. A delicate bud is borne in the axil of each of these bracts to be protected from all possible insect injury in an unusual way. Glands within secrete a copious supply of clear, watery slime that covers the buds and completely fills each cup-shaped scale, making it impossible for insects to gain entrance here without great danger of drowning. The buds finally develop into inconspicuous, pale yellow flowers that last less than a day.

The pungent rhizome of the awapuhi was powdered by the Hawaiians in former times to be used as a perfume for their kapa ( ), while the swollen ends of the club-shaped stems are gathered even today and squeezed over the hair to liberate their fluid in preparation for a shampoo.

The leaves of the ginger were used to flavor meat. If a pig, for example, were to be cooked, the Hawaiians in the early days dug a circular pit about four feet in diameter, or an oval one about four feet long, two feet wide and one to three feet deep. This was called the imu. It was lined with stones,

and then dry grass or leaves, and wood suitable for making a fire were placed within. Over this material stones were laid so that the entire mass projected above the surface of the soil. Only certain kinds of porous stones were used for this, however, as others might crack or explode into fragments with the heat, possibly injuring the people near at hand. Around the rim of the imu, a single row of large stones was placed. Then the fire was kindled as described on page hau. When most of the wood had burned away and the smaller stones were red hot, the remaining pieces of wood and smoldering embers were carefully removed as their smoke might impart a disagreeable flavor to the cooking meat. The ashes, on the contrary, were merely brushed aside with a branch or coconut leaf. Then the slaughtered pig was dragged back and forth over the red hot stones to singe away its bristles, the large stones around the rim of the imu preventing the pig from touching the soil and preventing the hot stones from being scattered. After that, the pig was scraped free from dirt and any remaining bristles with a special lava stone called olai which can be gathered along the shore. Such stones have congealed from their molten state while containing numerous bubbles of gas. Due to the wearing action of the waves, these stones usually are more or less rounded. The bubbles, partly worn away on one side, give the stone a pock-marked surface, each depression being bounded with sharp edges. After the cleaning, the pig was eviscerated. The heart, liver, lungs, kidneys, pancreas and alimentary canal were laid aside, the latter to be carefully cleaned by passing ti ( ) leaves through it and turning it inside out. Salt was sprinkled within the pig and some water added to form a gravy. Then the largest stones were kicked out of the way. Thereafter, the Hawaiians with bare hands, wetted in a calabash of water by their side, would hurl the heated stones into the body cavity of the pig, stuff several through the mouth into the throat, and place a large one in each gash cut into the side of the pig under each leg. Then if fresh ginger leaves were at hand, these were thickly laid in a slight depression in the mass of red hot stones. Wanting ginger, ti or banana leaves or the mashed trunk of the banana were

employed. The pig was then laid upon the leaves. To one side of the body a calabash, usually of kauila ( ) wood, containing the edible organs and the cleaned entrails was placed. The leaves were sprinkled with water and then covered with a large sheet of kapa to keep them clean. Thereupon everything received a layer of earth about ~~one~~ foot deep, forming a slight mound. The water and plant juices, gradually coming in contact with the hot stones, turned to steam. This and the radiating heat of the stones completely cooked the pig within two to three hours. The blanket of earth which kept the steam from escaping was then carefully removed with the kapa. The leaves that produced the steam were thrown aside as well as the rocks within the roast. The latter was then placed on a large, wooden platter, cut into pieces with the serrate edge of a split piece of bamboo, and served. The kapa and stones were saved to be used again in the same imu. This method of preparing food took the place of cooking in pots and pans, utensils which the Hawaiians lacked because of a dearth in clay suitable for pottery, and metals in a form available for smelting.

(28) COMMON GINGERLILY 10¢ 75

The common gingerlily, Hedychium coronarium Koenig, is not native to the Hawaiian Islands but to the Orient. It was purposely brought here over fifty years ago as an ornamental because of its large, white, fragrant flowers. A yellow-flowered kind was also introduced. Both plants soon escaped from cultivation and now may be found growing naturalized at lower elevations on almost all islands in damp localities. The ~~XXX~~ white- as well as the larger yellow-flowered gingerlily may be seen growing along the roadside between Hilo and Kilauea in great numbers.

The gingerlilies belong to the same family Alpiniaceae as the awapuhi ( ). Unlike the latter, however, they are tall, have only one kind of upright ~~false~~ stem, and bear larger flowers of different structure. Although producing flowers in abundance, they rarely mature seed. They spread from place to place chiefly by means of their creeping and branching rootstocks.

Flowers of both kinds of gingerlilies are gathered and strung into fragrant garlands, or lei. These are usually offered for sale by Hawaiian women dressed in flowing holoku to travelers the moment they disembark ~~to set foot~~ on these shores.

R

(29)

HAWAIIAN ORCHIDS

The Orchidaceae or Orchid Family is represented in these islands by only three native members, none of which grow elsewhere. All may be found within the boundaries of Hawaii National Park on the islands of Maui and Hawaii, but they are so rare and so inconspicuous that few visitors will ever see them.

The orchid still known botanically by the old name of Habenaria holochila Hillebr., is exceptionally rare. It has been found on the islands of Kauai, Molokai and Maui only. In the fog-swept Koolau Gap of Haleakala Crater, a spot where some of the most interesting plants survive, a few specimens have been seen growing in deep moss. This plant has a single, erect stem one to two feet high, bearing toward the top more than a dozen small, yellowish flowers.

The other orchid, going by the cumbersome name of Vrydagzynea sandwicensis Lindl., is found in very dark, wet woods on all the larger islands. It has oblong, pointed leaves, and fleshy stems that creep along the ground and branch before rising to a height of four to ten inches. It therefore might be easily mistaken for a Commelina or day-flower, a plant which is incorrectly called honohono grass in the Hawaiian Islands. This orchid grows in some of the deep earthquake crevices in the vicinity of Kilauea-iki and elsewhere.

The Hawaiian liparis or twayblade, Liparis hawaiensis Mann, is probably the least rare of the three Hawaiian orchids and therefore here illustrated (Plate). Its native name is awakuhiakanaloa. It may be found on the flanks of Haleakala and in the vicinity of Kilauea growing in open woods, either on the ground or on moss-covered trunks of trees. The plant has a short stem, surrounded by several protective scales, that is surmounted by two pale leaves each about three inches long. When these have manufactured a certain quantity of food, a flower stalk develops to a height of almost ten inches, bearing small, yellowish flowers. Upon their pollination by ~~the aid of~~ some insect, these develop into capsular fruits. At the same time food and water are stored in the basal part of the stem to such an extent that it swells enormously. When the seeds have been

disseminated by the opening of the capsular fruits and the leaves have died, nothing living remains of the plant excepting the swollen stem with its attached roots. After being dormant for a certain length of time, the old stem sends forth a new one from near its base. This finally develops into a complete plant that will bear the coming season's flowers. Now if the tree trunk or ground should dry during periods of drought, the young liparis can continue growth by drawing upon the water and food stored in the old stem that gave rise to it. Though the liparis grows under the same conditions as the astelia ( ), it ~~thus solved~~ evades the danger of dying from lack of water in an entirely different way.

The Orchid Family has some of the smallest seeds known. They are as light as dust and can be blown to great distances, like the spores of ferns, by even gentle currents of air. In the orchids so far studied by botanists, the seeds can develop into mature plants only if a fungus called a mycorrhiza can infect them and grow within their tissues. In this respect, the plants resemble the sexual stage of psilotum and of lycopodium previously described. In spite of this difficulty of developing to maturity, it is a mystery why only three kinds of orchids are native to the Hawaiian Islands when these plants are so numerous in other warm and tropical countries, and their seeds are so easily transported by the wind over extensive bodies of water.

The correct name of this plant and of certain others mentioned ~~herein~~ in this guide is purposely omitted so as to avoid publishing new technical plant names amid strictly non-technical discussions. The proper vehicle for such changes in nomenclature is the FLORA HAWAIIENSIS or NEW ILLUSTRATED FLORA OF THE HAWAIIAN ISLANDS.

30

CASUARINA, BEEFWOOD or FALSE IRONWOOD) -10 f c

Several kinds of beefwood or false ironwood trees will probably attract the attention of the visitor on his way to Hawaii National Park. ALL belong to the group of plants called Casuarina, comprising the Casuarinaceae or Casuarina Family. The entire family, consisting of about 30 kinds of plants, is peculiar to Australia and some of the Pacific Islands. None are native to the Hawaiian Islands, ~~although~~ but four or five have been introduced here.

The beefwood trees from a distance appear like tall pines bearing long, drooping needles and small cones. Upon closer inspection, however, one will see that these plants having ~~nothing~~ little in common with pines. The structures that seem to be needles or true leaves are actually long, green, jointed branches that wave pendant in the breeze. At each joint or node are five to fifteen minute teeth, the number varying according to the particular kind of Casuarina ~~studied~~. These teeth are actually the degenerate leaves that one would expect branches, no matter how specialized, to bear. ~~They are~~ These teeth are homologous to the needles of the pine, not analogous to them.

Some of the slender, green branches end in catkins. These consist of several whorls of minute leaves bearing pale staminate, or "male", flowers that are greatly reduced in size and structure. The pistillate, or "female", flowers, on the other hand, are borne clustered on shorter branches. ~~In this case,~~ The female flowers are also greatly simplified, each consisting of a single pistil with its scarlet end receptive to pollen. After the pollen has reached the pistil and the ovules within begin to develop into seed, the entire catkin increases in size to become ~~first a~~ green and then finally ~~a~~ brown, but at first a cone-shaped structure. This later sheds the ripe seed. It is not like the cone of the pine tree because that tree never forms pistils.

The wood of the beefwood or false ironwood, likewise, is ~~entirely~~ different from that of the pine. It is dark red in color as the name beefwood implies, while that of pine is light yellow; it is extremely hard as its other names indicates, while pine is soft. Study of the two woods under the microscope will show still greater differences, that of the beefwood being more like oak wood than pine.

R

Obviously the common beefwood, like the cactus, is highly specialized for existence in very dry regions. Its leaves have degenerated to such an extent that they are ~~practically~~ almost non-functional, the green stems functioning in their stead. By dispensing with leaves the plant has enormously reduced the surface that it would otherwise expose to the drying rays of the sun. And to conserve the moisture that would normally escape from the inner tissues of the plant, the microscopic air-pores or stomata necessary for respiration have sunken into sheltered grooves in the slender green stems. Thus the beefwood can flourish in regions of little rainfall where most plants with normal leaves would perish from drought.

The beefwoods have been introduced into the Hawaiian Islands for their ornamental and especially their economic value. They grow rapidly on the hot, coastal dunes and act as valuable sand-binders and wind-breaks where few other trees will live. They also grow in the drier uplands, thus being of value in reforesting regions from which the more interesting native trees have been exterminated. Some beautiful groves may be seen in Makawao, Maui, the town through which most travelers pass on their way to Haleakala Crater. (before the road to the rest house had been constructed).

R R

PEPEROMIA or ALAALAWAINUI)106 c

Only two groups of plants in the Hawaiian Islands belong to the Piperaceae or Pepper Family. The one is Piper, to which group the true black pepper of commerce belongs; the other is Peperomia.

Piper is represented locally by Piper methysticum Forst., the awa of the natives. This was undoubtedly introduced by the Hawaiians in prehistoric times and grown in the woods under conditions of semi-cultivation. It is a strong narcotic herb becoming as much as nine feet high. It was formerly much used by all classes of Hawaiians as a valuable medicine, and by the chiefs in large quantities as a pernicious drug. It does not grow in the Park but is found in considerable ~~numbers~~ abundance on the Island of Hawaii in the District of Puna and along the government road leading from the city of Hilo to Kilauea. A closely related plant, which has been mistaken for the true betel pepper, also grows in the islands. This, however, was introduced by the Orientals during the latter half of the nineteenth century.

The group known as Peperomia, or in Hawaiian as alaalawainui, is represented in the islands by well over a hundred kinds. These are fleshy herbs varying from a height of a few inches to ~~very rarely as much as~~ an extreme of three or four feet. They are typically found on the ground though a few kinds, exemplified by Peperomia deflexa (L.f.) Dietr., figured on Plate , are partial to growing on rocks and trunks of trees.

Most peperomia as their succulent character attest, are provided with water-storage tissues. This enables the plants to thrive during dry seasons when other plants would die. A surplus supply of water is simply retained in certain cells for possible future use during periods of drought. Another interesting feature in many of these plants is their leaf arrangement. As in the figured specimen which may be observed in the Kipuka Puaulu, near Kilauea, leaves appear to be borne in whorls of four each. This is not strictly true. Only two leaves are actually borne together at a single joint, or node. Alternate internodes, however, are so reduced in length that the two adjoining nodes are always approximated, their two separate pairs of leaves therefore

simulating a single whorl of four leaves. In flower structure, these plants are greatly degenerate. The flowers, borne on an erect stalk, are minute. Each consists of a single pistil and two stamens sunken in a depression of the stalk and protected by an axillating scale, or bract. As the pistil matures into a minute, seed-like fruit, it partly extrudes from the depression in which it had developed. The fruit, being sticky, is then readily scattered by birds of other animals that happen to come in contact with it.

The peperomia were not of much value to the Hawaiians. They were occasionally used in medicine and in the manufacture of a gray dye for staining kapa ( ).

BREADFRUIT or ULU

The breadfruit is known as ulu by the Hawaiians. Technically it is Artocarpus communis Forst. It belongs to the Moraceae or Mulberry Family to which the common fig, banyan or rubber tree also belong. It can be seen by the visitor on his way to both sections of the Park, or even within the Kilauea Section if he has the opportunity to tramp over the stretches of land near the coast.

The breadfruit is not strictly a native plant but was undoubtedly brought here in very early times by the progenitors of the Hawaiian Race. The reasons for considering the plant foreign to this flora is its inability to produce seed and disseminate itself, its occurrence near native dwellings or where these had stood, and the traditionary account of its introduction. It is said to have been brought from the Island of Upolu in the Samoan group around the twelfth century by the chief Kahai and first planted at Kualoa, Island of Oahu. The breadfruit is a tall tree of striking appearance. Like its relatives, the fig and the banyan, it exudes abundant milky juice when cut. It has large, lobed leaves and foliar stipules, or structures which protect the leaf when it is yet young. The same ~~tree~~ individual has two kinds of flower clusters. The staminate, or "male", are long club-shaped structures consisting of thousands of minute pollen-bearing flowers. The pistillate, or "female", clusters are almost spherical and consist of thousands of pistillate flowers. After pollination has taken place, each one develops into a fruit. As these increase in size, they press against each other with such force that they almost lose their individuality. They are no longer round and separate but angular and united. Consequently the entire breadfruit, sometimes ~~one~~ a foot across, is not a single fruit but a collective fruit. This is similar to the condition found in the pineapple ( ) and noni ( ).

The trunk of the breadfruit or of the coconut was fashioned into the pahu ( ), a large drum. To make this, a section of the trunk, at least one foot in diameter and about two feet long, was laboriously chipped out from each end. In this manner a cross-section of the log was left as a diaphragm one-third of

R

the distance from the base. The lower chamber was then usually carved as the often
figure clearly shows, while the upper had a head formed usually of the scale-
less skin of the shark. This was fastened to the sides of the cylinder by
means of cord frequently made of the fibers found in the husk of the coconut.
The tone of the pahu was produced with the palm of the hand; never with a
stick. It was the beating of these drums that emphasized the rhythm of most
hula dances (papa hee nalu

Surf boards were often made of the wood of the breadfruit because of its
lightness. These boards were varied from three feet in length and six to eight in-
ches in breadth, to fourteen feet in length and about two feet in breadth. Some were
flat though most of them were slightly convex on both sides.

On days when the waves were exceptionally high, both men and women advanced
toward the surf lying prone upon their boards, propelling themselves forward
with quick breast strokes. In this position, the Hawaiians used their feet
as a rudder, to direct their course. If the right foot was allowed to drag
in the water, the board quickly turned to the right; if the left foot, then
the board responded and turned in that direction. On meeting the waves as
they roll toward shore, the surf-rider glides over those that are smooth,
and plunges under or through those that are high or breaking.

After propelling themselves far beyond the line of breakers, these stal-
wart men and women faced shoreward and remained in that position, bobbing up
and down in the choppy sea until a very high swell approached. Then they
placed themselves before it either lying or standing upright on their boards
and gave two or three propelling strokes with their outspread hands. As the
great wave dashed onward and broke into a huge comber, the surf riders balanc-
ed themselves on the boards which are inclined at a steep angle just before
the crest of the wave. In this manner they dashed toward shore at a tremendous
speed, often exceeding forty miles per hour. Now and then a swimmer was dis-
lodged from his board, as it raced ahead of the breakers, and sank in the
foam to be mercilessly twisted in the whirling water. But the other riders dashed
gracefully toward shore until the wave became so reduced in size and force

R

that the board slackened its speed and finally stopped.

Today surf-riding is still a favorite sport practiced at Waikiki Beach, Honolulu, where the breakers begin to form far from shore because of the expanse of shallow water. Here the visitor may partake of this thrilling Hawaiian pastime under expert native instructors.

The surf boards were usually stained black and preserved with utmost care. After using, they were dried thoroughly in the sun, rubbed with coconut oil, often wrapped in kapa ( ), and suspended in some part of the house. This oiling prevented the boards from becoming water-logged with frequent use.

From the bark of the breadfruit the Hawaiians at times made an inferior grade of kapa ( ). They even used the male flower cluster, the noule, to mix with the fiber of the wauke (Paper mus papyrifera) to form a rare kind of malo, or loin cloth. This custom probably arose from the belief in the Doctrine of Signatures, a superstition held by most races and but recently abandoned by the Caucasian.

The stipules of the breadfruit were used as a fine abrasive. For example, the skilled Hawaiian wood worker first seasoned his wood by cutting it into blocks of suitable size and burying them in the mud of his taro ( ) patch. Here it soon darkened and acquired the appearance of having seasoned for many years. He next fashioned it into domestic articles, such as calabashes, by means of stone implements. Fine coral or lava was then employed as an abrasive to remove the rough surfaces. This was followed by treatments with soft brittle lava, next with pumice, or possibly charcoal, with kamboo leaves, and finally with dried breadfruit stipules.

As an article of food, the breadfruit was not of much importance in Hawaii. The fruit was baked in an imu and then eaten or, after baking, preferably peeled of its outer skin and deprived of its central, woody core. It was then pounded into a food similar to poi made from taro ( ). Where taro was not available, breadfruit was used in making a coconut pudding similar to kulolo ( ). To fatten their domestic pigs, introduced centuries before the coming of Captain Cook, the Hawaiians gave them breadfruit, taro and sweet potato peelings. Strange as it may seem, the Hawaiians never preserved the breadfruit in pits dug in the earth as did the Samoans, although In this state it would remain

edible for many months.

To make their precious cloaks, kahili ( ), helmets ( ), and certain idols ( ), the Hawaiians caught various forest birds, especially the mamo ( ), oo, iiwi and apapane for their plumage. The mamo, now extinct, was black in color but possessed a small tuft of yellow feathers under each wing, not two feathers as so many relate. The oo is likewise black and yellow, while the iiwi and the apapane are black and red. The royal bird catchers caught these birds by smearing the sticky juice, termed kia or kenau, of the breadfruit, endemic lobelias ( ), or of the fruit of plants belonging to the groups called Rockia and Calpidia on long, baited poles, laaukia, or on posts, pokia. These they scattered thickly about the haunts of the birds which alighting upon them thus became caught by their feet. The hunters were instructed by Kamehameha to liberate these birds after plucking their choice feathers so that a new supply might grow. [illegible] After washing their feet of the adhering sticky mass of bird-lime with kukui nut oil ( ) or with sugar cane juice, they were freed, having suffered no serious injury.

The mamake of the Hawaiians, of which several kinds are known, belongs to the group Pipturus. All are members of the Urticaceae or Nettle Family. They were the most abundant fiber plants of the ancient Hawaiians, being found throughout the islands in open woods, especially below 4000 feet elevation, in many perplexing varieties and forms. Very many of these plants may be seen along the road that leads from Hilo to Kilauea, growing with the ieie( ), ~~especially~~ chiefly in the burned over forest south-east of the village of Olaa. Within the boundary of the National Park a different kind may be found. This can best be studied near the Thurston Lava Tube.

The mamake is a shrub or rarely a small tree with somewhat hairy stems. The leaves are ovate in shape, light green on the upper side but underneath sometimes almost white with very fine, short hair. They possess three main veins which are often bright red in color. The flowers, of which two kinds occur, are borne in very inconspicuous clusters because the plant need not attract insect visitors to effect cross-pollination. ~~In some cases the~~ staminate, or "male", flowers ~~are found on one plant~~ and the pistillate, or "female, ~~on another~~, while ~~in other cases~~ both kinds of flowers ~~are found~~ on the same plant. The staminate flowers bear stamens which elastically hurl their dry, powdery pollen into the air. Borne by the wind, some of this may fall upon the pistillate flowers and fertilize the ovules contained within them. Only then will seeds be formed which will mature in the drying pistils. The groups of shorty united flower stalks of the pistillate cluster, in the meantime, also develop. Each becomes a waxy-white, fleshy structure about half an inch in diameter, harboring the dried, seed-like pistils in open depressions. These strange fruits built up of many flower stalks, though insipid to our taste, are palatable to birds which eat them as well as the indigestible, seed-containing pistils. The seeds thus pass through the body of the bird unharmed and may finally become planted in new localities. These fruits were occasionally eaten by the Hawaiians as a laxative and given to children as a remedy for thrush, or ea.

The mamake is the favorite host of a green caterpillar which finally pupates and emerges as the beautiful, redish-brown Kamehameha butterfly, known scientifically as Vanessa tameamea Esch. This insect and a small

metallic green kind are the only butterflies native to the Hawaiian Islands. The closest relative of the Kamehameha butterfly, strangely enough, seems to be V. callirhoe Fabr., native to Madeira.

The plant that furnished the best quality of bark cloth for the Hawaiians was not the mamake but the wauke or paper mulberry, Papyrius papyrifera (L.) Kuntze. This plant, whose native home is not definitely known, was carried to Hawaii and throughout the Pacific by the Polynesians in their migrations. In these islands it was carefully cultivated for the making of Kapa until two or three generations ago when the customs of the white man more generally displaced those of the Hawaiians. Even today, wauke plants may be found persisting in an occasional valley as, for example, near Kamalo on Molokai. The mamake, however, was the most abundant fiber plant and produced the second best type of kapa. Its fiber is of somewhat coarser quality. As the making of bark cloth from the wauke and the mamake was an important occupation of the Hawaiians up to a few generations ago, it is not amiss to describe it in some detail. Because no very good contemporary account of the local manufacture has come down to us, we can do no better than follow W. T. Brigham in Ka Hana Kapa, one of his many excellent monographs on Hawaiian customs. He quotes from Sir Joseph Banks' Journal concerning the manufacture of cloth in Tahiti from wauke bark, a method essentially the same as that practiced with wauke and mamake in Hawaii.

Sir Joseph, who accompanied Capt. Cook, the explorer, in his first voyage of discovery in 17 , states that the wauke is cultivated with much care and that young plants of one or two years' growth only are used. These are thin, straight, and tall and bear no branches because as often as the lower buds show a tendency to grow, they are removed with their axillating leaves. Then he describes their method of manufacturing the bark into cloth as follows:

"The thin bark they make thus; when the trees have grown a sufficient size they are drawn up, and the roots and tops cut off and stripped of their leaves; the best of the [wauke] are in this state about three or four feet long and as thick as a man's finger ####. The bark of these rods is then slit up longitudinally, and in this [manner drawn off the stick; when all are stripped, the bark is carried to some brook or running water, into which it is laid to soak with stones upon it, and in this situation it remains some days. When sufficiently soaked the women servants go down to the river, and stripping themselves, sit down in the water and scrape the pieces of bark, holding them against a flat smooth board, with the shell called by the English shell merchants Tiger's tongue (Tellina gargadia), dipping it continually in the water until all the outer green bark is rubbed and washed away, and nothing remains but the very fine fibres of the inner bark. This work is generally finished in the afternoon: in the evening the pieces are spread out upon plantain leaves, and in doing this I suppose there is some difficulty, as the mistress of the family generally presides over the operation. All that I could observe was that they laid them in two or three layers, and seemed very careful to make them everywhere of equal thickness, so that if any part of a piece of bark had been scraped too thin, another thin piece was laid over it, in order to render it of the same thickness as the rest. When laid out in this manner, a piece of cloth is eleven or twelve yards long, and not more than a foot broad, for as the longitudinal fibres are all laid lengthwise, they do not expect it to stretch in that direction, though they well know how considerably it will in the other.

R

"In this state they suffer it to remain till morning, by which time a large proportion of the water with which it was thoroughly soaked has drained off or evaporated, and the fibres begin to adhere together, so that the whole may be lifted from the ground without dropping in pieces. It is then taken away by the women servants, who beat it in the following manner: they lay it upon a [in the Hawaiian Islands termed kua kuku, &c.] long piece of wood, one side of which is very even and flat, this side being put under the cloth: as many women then as they can muster, or as can work at the board together begin to beat it. Each is furnished with a baton made of the hard wood ####: it is about a foot long and square with a handle*; on each of the four faces of the square are many small furrows, whose width differs on each face, and which cover the whole face. They begin with the coarsest side, keeping time with their strokes in the same manner as smiths, and continue until the cloth, which extends rapidly under these strokes, shows by the too great thinness of the gro[o]ves which are made in it that a finer side of the beater is requisite. In this manner they proceed to the finest side, with which they finish; unless the cloth is to be of that very fine sort #####, which is almost as thin as muslin. In making this last they double the piecesseveral times, and beat it out again and afterwards bleach it in the sun and air, which in these climates produces whiteness in a very short time. #####.

"Of this thin cloth they have almost as many different sorts as we have of linen, distinguishing it according to its fineness and the material of which it is made. Each piece is from nine to fifteen yards in length, and about two and a half broad. It serves them for clothes in the day and bedding at night. When, by use, it is sufficiently worn and becomes dirty, it is carried to the river and washed, chiefly by letting it soak in a gentle stream, fastened to the bottom by a stone, or, if it is very dirty, by wringing it and squeezing it gently. Several of the pieces of cloth so washed are then laid on each other, and being beaten with the coarsest side of the beater, adhere together, and become a cloth as thick as coarse broad-cloth,

* Before [in the Hawaiian Islands termed ia kuku, &c.] flat-sided beaters was used, a round one, termed kohoa was employed.

than which nothing can be more soft or delicious to the touch. This softness, however, is not produced immediately after the beating; it is at first stiff as if newly starched, and some parts not adhering together as well as others it looks ragged, and also varies in thickness according to any faults in the cloth from which it was made.

"To remedy this is the business of the mistress and the principal women of the family, who seem to amuse themselves with this, and with dyeing it, as our English women do with making caps, ruffles, etc. In this way they spend the greater part of their time. Each woman is furnished with a knife made of a piece of bamboo cane, to which they give an edge by splitting it diagonally with their nails. This is sufficient to cut any sort of cloth or soft substance with great ease. A certain quantity of a paste made of the root of a plant which serves them also for food, and is called by them Pea ##### [Tacca sp.], is also required. With the knife they cut off any ragged edges or ends which may not have been sufficiently fixed down by the beating, and with the paste they fasten down others which are less ragged, and also put patches on any part which may be thinner than the rest, generally finishing their work, if intended to be of the best kind, by pasting a complete covering of the finest thin cloth ##### over the whole. They sometimes make a thick cloth also of only half-worn cloth, which, having been worn by cleanly people is not soiled enough to require washing #####.

"The cloth itself, both thick and thin, resembles the finest cottons, in softness especially, in which property it even exceeds them; its delicacy (for it tears by the smallest accident) makes it impossible that it can ever be used in Europe, indeed it is properly adapted to a hot climate. I used it to sleep in very often in the islands, and always found it far cooler than any English cloth."

R

Cloth of this type made by the Hawaiians is called kapa, commonly but less correctly written tapa by those who are not of native ancestry. The origin of the word indicates the essential procedure necessary for making the stuff, being derived from the Hawaiian ka, meaning the, and pa, meaning beaten.

Kapa was frequently stained or figured with various designs in black, brown, purple, red, yellow, and very rarely blue or green. This was accomplished in three different ways. Apparently the simplest method was that of dipping the kapa in a dye. The result might then have been considered sufficiently ornamental and no further coloring attempted. Or the dipped kapa might have had lines or other designs in different colors painted upon it. The lines were made by drawing across the cloth the end of a bamboo stick, called lapa, steeped in dye, that had been cut into prongs like those of a fork. The other figures were often painted with a brush made from a segment of the hala fruiting head (page). The highest type of ornamentation, however, was accomplished by printing. Quoting W. Ellis, an eyewitness of this method in Hawaii, we read: "Their manner of printing is ingenious. They cut the pattern they intend to stamp on their cloth on the inner side of a narrow piece of bamboo [called ohe kapala, or better ohe kapalapala, fig.], spread their cloth before them on a board, and having their colors properly mixed, in a calabash by their side, dip the point of the bamboo, which they hold in their right hand, into the paint, strike it against the edge of the calabash, place it on the right or left side of the cloth, and press it down with the fingers of the left hand. The pattern is dipped in the paint after every impression, which is repeated until the cloth is finished."

Some of the dyes used in coloring kapa and some of the perfumes employed in rendering it fragrant are mentioned in the discussion of the plants from which they were derived (see pages ~~8,12,16,23,31,35,36,52,53,74,83,84~~). ~~In~~ Some cases the dyes in the kapa were permanent or fast without any special treatment to the cloth, while in other cases it was necessary to use various mordants to fix the dye, as seawater, mud, urine, or burned coral sand. The complicated method of making many of these dyes has already become a lost

art. The procedure for making most of the others will be lost to posterity within a generation unless the few remaining people that possess this interesting knowledge put it into writing without delay. The good and bad customs, the history and the myths of both the White Race and of the Oriental Race may be found filling hundreds and even thousands of volumes where they can be studied by anyone until the end of time. But the knowledge of most of the customs, history, myths and beautiful mele of a great Pacific Race, the Polynesian, is gradually passing into oblivion because so many of the older people belonging to that race neglect to record, in some language, their priceless information and the interesting sayings that they remember their parents or grandparents to have used. It is safe to say that practically every man and woman of Hawaiian ancestry, born before 1880, possesses knowledge or impressions well worthy of record in a book on Hawaiian civilization.*

The kapa was always made by women, the chiefesses vying with one another in designing intricate and beautiful patterns. Its main purpose was that of furnishing a suitable material for clothing, although it was used also for bed coverings, wicks, sandals and for religious purposes.

In a semi-tropical country where the greater part of the inhabitants live within a few hundred yards of the ocean and gain their chief livelihood from it, the problem of clothing is relatively unimportant. For that reason, the dress of the early Hawaiians was scant. It was a little more abbreviated than the costumes worn today by men and women for swimming and relaxation on the beaches of Hawaii and throughout the civilized world. That of the Hawaiian man was the malo. This consisted of a strip of cloth nine to twelve inches wide and that many feet long. It was usually adjusted by holding one end under the chin and passing the rest of the cloth backward between the legs. It was then drawn up to and around the waist over the vertical end of the strip still held by the chin. The free end was then twisted around the part encircling the waist in the back, while the other end was allowed to fall gracefully down below the navel. Malo of several qualities and of various designs were made. These frequently indicated the social status of the wearer.

* Regard for the ancient customs of the Hawaiians appears to be on the wane. So little interest seems manifest in local Ethnology that some of the very few men in the islands trained in this science are obliged to enter other fields for a livelihood. Such men should be enabled to gather the wealth of information still locked in the memories of the older Hawaiians.

For a commoner to wear the malo of a chief was a serious offence, punishable with death. In 1818 the last human sacrifice was made at the City of Refuge, or puhonua, at Honaunau, Island of Hawaii, because of the breaking of this kapu. During battle, it is said, the common soldier and frequently even the chief, laid the malo aside because of the ready hold it would otherwise give of his person to an enemy during hand to hand encounters.

The costume of the Hawaiian woman corresponding to the malo was the paŭ. This was commonly 25 to 35 inches wide and 9 to 15 feet long. It thus reached from the waist half way down to the knee. It usually consisted of five sheets of cloth of which the four inner were commonly white or yellow, while the outer one was usually beautifully printed with red, yellow and black and then covered with a varnish ( ), according to some authorities, to protect the colors, and to make the cloth more durable and somewhat waterproof. The paŭ worn by the queens at special occasions were so incredibly long that the wearer was at times surrounded by seventy thicknesses of cloth.

A third article of clothing that might better be considered a wrap for wear during cold weather was the kihei. It was worn by both men and women, especially the aged, by passing it under one arm and tying it over the shoulder opposite. Children up to nine or ten years of age went entirely naked.

The Hawaiians used no footwear excepting when traversing some of the flows of extremely jagged and sharp lava on the Island of Hawaii. Then temporary sandals or bandages called kamaa were made of braided kapa, of the bark of the hau ( ), of the leaves of the lā i ( ), or of the leaves of the hala ( ), or of any other suitable material available.

Bed coverings, termed kapa moe or kuinakapa, were used for warmth at night by the higher classes at least. These consisted of five separate sheets of thick kapa, each three to four yards square, sewed together only at one end usually by means of a kapa tape. The kilohana or upper sheet of this set was often elaborately decorated.

Fragments of old kapa were used as wicks in the stone kukui lamps figured elsewhere ( ), while the old kapa moe were stripped into string-like

lengths. One of these was then loosely coiled and lit from the fire that had been ignited laboriously by friction ( ) before that was extinguished. Such strings slowly smoldered on and thus offered a convenient way of relighting their ovens or lamps when necessary.

Kapa was used in the usual marriage ceremony, the bridegroom casting a piece over the bride in the presence of her parents and relatives. Or a chief or friends threw the kapa over both the youth and maiden. If the lovers were of high rank, however, they came in state with their attendants and joined noses, honi, the Polynesian sign of affection, before the assembled multitude amid shouts that the chiefs are married. A luau, or feast, invariably followed these ceremonies.

White or red kapa was used in the heiau, or temples, to clothe the idols, and white kapa was used for the flat sides of tall, obelisk-like structures called anuu built usually of bamboo down which the voice of the god should pass from heaven to the oracle standing within. These anuu were sometimes fifty feet in height and usually four to five feet square. A small white kapa called oloa was placed over the idols while an incantation was made. White kapa on a stick placed in a path or bound around the trunk of a tree indicated that trespassing was forbidden or that the fruit of the tree was kapu.

The making of kapa, according to the old Hawaiians, was responsible for the naming of the Crater of Haleakala. Maui, so the myth relates, lived with his mother, Hina on the western part of the Island of Maui. His mother, who was wont to make kapa, found difficulty in drying her product because the days were so short. Almost as soon as she spread her kapa out to dry, the sun set and she was obliged to take it into the house again. Maui resolved to help her. After a little reconnoitering he discovered that the sun passed directly over the enormous crater forming the central part of eastern Maui. He returned home and then journeyed to Waihee where he cut down all the coconut trees to manufacture a strong rope from the husks of the nuts. Armed with his rope he ascended the mountain again, made a noose, and with it caught one of the sun's larger rays with which she was walking across the earth. This he broke off. He continued catching and breaking the larger rays until only the shorter and weaker ones remained. Now having the sun in his power he threatened to kill her for having traveled so fast. Upon begging for her life and promising to go more slowly hereafter, Maui liberated her. From that time on the days were longer, Hina could more easily dry her kapa, and the crater was called sun snarer. This name should properly be spelled Alehekala in Hawaiian and not Haleakala which means house of the sun. The latter of the cinder cones within the crater is still named after Maui as that is where his exploit is supposed to have taken place.

Today kapa is no longer made in the Hawaiian Islands because all the men and many of the women of native ancestry wear the usual costume of the European. Most of the older women fortunately still adhere tothe custom of wearing the stately ~~white or black~~ holoku, of the "Mother Hubbard" type, introduced by the American missionaries in the early days. This dress, however, is not made of native cloth. The only material for sale in the islands that resembles Hawaiian kapa closely is siapo, the kapa of the Samoans. This may be purchased for a reasonable sum. The buyer should insure the continued making of true native Samoan kapa by refusing to accept pieces that appear to have been colored by other than the native dyes. For want of Hawaiian kapa, a Samoan sample is here inserted as a bookmark.

(33) SANDALWOOD or ILIAHI 1942 96

More than fifteen kinds of true sandalwood exist. All belong to the group known as Santalum which, with about twenty-five other related groups of plants, comprises the Santalaceae or Sandalwood Family. Though of this family the members found in the Hawaiian Islands have been twice monographed, much work must yet be done before we can be certain whether eight or more kinds are peculiar to these islands.

Sandalwoods are shrubs or trees which, with very few exceptions, have a strange method of gaining food. This method is hidden from view until we carefully wash the soil away from one of the plants. Then we see that the roots of this plant, as in most kinds, have ramified in all directions in search of moisture and soil salts carried in solution. But unlike the roots of other plants, some grow toward those of certain neighboring shrubs and trees and actually send sucking organs called haustoria into them. By this means, the sandalwood is able to rob them of some of their food. The result of such partial parasitism over countless generations is that the plant has become degenerate. The leaves are no longer obliged to manufacture the entire supply of food necessary for the plant out of water, air and soil salts with the aid of sunlight falling on the green chemical, chlorophyll, within them. Hence they have become comparatively small, thick and pale green.

The sandalwoods native to these islands are called iliahi by the Hawaiians. All have small four- or five-parted flowers that are either greenish-yellow or red. In the vicinity of Kilauea Crater, particularly along Sandalwood Trail, the Kilauea sandalwood known as Santalum paniculatum Hook. & Arn., may be seen (Plate). This is a shrub or small tree exceeding rarely fifteen feet in height and bearing greenish flowers. Though not particularly attractive, it is worth visiting because of the commercial and historical importance of plants like it. In Koolau Gap within Haleakala ~~Crater~~, ~~on the other hand~~, another grows a very beautiful kind named after the crater where it grows, Santalum haleakalae Hillebr. This bears dense clusters of dark red flowers.

The heartwood of the sandalwood tree has always been highly prized be-

R

cause of its close grain and fragrance. It was particularly valued in the Orient where it was burned extensively for incense, used in ornamental carving and cabinetwork, and used as a repellent against insects. Before the discovery of the Hawaiian Islands by Capt. Cook in 1778 and '79 almost all such wood was derived from the white sandalwood, Santalum album - of the East Indies. But soon after the discovery, the presence of sandalwood growing here in great abundance in the drier regions became known to the world. The Hawaiians, of course, had long known the properties of this wood as their name laau aala, meaning fragrant wood, indicates. They used the powdered heartwood as a perfume and frequently sprinkled it among their kapa ( ) to offset the objectionable odor that was particularly strong shortly after its manufacture.

In 1791 Capt. John Kendrick, a New Englander then engaged in the fur trade between the northwest coast of America and China, left three of his sailors on Kauai to collect sandalwood and pearls for him until his return voyage from Boston. Thus began the sandalwood industry in the islands which grew to huge proportions, being at its height from 1810 to about 1820. Due to the cutting of all trees of marketable size and lack of ~~reforestation~~ reforestation, the industry ended before 1845. It is estimated that during this time from the sale of the wood for export to Canton the Hawaiian Islands were enriched by three or four millions of dollars in money and merchandise, mostly the latter. As the Chinese name of sandalwood is tan heong, meaning fragrant tree, these islands became known to them as Tan Heong Shan, or the Sandalwood Mountains. This was later shortened to Tan Shan.

The sale of sandalwood at $125 and upward per ton was a ready means of obtaining money with which to buy necessities and some of the most extravagant luxuries. It was also acceptable for barter. For example, if a vessel were to be bought, the chief agreed to give an amount of sandalwood in exchange equal to its bulk. A pit was then dug with dimensions equal to the greatest length, depth and breadth of the hull of the vessel desired. This was then filled with sandalwood, which quantity amounted to the price of the purchase.

R

Because of their desire for wealth, the chiefs obliged their retainers to gather sandalwood in great quantities in addition to demanding the same commodity in payment of taxes. They were not only forced to search for the tree but also to fell it, cut it into pieces 18 inches in diameter and from 6 to 8 feet long, and to carry it like so many pack horses to the royal storehouses. As the forests became more and more depleted of these valuable trees, the common people were forced to undergo greater hardships to satisfy their masters' wants. Little time for agriculture remained so that once actual famine threatened the islands. What this industry meant to the common people is clear from a quotation from William Ellis who was staying in the District of Kohala, Island of Hawaii, around that time:

"Before daylight ----- we were roused by vast multitudes of people passing through the district from Waimea with sandal wood. ---- There were between two and three thousand men, carrying each from one to six pieces of sandal wood, according to their size and weight. It was generally tied on their backs by bands made of ti leaves [la i], passed over the shoulders and under the arms, and fastened across their breast. When they had deposited the wood at the storehouse, they departed to their respective homes. ---- Though we had numbered, in our journey to-day, 600 houses, we had not seen any thing like four hundred people, almost the whole population being employed in the mountains cutting sandal wood."

Such unjustly hard labor, for which the common people received little gain, was naturally irksome to them. It is said that during their trips into the mountains, they would surreptitiously destroy many seedling trees to prevent their growth to marketable size. They realized that the fewer sandalwood trees existed, the lighter would be their future toil in cutting them down and carrying the heavy logs to the coast. This is in sharp contrast to the time of Kamehameha the Great, a score of years earlier, who stringently prevented the cutting of the smaller trees, observing that such wood was to be preserved for his successors.

As early as 1816, Kamehameha bought a vessel called the "Forester" from

a Capt. Piggot . Its name was changed to "Kaahumanu", in honor of his favorite queen, and in March of the following year sailed for Canton, laden with sandalwood. Instead of returning filled with Chinese goods, the "Kaahumanu" arrived nearly empty and in debt for $3,000. The failure of this first Hawaiian trading enterprise according to the captain, was that some of the money from the sale of sandalwood had been stolen and that the Chinese had demanded exhorbitant port charges and fees for pilotage. From that time on, port charges were collected from vessels visiting the Hawaiian Islands.

The disastrous end of the sandalwood industry conducted by the Hawaiians is connected with the enterprising High Chief Boki ( ). He accompanied Liholiho, or Kamehameha II, with Queen Kamamalu to England in 1824 where both died of measles, and returned with their bodies to the Islands on the British frigate "Blonde", commanded by Lord George Byron, cousin of the poet. Upon his ~~arrival~~ return, Boki was made Governor of Oahu. ~~Because of~~ During the minority of Kamehameha III, Queen Kaahumanu, the widow of Kamehameha I, was Regent of the Kingdom. Within a few years after his return from England, Boki aspired to greater power than governorship and even drew up an armed force at Waikiki to accomplish his ambition. He was fortunately persuaded almost at the last minute against causing a rebellion and dismissed his troops. When he heard in November 1829 that an island had been discovered in the South Pacific on which much sandalwood grew, his energies and ambition were diverted into fitting out an expedition for colonizing it and wiping out his debts by procuring the precious wood that had become locally scarce.

The man-of-war brig "Kamehameha" and a smaller vessel named "Becket" were selected for the undertaking. Each was well provided with arms and ammunition as well as provisions desired for colonizing purposes. Against the advice and remonstrances of many Honolulu people, the two vessels sailed Dec. 2, 1829, hastily equipped and insufficiently manned with skilled sailors. Almost 500 men had enlisted as soldiers, sailors and attendants. Among this number were some of the most energetic and venturesome Hawaiian youths and ten foreigners as navigators, some of the latter being utterly unscrupulous

footnote

99a

The missionaries represented the sounds of the Hawaiian language by the only letters a, e, i, o, u, h, k, l, m, n, p and w. In general, these letters were pronounced as in German, ~~K~~ or Spanish. ~~and t, and l and r were somewhat interchangeable~~ K was sometimes interchanged with t, and l with r due to the fact that the Hawaiian language really had two sounds, one being intermediate between each of these pairs of consonants. In the speech of the natives on some islands these two sounds approached k and l, while on the remaining islands they approached t and r. Only after the unification of the Hawaiian Islands under the rule of Kamehameha I did the language become more uniform. The absence of the letter b in the Hawaiian language yet its presence in the name of a Hawaiian chief needs explaining. Kahekili, an enemy of Kamehameha, owned several dogs trained to attack men. These he had procured from foreign ships. While one of these English dogs, answering to the name of Boki, was at its height of fame among the natives for its exploits in battle, the chief was born. He was accordingly named in honor of the dog.

adventurers. On the "Kamehameha", commanded by Boki, about 300 men were crowded for the long voyage through the tropics. On the small 100 ton "Becket", commanded by Manuia, a trusted follower of Boki, the remaining 179 men were obliged to live. The expedition was first to stop at the small island of Rotuma, one of the New Hebrides north of Fiji, before continuing to the larger sandalwood island called Eromanga.

Boki in his vessel arrived at Rotuma first. He treated the natives of the island with harshness, forcing them to cut sandalwood for him, while his companions became discontented due to the hardships of the undertaking. After completing his preparations on Rotuma, Boki and his followers set out for Eromanga, which was distant but a few days' sail. From that day on, no sign of the "Kamehameha" or of the 300 men has ever been seen. All perished. It is probable that either the powder was accidentally ignited by a careless smoker and the vessel blown to pieces with all on board or that she struck some unknown reef and foundered. The "Becket", on the other hand, arrived at Rotuma Island ten days after the "Kamehameha" had left it, and, not finding her there, sailed on to Eromanga to meet her. Here Manuia and his followers waited in vain for the "Kamehameha" whose fate could only be conjectured, and committed various outrages on the natives which lead to frequent hostilities. At length a disease broke out among the voyagers of which many died, including the commander, Manuia. After a five weeks' stay on Eromanga, during which nothing was accomplished, all but a few of the survivors set sail to return to Oahu. In addition, forty-seven natives from Rotuma embarked as passengers. Crowded with the sick and the dying, the "Becket" slowly crept toward home. Due to lack of medicines and insufficient food and water, the wake of the vessel was strewn with corpses. Finally crazed by the agonies of famine and thirst, it is reported that the stronger cast the dying as well as the dead overboard. On August 3, 1830, the "Becket" arrived in Honolulu with only 20 survivors, and of these 8 were foreigners. Thus ended the sandalwood expedition as a national disaster. A desultory trade in Hawaiian sandalwood lasted about ten years longer when it ceased entirely with the forests despoiled of ~~practically~~ nearly every tree.

(34) 104c (HAWAIIAN MISTLETOE, HULUMOA or KAUMAHANA 101
known as hulumoa or kaumahana to the natives.

The Hawaiian Mistletoe, belongs to the Loranthaceae or Mistletoe Family, a family apparently derived from the one to which the sandalwood belongs. Some excellent specimens may be seen most conveniently in the Bird Park, or Kipuka Puaulu, a few miles from Kilauea Crater on the Island of Hawaii. The herb is rather interesting as it shows us what has happened to a race of plants like the sandalwood as a result of concentrating on a parasitic means of existence.

The sandalwood, as described in the preceding pages, usually robs neighboring plants of some of their food by means of sucking organs, or haustoria, attached to the roots. The mistletoe has gone a step a further. It is a plant whose roots have degenerated to such an extent that nothing remains excepting one highly developed haustorium. This is attached not to the roots of its host, but to one of its branches. In addition to the loss of its roots, the mistletoe has lost its leaves, though the nodes where they once were borne, are still visible as joints. The leaves have gradually dwindled away from generation to generation ~~mainly because of~~ for two chief reasons, which They expose too much surface to the drying influence of the air for plants who gain a comparatively meager supply of moisture from their hosts. They have become superfluous, for in addition to the nourishment which is derived from the host, the stem by flattening out and exposing more surface to the light, has taken over their manufacture of plant food. The result of such changes ~~produced~~ is the cactus-shaped mistletoe figured on Plate .

The mistletoe bears distinct pistillate, or "female", flowers and staminate, or "male", flowers in minute clusters at the joints, or nodes. After pollination has occurred, the pistillate flowers develop into small globular fruits that are ~~considered edible~~ eaten by certain birds. After their meal, these scatter the sticky seeds, without design, from tree to tree. Provided the seeds have reached a plant that is suitable as host, the seedling growing from it bores into the bark for nourishment and then, finally, produces its green, jointed branches. These parasites are, of course, injurious to the host upon which they feed but seldom cause its death as that would involve their own.

R

9) Not all the mistletoes in the Hawaiian Islands are ~~not~~ of the same shape nor do all grow on the same kind of host. Some have extremely flat branches, while others have them almost round. Some are found growing on a plant called Straussia, as the upper part of the plate clearly shows; others, for example, grow on Elaeocarpus. How many of these differently shaped mistletoes owe their characteristics to the type of juice they absorb, either from one host or from another, is not yet definitely known. Nor are we sure on how many different kinds of trees and shrubs a certain mistletoe can live. We do know, however, that the Hawaiian plants ~~do not~~ belong to the group called Viscum ~~as stated in the older books. What each must be called~~ is not in the province of this Guide but in that of the Flora, which discusses the correct name of each kind of Hawaiian mistletoe.

About one hundred fifty kinds of dock or sorrel, known scientifically as Rumex, are found throughout the World. All belong to the Polygonaceae or Buckwheat Family. Five or six of these may be seen in various parts of the Hawaiian Islands

The Sheep sorrel, Rumex acetosella L., may be found along the roadside, particularly near the Military Camp in the Kilauea Section of the Park. It grows also within Haleakala Crater on the Island of Maui. The seeds of this plant were, no doubt, accidentally introduced from Europe by way of America probably in fodder imported for cattle. This sorrel may be distinguished easily from other kinds of Rumex because its "male", or staminate, flowers and its "female", or pistillate, flowers are borne on separate plants. It also differs in being small, rarely exceeding one foot in height, and in possessing spear-shaped leaves of pleasantly sour taste. These can be cooked and eaten like spinach.

Rumex giganteus Ait., (Plate), the pawale of the Hawaiians, and its varieties are native to these islands. Plants may be found growing on the inner slopes of Haleakala Crater ~~XXXXXXXXXXXXXXXXXXXX~~, in the Crater of Kilauea and notably in Kilauea-Iki.~~XXXXX~~ They grow well in the crevices of cliffs and on extremely arid and barren lava flows where few other plants are able to gain a foothold. In such places they are stocky, upright shrubs several feet in height. In the wet forests in the District of Kohala on the Island of Hawaii, ~~on the other hand,~~ some plants have been found with stems thirty feet long clambering over the bushes and small trees in a way that is reminiscent of the climbing grapes of the Eastern United States.

It is probable that the Hawaiians in the early days used the pawale as a remedy for some skin disease common to these islands. Then when leprosy gained entrance here around 1840 with the return of a native chief who had contracted the disease abroad, the Hawaiians employed this same medicine as an alleged specific

R

against that malady. It was prepared by taking the clean bark, stripped from the root, and boiling it for about four hours. This was then mixed with awa (~~[illegible]~~) and administered to the leper in small doses. This boiling was accomplished in the typical Hawaiian way. As the natives possessed neither earthenware nor metal dishes but only wooden ones or calabashes, both of which are inflammable as well as poor conductors of heat, they naturally did not expose them to the fire. Instead, they would drop clean, red-hot stones into the liquid contained in the vessel to bring it to a boil.

The Curly Dock, Rumex crispus L., (Plate), grows along the roadside near the Hilo entrance to Hawaii National Park. This plant, like the sorrel, has been accidentally introduced into these islands. It is conspicuous because of its slender flower stalks that become one to four feet tall. The plant can be readily distinguished from all others by the crisped or wavey margins of its oblong leaves, as the plate clearly shows.

The flowers of Rumex bear no petals, but instead have six inconspicuous sepals arranged in two whorls of three each. The single large seed that forms in the ripening pistil never leaves the latter. The pistil merely fries around it, furnishing it with an additional protective covering. In the sorrel, the sepals do not enlarge as the seed matures. The plant, consequently, has no special method for being disseminated. ~~In the case~~ However, the giant dock peculiar to these islands, the inner sepals develop into wings that completely hide the seed from view as fig. on Plate will show. The resulting structure, called botanically a fruit, is now adapted for distribution by the wind, probably rolling over the ground for a considerable distance before lodging in some crevice where the seed may germinate. The fruits of the curly dock are still more highly specialized for distribution. Each of the three inner sepals not only grows into a wing as in the case of the Hawaiian plant but develops a cork-like swelling at its base. This is clearly shown in fig. of Plate . Now if the wind should carry the fruit into a stream or lake, it will not sink to die at the bottom but will most likely ~~float to some distant shore~~ drift ashore where its central seed can

over A

germinate and produce a new plant. Some foreign kinds of Rumex have even developed hooks upon their fruits, thus enabling the seeds not only to be disseminated by wind and by water, but by animals in whose fur the hooks may catch.

SILENE or CATCHFLY

About 250 kinds of catchfly grow throughout the world, more than half a dozen being found in the Hawaiian Islands. All comprise the group known as Silene, belonging to the Caryophyllaceae or Pink Family.

Silene struthioloides and its variety are catchflies typical of the volcanic regions on Hawaii and Maui only. They grow in ash and in cinders where no other plant except the silversword ( ) can thrive. In the Kilauea Section of the Park, the plants may be found in considerable numbers between Keanakakoi Crater and Halemaumau, while an occasional one may be observed near Uwekahuna Observatory and elsewhere. In the Haleakala Section, they are most numerous in the bottom of the crater near the cinder cones.

This Silene, growing in extremely arid ground usually more or less impregnated with salts, has been obliged to curtail its requirements for water. It has accomplished this by reducing the number and size of its leaves, organs through which most of the water within a plant is given off. Consequently, , the plants near Kilauea resemble dead twigs, one to three feet high. Closer examination, however, shows that they are alive, bearing awl-shaped leaves toward their ends and sometimes clusters of pale flowers that open only at night. The Haleakala plants, one of which is here figured, have a slightly different aspect, being low and extremely compact in form.

The Silene are called catchflies because the stems of most kinds bear hairs that exude a sticky substance by which insects, attempting to crawl to the flower for nectar, are caught. In this way, the plants prevent unnecessary waste of pollen and reserve it for other visitors. Insects crawling from one flower probably would drop most of the pollen adhering to them before reaching another flower. In the case of flying insects, like moths, no such loss would occur.

(38) BUTTERCUPS typical of 106

The Ranunculaceae or Crowfoot Family is ~~primarily represented in~~ temperate and cold regions of the northern hemisphere. When any of its members are native to the tropics, they usually grow at considerable elevations where the temperature is low. Thus in these islands only two native members of the Crowfoot Family are known and neither one has been collected below an elevation of 2000 feet. Moreover, two members of ~~XXXXXX~~ recent, accidental introduction grow above 3000 feet. All these plants, curiously enough, are buttercups, known botanically as Ranunculus.

The Maui buttercup, Ranunculus mauiensis A. Gray is found on all the larger islands of the group, being especially numerous in the Kokee region of Kauai. It has not yet been collected within the boundaries of the National Park.

The Hawaii buttercup, R. hawaiiensis A. Gray, here shown, is limited to the Island of Hawaii and to the eastern part of the Island of Maui. It has not yet been found in the Kilauea Section of the Park but may be seen on the moister grassy slopes of Haleakala as well as within the crater near Koolau Gap. It is an erect, coarsely hairy herb two to four feet high having a hollow stem. The leaves are divided into three segments and each of these, in turn, has the tendency to split again into three more. The flowers are terminal, yellow, and rather small.

The creeping buttercup, R. repens L., a native of Europe and possibly of western North America, was accidentally introduced, probably in impure vegetable seed, shortly before 1922 near the Kilauea Section of the Park. As it has overrun large patches of ground not far from the Hilo Entrance within eight years, this weed may become a part of the Park's introduced flora in the future. The plant may be recognized by its extensively creeping habit, bright yellow flowers almost one inch in diameter, and three-divided leaves marked with light green areas.

The spiny-fruited buttercup, R. muricatus L., is a native of Eurasia but has become extensively naturalized in North America. In these islands it was

first discovered in 1922 growing in the pastures not far from the Hilo Entrance of the National Park. By 1930 it had spread extensively and was growing in large patches in the Bird Park, or Kipuka Puaulu. This plant likewise is of accidental introduction. It is an upright, hollow-stemmed herb becoming two to three feet high. It bears small flowers which, upon further development, produce seed-like fruits differing from those of all the other buttercups found in the islands by being beset with small spines.

The buttercups are interesting representatives of rather primitive flowering plants. By studying them and their still simpler relatives, one gains a clue to the general way in which true flowers have evolved in the Plant Kingdom. A flower is, apparently, the greatly shortened upper part of a branch which in former ages bore an indefinite number of highly modified leaves in spiral arrangement. Those toward the apex originally bore ovules, or unfertilized and undeveloped seeds, freely exposed to danger. They were attached to the margins of the leaves in a manner very similar to that observed in the leaves called megasporophylls (fig. a) found in the "female" cycad or "sago palm" planted in gardens in the Hawaiian Islands and in other warm countries. Though no irrefutable proof is at hand, it is the belief that such ovules finally bent in for protection toward the upper surface of the leaf to lie just within its margin. Thereupon the two halves of the leaf folded together along the midrib as the diagram (fig. b) indicates. The resulting structure (fig. c) was called a carpel and closely resembled the pod of a pea with its enclosed seeds. To derive the one-seeded carpel of the buttercup shown adjoining it (fig. d), we must imagine that the pod had decreased in size and that the number of ovules within had been reduced to a single one.

Below the series of carpels, the hypothetical stem bore numerous leaves, each bearing pollen-producing anthers. These leaves obviously are today represented by the stamens. In the case of the buttercups, there is considerable evidence to indicate that some of the lowest stamens flattened out and became colored petals. In many other types of plants, on the contrary, leaves below the staminate ones, by becoming showy, developed into petals. Petals, consequently, are not homologous structures in all kinds of flowers; in some are

~~cases being~~ modified stamens, ~~while in~~ which others are merely colored leaves that ~~had~~ never passed through a staminal stage in their evolution.

Below the petals comes a series of leaves that are the least modified of all. They are called sepals. They are usually green and protect the more delicate parts of the flower above them.

In comparing the buttercup flower with the hypothetical shoot mentioned above, we observe that the individual parts of the former are arranged spirally on a steeply conical base, as the longitudinal section of the flower shows (Fig.). This is to be expected in an organ that stands at a comparatively low stage of evolutionary development. The floral parts are spirally and not cyclically arranged as in more highly evolved flowers, because a spiral arrangement is the primitive position of leaves on a stem. And the common base of the floral parts of the buttercup is conical and not flat as in more highly evolved plants, because the stem bearing these structures has not yet shortened to a flat disk - the stage beyond which it can shorten no more.

The different members of the buttercup flower vary considerably in number, even in flowers on the same plant. This also is a primitive feature. This shows that the flower has not yet become stereotyped in structure. Its floral leaves vary in number on its shortened stem just as foliage leaves may vary in number on a sterile shoot of a certain definite age.

The carpels in the buttercup are numerous and distinct, while in the flowers of most other plants they are not only reduced in number but the few remaining ones have usually grown together so that their individuality is not apparent without dissection.

The native buttercups were apparently of no special use to the Hawaiians. They were known as mākou, or less commonly as awakanaloa.

Some extinct member of the Sandalwood Family by concentrating on a parasitic means of existence gave rise to the mistletoe as previously described ( ). Some extinct member of the Morning Glory Family, in a similar manner, gave rise to the dodders of which two kinds are native to the islands though not found within the Park. A third family which has thus adopted a parasitic mode of life is the Cassythaceae or Love-Vine Family, which is derived from some now extinct member of the Lauraceae, the family to which the avocado belongs.

One of the representatives of the Love-Vine Family is Cassytha filiformis L., a native of the Hawaiian Islands as well as most tropical countries. The plant prefers dry, hot districts and therefore does not grow above an elevation of a few thousand feet. Within the boundaries of the Park it can be found only on the lava plains adjoining the sea south of Kilauea Crater. A striking station for this plant, easily observed by Park visitors driving around the Island of Hawaii, is the aa lava flow that crosses the government road about five miles south of the old Pahala sisal plantation. Here the plants can be seen in their best development.

The cassytha is a rootless vine devoid of foliage. Its leaves have degenerated into useless scales and no longer function to manufacture plant food. Instead, the slender branches sink haustoria or sucking organs into neighboring shrubs such as the lantana here shown (Plate), the guava and the plectronia, to rob them of food. It sometimes happens that one branch of a cassytha may sink its haustoria into another branch so that the individual plant may be parasitic on itself as well as on other kinds of plants. The cassytha often covers its host with so many of its slender thread-like branches that the latter may appear as though covered with a coarse, green fish net.

That cassytha is closely related to the Lauraceae or Laurel Family is apparent on comparing their flowers with those of the avocado, a typical representative of the Laurel Family. The stamens of the cassytha even dehisce in the same peculiar way by means of minute valves which open from below upwards. The fruit of the cassytha is a spherical structure consisting of the ripened ovary surrounded by the fleshy, united bases of sepals and petals. These fruits are probably eaten by birds which aid in the dissemination of the plants.

OVER

The cassytha must not be confused with the dodder, an entirely different plant. Both parasites superficially resemble each other because both have perfected themselves for the same unusual mode of existence. In flower structure they are strikingly different. For the casual observer, cassytha can be distinguished from the dodder by having green branches tinged with yellow or orange. Those of the dodder are yellow without the slightest shade of green.

15

#40 HAWAIIAN POPPY or PUAKALA) 10¢ Stop!!

When Capt. Cook reached the Island of Hawaii in 1779, he noticed a conspicuous herb belonging to the Papaveraceae or Poppy Family growing in the lowlands, especially in very dry localities. This plant was called by the natives puakala, pua meaning flower and kala, thorny. Later the settlers, and even most botanists, named it the Mexican Poppy, mistaking it for a plant with yellow petals native to tropical America. This was an unfortunate error as the puakala is peculiar to the Hawaiian Islands, having, however, a close relative native to Florida and a more distant one native to Colorado. Instead of continuing to call the plant by an inappropriate name, it should be known henceforth either by the Hawaiian name of puakala, by the corrected English name of Hawaiian poppy#, or by the scientific name of Argemone glauca. as soon as published with Flora Hawaiiensis —.

The puakala is a striking herb, as (Plate shows), two to five feet tall. Its stem and leaves are densely beset with prickles that are so sharp that both man and beast avoid touching them. The plant is also covered with microscopic granules of wax that impart a powdery appearance or bloom, ~~to it~~. This hinders evaporation and thus aids the plant in growing in dry regions ~~where water is scarce~~. The flower buds are also beset with prickles and covered with this bloom. When they are about to open, the sepals do not spread apart as in other plants. They remain united and are torn from their base by the swelling petals. As these unfold to attract insects by their brilliant whiteness, the hood-shaped sepals fall to the ground.

Like all members of the Poppy Family, the puakala contains abundant milky juice of yellowish color. This harbors most of the narcotics found in the juice of the opium poppy. It speaks well for the medical lore of the early Hawaiians that they were accustomed to use this plant to deaden the pain from toothache, thus practicing in a crude way ~~a method~~ which the dentist today ~~has learned to refine~~. The natives merely pounded the rind of the plant, heated it and then placed it on the aching tooth. To remove warts, the juice of the stem was placed upon such growths and exposed to the sun. As soon as the juice had dried a second application was made and allowed to

refine / methods of

OVER

dry. This was repeated several times with the result that the wart finally sloughed away.

According to the recommendation of the American Joint Committee on Horticultural Nomenclature in Standardized Plant Names, 1924, the common name for Argemone should be pricklepoppy. But here that name has been displaced by the simpler poppy for the sake of euphony, no danger existing as to what plant is implied as no other native member of the Poppy Family exists.

(41)

BROUSSAISIA or

The Broussaisias, known by some Hawaiians as , belong to the Hydrangeaceae or Hydrangea Family. Only two kinds are known and both are found exclusively in the Hawaiian Islands where they thrive in wet forests. They are usually small, shrubby trees with thick branches hairy toward their ends. The two kinds can be readily distinguished from one another. Broussaisia arguta Gaud., has its leaves in opposite arrangement on the stem while B. pellucida Gaud., as the accompanying drawing of leaves and leaf scars shows, has them in whorls of three each. The latter plant is rather quite common in the denser forest of the Kilauea Section of the Park.

The Broussaisias exhibit two general principles that find expression in many plants. Namely, they have condensed their flowers into compact clusters, and they have made their flowers unisexual.

The Broussaisias bear small, inconspicuous flowers. If these were to stand alone in the axils of the leaves, they would be rarely noticed by insects, and those insects that might notice them would be seldom induced to visit them for the small quantity of nectar secreted. Thus the plants would lose many opportunities of having their flowers cross-pollinated to insure the production of seed. To make up for such a defect, the flowers are massed together into large, terminal clusters, which, by sheer size and position, command attention. Insects, especially flower beetles and wasps, now visit them and with ease satisfy their hunger with the nectar secreted in a single cluster.

In the Broussaisias we have plants that are just on the point of perfecting their flowers into unisexual structures. In studying them, therefore, we solve the mystery as to how the unisexual flowers had originated in Freycinetia ( ), Coprosma ( ) and in many other plants. The Broussaisia plant depicted on Plate bears only staminate or "male" flowers. These consist of five minute sepals, five whitish petals often tinged with red, ten well developed stamens and one degenerate pistil in the very center. The latter never

OVER

produces any seed and is apparently of no value to the plant. It is a worthless relic of the past that shows that one and the same flower in the Broussaisia of early times had produced seeds as well as pollen. In future ages, the staminate flowers of these plants probably will lose their degenerate pistil entirely. The pistillate flowers of the present Broussaisia, in contrast to the staminate, have apparently already reached perfection. They possess well developed pistils but lack even rudimentary stamens. From this we can safely conclude that unisexuality in flowers in most cases has originated by the progressive abortion of one of two sex organs originally borne within them.

(42) UULEI Note 112

The uulei of the Hawaiians is Osteomeles anthyllidifolia (Smith) Lindl. It is a member of the Rosaceae or Rose Family and not far removed in relationship from the hawthorn and the common apple. The plant is peculiar to the Hawaiian Islands where it grows in the drier regions below an elevation of about 4,000 feet. It is one of the more common plants of the Kilauea Section of the Park.

The uulei is a woody plant with compound leaves and clustered, white flowers resembling those of the apple. These at length develop into small, whitish, somewhat sweet fruits, each containing five stones. Usually the plant is a straggling, much branched shrub creeping over the ground or rising to a height of a foot or two. But in the aa ( ) lava flows along the government road in the districts of Kau and Kona, Island of Hawaii, the plants develop into trees a dozen feet high.

The uulei has very strong but pliable wood. Its long branches were therefore stripped of their bark and tied to the rims of fish nets, acting like a hoop to keep them open. In this way, for example, the Hawaiians constructed their nets for catching the opelu, a fish that swims in schools and is a favorite for eating raw either when freshly caught or after it has been dried in the sun. A net about 25 feet long was prepared by sewing it in the form of a huge bag. To the upper rim of the wide mouth a series of long, slender branches of the uulei were fastened to keep it gaping. This was then lowered on ropes in moderately deep water by the fishermen in their outrigger canoes. In the meantime, raw, grated taro had been cooked and tied in kapa ( ). This was then lowered as bait on a string into the sea so as to hang midway between the surface and the bottom. When a school of opelu had been attracted by the taro, the net which had been hanging below the bait, was carefully raised toward the surface. The enclosed fish, frantic with fright when one of the fishermen jumps in among them, dart in all directions and are caught by their gills in the meshes of the net.

The opelu and the aku, a kind of bonito, were connected in an interesting way. In January a human sacrifice and an aku were offered together at the

heiau, or temple, where a man who personified a god gouged out and ate an eye of each. From that day on, the opelu was kapu, or forbidden to be eaten on pain of death while the aku was noa, or free to be caught for food. Six months later, namely in July, a more elaborate ceremony was performed for which, however, no one was sacrificed unless, of course, he failed to observe the required religious regulations. During part of this ceremony the head fisherman, dressed in a new, white malo ( ) and furnished with a new net, put out to sea. As soon as he and his crew had made a haul of opelu, they paddled to shore. Here the leader carried seven of the fish to the priest who sent some to the king and placed the rest in the heiau. After more ceremonies were performed in which the right eye of the opelu was eaten, the kapu was lifted from that fish for the following six months and imposed on the aku instead. These two ceremonies were repeated year after year.

(43) 10½

HAWAIIAN RASPBERRY or AKALA and its relatives

No one knows how many different kinds of blackberries, dewberries and raspberries exist in the world. Some authorities have estimated that there are about 200, while others maintain that more than twice that number occur. This uncertainty is due to the fact that many kinds are extremely variable and that some readily produce hybrids with others, and that these hybrids may or may not resemble their parents closely. The student gathering a specimen, therefore, may not be sure whether he has found a hybrid, a new kind of plant, or an unusual variation of a plant already well known. All botanists, however, are agreed that these plants belong to a single group named Rubus which belongs to the Rosaceae or Rose Family.

A blackberry, ~~known as Rubus~~ _____, introduced into these islands from continental America before 1900, has escaped from cultivation and may now be found on western Oahu, on Maui along the Olinda Pipe-Line Trail just below the Haleakala Section of the Park, and on Hawaii in the vicinity of Kilauea. The plant has white flowers like most kinds of Rubus. It grows in the cool, open forest and is yearly becoming more numerous. Though producing an abundance of palatable black fruit in summer, these thorny shrubs should be hindered as much as possible from spreading because of the indication that otherwise they may become obnoxious weeds.

Another introduced Rubus is the Rose-leaved Thimbleberry whose botanical name is Rubus rosaefolius Smith, not R. jamaicensis as stated by previous writers. This plant is a native of the Orient but unfortunately has been introduced into almost all the larger islands of this group excepting Molokai. Like the blackberry, it bears white flowers, but, unlike it, it produces fruit ~~practically~~ throughout most of the year. It thrives from sea level to an elevation of 5000 feet or more and is ~~quite~~ rather common in the forest and clearings around Kilauea. A disease of leaves and stems caused by a microscopic fungus, however, killed a great number of the plants in 1926 and may continue to check the rapid increase of this plant in the future. The bright red fruits ~~are~~ is

edible but lack the delicious flavor common to the fruits of many other kinds.

Two native raspberries, named akala by the Hawaiians, are found in these islands at higher altitudes. Both produce pink flowers and therefore can be differentiated at once from the introduced blackberry.

Macrae's Raspberry or akala, Rubus Macraei Gray, is comparatively rare. It may be seen sprawling over the fog-drenched moss at the head of Koolau Gap, the most interesting spot botanically within Haleakala Crater. This plant produces enormous but little fruits of no economic value to man because of their bitterness.

The Upright Hawaiian Raspberry or akala, known as Rubus hawaiiensis Gray, shown on Plate , is a perplexing plant. Along the Olinda Pipe-line Trail on Haleakala, where it is very common, some of the plants bear prickles on their stems while others are entirely unarmed. In a third type, the prickles drop from the stems in a year or two. Apparently this raspberry is on the point of splitting up into two or more distinct kinds. It is conceivable that if one of these unarmed plants, for example, should in some way become isolated from the prickly ones and be able to reproduce, its offspring would in time evolve into a new kind of raspberry that would never bear prickles. Possibly this is now coming to pass. The stems of all the raspberries seen growing on isolated Molokai lack prickles. There were one exception, and this ~~Only once were they observed, and these~~ occurred on an abnormal sprout that had probably reverted to the ancestral armed condition so characteristic of most of the plants on Maui. On the Island of Hawaii, other variations may be noted. Some plants bear yellow fruit while the typical color on that and all the other islands for them is a very dark red. Only a very few akalas grow in the neighborhood of Kilauea, probably because the altitude is rather low for them.

The fruits of this Hawaiian Raspberry or akala sometimes attains two inches in length. They are juicy but vary considerably in bitterness. This makes some of them unfit for food. They also possess slightly laxative qualities if eaten in great numbers. Because of the ability of these shrubs to flourish here and because of their unusually large, juicy fruit, Dr. Willis

T. Pope of the Federal Experiment Station in Honolulu has been growing and hybridizing Rubus hawaiiensis since 1928 with various raspberries native to North America. By this method a cross may be developed which should flourish in this climate, and at the same time bear fruit that is large and juicy like that of its native Hawaiian parent and yet possess the delicate flavor of its continental one. Such an undertaking is by no means visionary. We owe the existence of most of our best fruits, vegetables and ornamentals to the success that rewarded the patient industry of horticulturists, like Burbank and many others.

The Hawaiians in the early days no doubt ate the akala when on their infrequent trips into the cold and usually wet mountains. It is definitely known that they prepared a dye for their kapa from the juice of the fruit of the Hawaiian Raspberry, and that they even manufactured kapa cloth of inferior, yet not poor, quality from the bark stripped from its stems and from those of its relative. Kapa, however, made from the bark of the wauke and mamaki was superior

There are several varieties and forms of the koa, varying in the shape of their flowers, leaves and pods. They are found exclusively in the Hawaiian Islands. ~~while~~ Related plants, however, are found ~~quite~~ rather common in Australia where they are known as wattles. Botanically, our plant is known as *Acacia koa* A. Gray, and belongs to the *Leguminosae* or ~~Legume~~ Pea Family.

The koa is one of the largest trees of the islands, inhabiting usually the drier forests between an elevation of 1000 and 6000 feet. Many of the trees are over 70 feet high. Near the Kipuka Puaulu in the vicinity of Kilauea Crater stands a dying giant which in its prime had a height of ? and a girth of ? feet. The flowers of the koa are pale yellow, have five ~~equal~~ petals, which are of equal size, and are massed into small, spherical clusters. ~~In~~ The flower structure ~~the plant~~ is therefore simple in comparison to the other legumes figured, the latter having their petals of different sizes so as to protect the stamens and pistil from injury.

Though primitive in flower structure, the koa is highly evolved in leaf shape. The leaves are normally falcate. But in searching diligently for seedlings and for water sprouts, one will usually find a second type of leaf, similar to the one shown near the bottom of Plate , which consists of a stalk bearing about eight leaflets. The reason for the ~~occurrence~~ existence of these two types of leaf on the koa seems clear.

It is certain that the early ancestor of the koa habitually bore compound leaves, namely leaves consisting of a stalk, or petiole, and a certain number of leaflets. As time went on, the environment inhabited by this kind of plant became arid. In order to thrive under these changed conditions, the offspring of these plants were gradually obliged to reduce their leaf surface, thus conserving water which otherwise would be lost by evaporation. After living under these conditions for probably hundreds of ~~millions~~ thousands of generations, the plants ~~had~~ retained only the round petiole of the leaf ~~remaining~~. When the climate became wetter again, these desert plants with reduced leaves were at a distinct disadvantage. Many, doubtless, became extinct while others were stimu-

lated to increase their leaf surface again to meet the changed conditions. Because they had long lost the ability normally to produce their old type of compound leaf again, the plants from generation to generation gradually flattened out their petioles to simulate true leaves. At the present day, these curiously modified plants are the Hawaiian koa with their strange sickle-shaped leaves, termed phyllodes. The seedling koa reverts to the normal leaf-character of its distant ancestors and produces compound leaves. Water sprouts and branches arising from injured areas on the mature trees frequently revert to the ancestral condition likewise. One may find all gradations from a true, compound leaf to a perfect phyllode on the same twig.

The Hawaiians made their calabashes, or umeki, from the kou tree ( ) and practically never from the koa because, according to a recent publication, it imparted a disagreeable flavor to food stored within it. For souvenirs, however, umeki are now commonly made of koa wood and then given a shiny polish which the Hawaiians never attained. The Hawaiians did make use of the bark of the koa, however, as a dye for kapa ( ).

The koa was at times used for the timbers of their houses ( ), but its prime importance, however, was in the making of canoes, of which the Hawaiians had not only single kinds, kaukahi, but even double kinds, kaulua, which consisted of two canoes lashed together in a special way. Of these two fundamental types, there were many modifications to suit special needs. They ranged, for example, from small, narrow, single canoes, the kiloa, well-fitted for the use of one fisherman, to single or double, war or travel, canoes, the peleleu, used in war or for long voyages. The canoes small enough for one to six or eight men to handle were -- feet long and very narrow, being scarcely twelve inches wide at the broadest part. They were about two feet deep. The war and travel canoes were usually about fifty feet long but some were 100 and even 150 feet long and had a depth of 6 to 12 and even 15 feet. Such canoes were 1 to 2 or more feet wide. All were invariably hollowed out from a single log. Some of the largest and most famous war canoes were made from the trunks of giant evergreens that had been carried by ocean currents and winds from the American coast to these shores.

Before making a canoe, the Hawaiians employed a kahuna, or priest, to offer prayers and sacrifices to Ku, the long-bearded god of canoe makers, that the work should be successful. Then the kahuna aided the men in selecting a suitable tree in the forest. This was laboriously felled with stone adzes ( ) and then roughly hewn into shape with the same tools. If the elepio (Chasiempis sps.) or the native crow, alala (Corvus hawaiiensis Peale), were to settle on the log, this was considered an ill omen and work on it abandoned. Another tree was sought in its place. If all went well, the shaped log was dragged with ropes of hau ( ) bark to the coast to be hollowed out further. Finally it was smoothed and polished by rubbing it with the olae or kawaewae, a

piece of abrasive lava or coral. After all the preliminary work had been completed and the canoe had returned from a preliminary excursion out to sea, the kahuna was again called to offer suitable prayers and to sacrifice a hog, or in case the canoe was to be of considerable importance, a man.

The part made from the koa trunk was the waa. To this a gunwale or rim, termed moo, six to eight inches high, was accurately sewed or fastened with wooden pegs. This was made of the more durable ohia ( ) or of the yellow ahakea (Bobea sps.), so that the paddles might rub here without much damage to the canoe. Additional pieces of thin wood of koa, breadfruit ( ), tamanu kamani (Calophyllum inophyllum L.), or kukui ( ) were attached to both ends of the canoe to deck them over for several feet. These formed a prow, manu mua, and a stern, manu hope, each rising at the extreme end to a height of about 15 inches.

As these round-bottomed canoes were very narrow compared to their width they always had an outrigger, or ama, attached to them. This consisted mostly of a piece of hau ( ) or wiliwili (Erythrina monosperma Gaud.) wood, both being almost as light as cork when dry. It was half to two-thirds the length of the canoe, round, slightly upcurved at the middle, and turned up at the ends. It rested on the water parallel with the canoe at a distance of 5 to 10 feet. It was attached by means of coconut husk fiber ( ) to the ends of two downwardly curving yokes, the iako, of light wood that, in turn, were fastened at the top to both sides of the canoe near the ends (fig.). The buoyancy of such an outrigger prevented the canoe from turning over toward it while the weight of the outrigger and the two iako prevented the canoe from tipping in the opposite direction. These canoes were frequently furnished with sails made of pliable hala bracts ( ). Instead of being wide at the bottom as were those of other races, these sails were wide at the top and narrow below.

The bodies, or waa, of the canoes were generally covered with a black paint made of the milky juice of a native Euphorbia relative mixed with the juice of the inner bark of the kukui root, the juice of the bud of the banana ( ), and charcoal derived from hala leaves. Thereafter, the wood was rubbed with oil derived from kukui kernels. To such a black body, the unpainted, usually yellow moo gave a pleasing contrast.

The paddles of the Hawaiians were usually of koa. These consisted of a

rounded ~~handle~~ shaft 3 to 4 feet long and a thin blade 12 to 18 inches long and 8 to 12 inches wide. They were held by one hand near the blade and by the other hand at the ~~extreme~~ upper end of the ~~handle~~ shaft. The paddlers made rapid, regular strokes, first all on one side of the canoe and, at the giving of a signal, all on the other. At each stroke, they raised their heads erect and lifted one hand high to throw the paddle blade forward beside the canoe before dipping their blades into the water and sweeping them back in unison. Such a craft was steered by a common paddle, held by a man sitting in the stern. In ~~case of~~ double canoes, one steersman sat in each canoe.

In double canoes, the second canoe really took the place of the outrigger. For long voyages, as remarked before, each of these might be 100 to 150 feet long. Between them a curved platform, called pola, was built three to four feet above the surface of the water. This was covered and often shaded with mats. The paddlers sat in the canoes while the passengers remained on the pola. Such complicated rafts often carried chiefs and retainers to wait on them, priests with their idols, astrologers, and musicians for entertainment. Enough food was taken to last for many weeks, gourds filled with water and fresh coconuts ~~serving as~~ provided drink. Livestock, consisting of pigs, dogs and chickens, were also carried along.

At times as many as fifteen such double canoes formed a fleet. ~~It~~ During the day, as they sailed or paddled along, they spread in a broad line so as to increase the chance of seeing islands. At night the canoes kept close together to avoid separation. To return, for example, to the Island of Hawaii which had been visited previously, these bold navigators made use of ~~several~~ an ingenious sextant. While in Hawaii they noted the exact height of the North Star above the horizon. A gourd calabash was taken and four holes drilled into its sides at right angles to each other. The upper part of the calabash was then probably ground down carefully until by applying the eye to one hole the navigator could sight the North Star over the rim of the calabash above the hole on the opposite side. To make sure that the calabash was held level while sighting, it was filled with water to the height of all four holes. With such a sextant on hand, the voyagers

most
~~xxxx~~ likely found Hawaii again on their return. They merely sailed north-east until they could sight the North Star through the hole made in their calabash. At that time they were on the correct degree of latitude for Hawaii. As they had been traveling north-east, they were certain that Hawaii lay to the west of them. By sailing west on the same latitude, they were sure to reach one of the Hawaiian Islands.

(45) MAMANI

The tree known by the Hawaiian name of mamani is botanically called Edwardsia chrysophylla Sch. and is peculiar to the Hawaiian group, being at present found on all the larger islands except Molokai and possibly Oahu. On the latter island, a few sickly trees were seen some years ago that may now be dead. On the Island of Hawaii the visitor may see the mamani best in the Kipuka Puaulu, a few miles from Kilauea Crater, and in the aa ( ) lava desert near the Kau entrance of the National Park. Within Haleakala Crater on the Island of Maui, ~~on the other hand,~~ there are a few trees ~~may be observed~~ near the northern wall and on the more grassy plains near Kaupo Gap. Most of these, unfortunately, were in a dying condition in 1927 due to native beetles (Plagithmysus funebris Sharp and Proterhinus sp.,) that riddle their branches with galleries for their young. They were also being attacked by caterpillars and goats which eat their leaves. The trees cannot be found in wet, shaded forests nor in the lowlands, as they are particularly adapted to barren slopes and rugged lava flows in very arid regions between 3,000 and 9,000 feet elevation.

The mamani is usually a small tree, though in particularly favorable localities it may grow to a height of forty or more feet. It bears clusters of beautiful, golden yellow flowers (a). As each of these flowers becomes pollinated by insects that gather the secreted nectar, its pistil swells and develops into a woody pod, called legume. This bears four longitudinal wings, as the drawing (b) of its cross section shows, and may be more or less constricted otherwise (c). Within are borne extremely bitter seeds (d) that are either reddish or yellow in color. As these are heavier than sea water, they could not float from one island to another to disseminate the plant. But they could be readily transported the short distances between the various Hawaiian islands by ocean currents while yet contained in their woody pods. Because of the structure of the flowers and of the pods, we know that the mamani belongs to the Leguminosae or Pea Family, termed

The leaves of the mamani are ~~XXXXX~~ compound because they bear leaflets.

R

These, when young, as well as the new shoots, are covered with silky hair. As the twigs mature, this hair, or pubescence, is sometimes lost, especially by plants inhabiting lower altitudes.

The native enemies of the mamani are the beetles and caterpillars mentioned above. Their injury cannot endanger the existence of the plant, otherwise it would have been exterminated ages ago. Introduced enemies such as horses, cattle, and feral goats and pigs are the real menace to these plants and to the beautiful wild groves and forests in general. They eat all of the young seedlings except the root which must die soon after the upper part is gone. They also eat as much of the leaves and green twigs as they can reach on the older trees. Few seedlings survive the ravages of these grazing animals to take the place of the old trees as they finally succumb to the usual dangers of old age. Thus such interesting Hawaiian forests become more and more depleted of trees until there remains nothing but a monotonous turf-covered landscape, punctuated with an occasional decaying tree. Such a region has become economically valuable for the raising of livestock and perchance a few crops, but spiritually it has become worse than worthless to lovers of Nature. Striking examples of this necessary advance of Civilization over Nature may be studied between Waimea and Honokaa and between Waimea and Kohala on the Island of Hawaii, as well as in numerous other regions on the other islands.

As no livestock is now tolerated within the National Park and the goats are diligently hunted and shot, these regions on Hawaii and Maui should forever remain a refuge for the native plants, as well as for the native animals, that now live within their boundaries. Neglect in strenuously pursuing this policy in the early days has resulted in irreparable loss to the science of Botany by the virtual extermination of certain kinds of plants that would otherwise have been preserved. Many of the plants that are not found within the Park nor in the extensive forest reserves are doomed to ultimate extinction. Since it is impossible to save them alive, the most practical plan to follow is to collect them now while there is yet time and to preserve them as herbarium specimens. Dup-

licates should be distributed to the various leading Herbaria and Botanic Gardens in America and Europe for study and safe keeping. It is certainly unwise to put all one's eggs in one basket as then the loss of the entire collection, which could never be duplicated, might easily occur from accident or neglect.

The wood of the mamani is very hard and durable. It was used by the Hawaiians in the early days as a substitute for the more valuable and rarer kauila ( ) wood in the making of agricultural implements and adz handles. It was sometimes used for the posts and beams of their houses ( ). Often the sap wood of such timbers was carefully cut away as that is not as strong and durable as the older, heart wood. During certain religious ceremonies to ward off evil, the high priest, or kahuna nui, would hold in his hand a piece of mamani or kauila wood wrapped in dark kapa ( ) as a symbol of his authority.

Mamani wood was preferred for the making of the runners of the holua sled, or papa holua. These sleds were often 12 feet long, having the runners spaced as little as two and a half inches apart at the base and about six inches apart at the top where the body of the rider was to lie. Before using, the runners were lubricated with the oil expressed from the kernel of the kukui nut. With these sleds the chiefs amused themselves by sliding at great speed down certain courses, about 18 feet wide, that extended from a steep hill onto the plain below. These courses were first paved with flat rocks and then covered with earth that was beaten hard. A layer of dry grass, because of its slipperiness, was then laid on top.

In more recent times, the trunks of the mamani trees were cut into fence posts by the ranchers because of their great durability in the soil.

GORSE) 10ttc

The Gorse, scientifically known as Ulex europaeus L., bears flowers and pods of essentially the same structure as those of the mamani ( ). Therefore it must belong to the same Leguminosae or Pea Family. It is not native to the Hawaiian Islands but to Europe from where it was purposely introduced into the Island of Maui before 1901 by Alexander. It was planted by him as a hedge around his garden near Olinda to prevent sheep from gaining access. Within a decade, this dangerous weed has spread extensively over the western slope of Haleakala, making the pastures in which it becomes abundant absolutely impenetrable and worthless for grazing because of its sharp thorns which can inflict painful wounds. Much good has been accomplished by prisoners who have been employed in eradicating and burning the plants. As the weed had time to spread extensively before this meritorious work was begun, sufficient plants will probably long remain to attract the attention of the visitor on the ascent of Haleakala from the Makawao side.

The Gorse is a compact shrub four to six feet high, bearing numerous small branches that have been modified into sharp spines. These branches are green in color and thus aid the pointed, degenerate leaves in their proper function of manufacturing food to sustain life and promote growth of the plant. The flowers are bright yellow and add to the beauty of this odd and formidable weed.

The plant is disseminated in two important ways. Short branches bearing ripening pods become entangled in the tails of cattle and are carried considerable distances before the seeds are liberated and fall to the ground. Thus new clumps of plants may arise miles away from the parent plant. The usual method of distribution, however, is ~~secured~~ by the elastic mechanism of the pods that burst open with a clicking noise to hurl their seeds several yards in all directions. As each of these bears an oily, yellow appendage called elaiosome that is palatable to ants, these insects gather them and carry them to their subterranean nests. Here they can feed on the elaiosome at their leisure. Thus the seeds are effectively planted underground by ants which, in turn, are satisfactorily repaid in food ~~by the plant~~ for their labor.

R

#7

PIGEON PEA

The pigeon pea, best known botanically as Cajan cajan (L.) Millsp., is a member of the Leguminosae or Pea Family. As the plant has not been found in a truly wild state, its native home is not known with certainty. Various authorities, however, attribute its origin either to Malaya, to India, or even to tropical Africa. In Malayan the plant is called katjang and this word is responsible for its scientific name.

The pigeon pea was undoubtedly introduced into the islands since their discovery by Capt. Cook, yet no definite date is known for the introduction of this valuable plant. The earliest record that has been noted of its occurrence here is that of Horace Mann, the son of the famous educator, and William T. Brigham, the very versatile dean of Hawaiian scientists. As college students, they collected the plant as early as 1864 and at that time considered it "probably of aboriginal introduction". To enable the pigeon pea to spread so extensively as to appear to them fully naturalized in 1864 would indicate that it had gained access to these islands at least a decade or two before.

The pigeon pea is a perennial shrub thriving in these islands up to an elevation of about 3,000 feet under rather dry and even semi-arid conditions. It has been found growing in a stunted state along the roadsides in the Kilauea Section of the Park but never in wet localities. Normally, however, it grows to a height of four to ten or more feet. Its leaves are trifoliolate, namely composed of three leaflets attached to a common petiole or stalk. The flowers, borne in axillary clusters, are yellow to orange and often marked with brown or other colors. These flowers finally develop into compressed pods having diagonal depressions separating the contained seeds. The roots of this plant, like those of all members of the Pea Family, are remarkable. On freeing them of soil, one will see small swellings, or nodules (fig.), attached to them. These contain myriads of bacteria which are highly beneficial to the plant. They take the nitrogen from the atmosphere, a process which flowering plants are unable to accomplish, and change it into unavailable forms.

an available form. This the roots of the pigeon pea forthwith absorb. Thus the plant not only gains for its growth the little nitrogen usually available in the soil but even an additional supply from the atmosphere, a source from which other plants are deprived. In case a field of pigeon peas is plowed under and allowed to decay, the crop planted in its stead benefits from the additional fertility the bacteria had originally gained from the air.

The seeds, when fresh and immature, can be eaten like green peas. Moreover, when they are old and have been freed of their leathery seed-coat, they form a substitute for lentils. They are also made into a sauce known as dhal and eaten curried. In this way the plant has become the staff of life of five million people in India. In the Hawaiian Islands, however, the pigeon pea is valued not so much as human food but as forage for cattle and horses, as a grain for poultry, and as a green manure for pineapples and other crops. For these purposes the plant was first grown as a cultivated field crop in the islands by F.G.Krauss of the Federal Experiment Station in 1906, and first grown commercially by the same man at Haiku, at the base of Haleakala, in 1912. Previous to 1920 Prof. J.F.Rock introduced a new strain of the plant from Benares, India, while in 1928 Director Krauss, the pioneer grower, gathered numbrous strains in many parts of the Orient. These were planted at the University of Hawaii and by 1930 about 500 different horticultural varieties and hybrids were growing there for experimental purposes under his direction. That year the estimated area covered by the pigeon pea throughout the islands totalled 10,000 acres. About half of this was grown for fattening cattle and the remainder as a green manure for pineapples.

As stock feed, the visitor on his way to the Park will most likely observe extensive fields of this plant. The seeds had been planted either in fall or preferably in spring in rows from four to five feet apart. Then when the plants are maturing their nutritious pods, six to eight months later, the cattle are usually turned into the enclosure to fatten. Here they browse on the pods, containing the seeds rich in nitrogen, and less eagerly on the

R

leaves. As a green manure for pineapple, on the other hand, the pigeon peas are usually planted in rows spaced about two feet apart. Thus they are left for four to five years before being plowed under. Pineapples are then planted in their place and allowed to grow for an equal length of time. In this way many acres of otherwise useless land is being reclaimed for pineapple produc - tion.

HINAHINA

(48-49)

At higher elevations on the Islands of Kauai, Maui and Hawaii occur very strange plants, some of which are known as hinahina or kaluanui to the natives. These constitute a ~~distinct~~ botanical group related to the one to which the common geranium belongs. All these plants are members of the Geraniaceae or Geranium Family.

The hinahina are small shrubs with the exception of one tree-like type which grows to a height of ten or more feet. Most of them bear leaves that resemble in shape the individual scales of a butterfly's wing. These leaves are usually densely covered with hair which imparts to them a beautiful silvery appearance. In one kind of ~~plant~~ hinahina the flowers are red and bilaterally symmetrical in regard to the position of the petals; in all others they are white, often marked with purple, and always star-shaped. They invariably mature their stamens and their pistils at different times, thereby preventing a flower from being fertilized with its own pollen.

The plant that at present goes under the name of Geranium tridens Hillebr., ( ) is still quite common on the northern and eastern slopes of Haleakala where cattle roam. It grows in the open among the rocks and hard soil above 5000 feet and, therefore, may be seen along the trails leading to the Rest House. It is a small, stiff shrub, rarely attaining a height of three feet. The flowers are white, and more or less purplish-veined especially toward their centers. The leaves usually stand erect and are about as silvery with hair as are those of the famous silversword ( ) occasionally found in the same region. This is probably a special adaptation to withstand the rays of the sun which are more active and numerous at higher elevations than at low because of the lesser distance of atmosphere which they must penetrate. Leaves that stand upright expose considerably less surface to the sun than do those that lie flat. And leaves that are covered with white hair not only repell many of the sun's rays like a mirror from their surface but hinder the excessive evaporation of moisture through the epidermis.

Two plants that are similar to G. tridens are G. multiflorum A. Gray and

G. ovatifolium A. Gray, the latter being the arborescent type mentioned above. Both grow in the Koolau Gap of Haleakala Crater where they are exposed to the fog and rain that usually begins to sweep into the crater in the late morning. At that time, however, neither can penetrate far beyond the Gap into the crater before being absorbed by the drier air with which it there mingles. As the day progresses, the clouds roll farther and farther into the crater until in the late afternoon it often drenches the surface of the cinder cones where the silverswords thrive, or may even fill the entire bowl of Haleakala. In this way, the kinds of Hinahina are enveloped and drenched by clouds for most of the day while the silverswords, growing barely three miles away, are exposed to intense sunlight and dryness.

G. arboreum A. Gray, the kind with red flowers, is the strangest plant of the entire group. It is a shrub growing in a few ravines on the outer slopes of the crater above Ulupalakua and Olinda. This plant grows within the cattle ranges and therefore may become exterminated any day. G. cuneatum, a kind resembling the one figured on Plate , grows within the Kilauea Section of the Park but only near the summit of Mauna Loa where few visitors will ever find it.

All these native geranium relatives of the are highly ornamental and extremely interesting. Unless considerable care is taken to protect the rarer kinds by fencing them from cattle and pigs, they will be exterminated within a comparatively few years. Those requiring particular care at this time are G. arboreum and the plants growing in Koolau Gap, the most interesting botanical region in the crater. This is, unfortunately, just beyond the boundary of the National Park.

PELEA, ALANI and MOKIHANA

The group of plants named Pelea by the American botanist Asa Gray in honor of Pele, goddess of Hawaiian volcanoes, is almost entirely limited to these islands, only three or four kinds being known from other ~~Pacific~~ all in the Pacific regions. About thirty kinds have been described from ~~here~~ Hawaii and several yet remain to be described from the writer's herbarium. It is probable, also, that over a dozen undiscovered Pelea still grow in our forests. All these plants belong to the Rutaceae or Orange Family.

The Pelea, known chiefly as alani by the Hawaiians, are trees of usually small size. They bear rather inconspicuous, yellowish flowers, some of which finally mature into capsules. In certain kinds, these are rounded in shape ~~while~~ but in others they are square or even roughly cross-shaped. Before these capsules dry and split along their four grooves to liberate their black, shiny seeds, one may often see many small dots clearly marked upon their surface. These are reservoirs containing volatile and usually fragrant oil. The leaves of the alani are more or less leathery, have smooth margins, and usually emit a fragrant odor when bruised. This is caused by the breaking of still smaller oil reservoirs that are scattered by the thousands just below the surface. The leaves and rind of the orange contain ethereal oils in a similar manner and produce a somewhat similar odor when crushed. Therefore, when the orange was introduced into these islands by Vancouver, the Hawaiians named the tree alani because it reminded them of certain Pelea.

A typical plant, figured on Plate , may be seen in the interesting Kipuka Puaulu near Kilauea. It is known as Pelea Zahlbruckneri Rock. As in all plants of this group, it bears flowers that are on the point of becoming unisexual, a condition paralleling that of the Broussaisia (page). The ancestors of the Pelea, no doubt, produced flowers possessing normal stamens and pistils. Today, however, about half of the flowers on a tree bear functioning pistils and abortive stamens, as the figure of the dissected flower shows, while most of the others bear functioning stamens and degenerated pistils. The remaining type of flower in which both stamens and pistils

can function as a persistent ancestral type.

Though the particular Pelea called P. anisata Mann because of its aromatic, anise-like fragrance is not found within the area covered by this floral guide, it must be mentioned because of its high esteem in the eyes of the Hawaiians, who know it as mokihana. The plant is peculiar to the Island of Kauai where it grows in the rain forest. Its capsules, the most fragrant part of the plant, were strung into lei, or garlands, which remain fragrant almost indefinitely. These could not be worn by some people without producing a rash where they touched the skin most often. In the Song of the Lei of the Islands, the mokihana was emblematic of Kauai.

(51)

CANDLENUT TREE or KUKUI

The Candlenut tree, known throughout the Hawaiian Islands by the native name of kukui, is a member of the Euphorbiaceae or Spurge Family. Its scientific name is Aleurites moluccana (L.) Willd. It is a plant of wide geographic distribution, ~~occurring~~ growing in the tropics and subtropics of the Old World, in the West Indies, in Brazil and elsewhere. It is native to these islands where it grows abundantly on the lower slopes of mountains and in the lowlands, particularly in ravines.

Along the roadside from Hilo toward Kilauea, one can easily recognize the kukui. The light-colored, greenish leaves, covered especially on the under sides with a silver-gray powder, makes it very conspicuous in the forest. The tree in the most favorable places for growth frequently exceeds a height of 90 feet, although usually it is but half as high. The trunk is occasionally smooth and unbranched to a height of 40 or more feet. The small flowers are borne in clusters at the ends of branches. Two kinds exist; the staminate, or male, bear about eighteen stamens each and no ovary, while the pistillate, or female, bear a two-celled ovary and no stamens. The petals of both staminate and pistillate flowers are pale cream-color.

The pistillate flowers finally develop into more or less spherical fruits about one and a half inches in diameter, each containing one or rarely two seeds. The outer part of the fruit consists of a hard, green covering about one-fourth of an inch in thickness. Within this is found a thin crust-like shell most easily visible after the fruit has partially decayed. This surrounds the seed. The latter, in turn, consists of a thick, wrinkled, woody seed-coat which protects a large quantity of oily tissue called endosperm. This is not part of the embryo which later develops into the seedling but food stored up for it by the parent plant. The embryo, composed largely of a minute stem and two flat leaves, termed cotyledons, lies between the two halves of endosperm. When conditions are favorable for germination, the cotyledons exude a slippery secretion which actually softens and liquifies the endosperm. This is then gradually absorbed by the seedling, thus furnished

with nourishment until it has had the opportunity to become established in the soil and to begin the manufacture of food for its own life processes.

The kukui was of great value to the early Hawaiians, being used for light, navigation, fishing, tanning, dyeing, food, medicine, catching of birds, ornamentations and even for the detection of criminals.

The use of the kukui for illumination by the various Polynesians has always impressed strangers as the common English name, candlenut tree, testifies. The Hawaiians, alone, had four ways of using the kukui for light. The simplest way was probably by means of the lama. This was essentially a torch consisting of a piece of bamboo whose hollow had been stuffed with roasted kukui kernels or some other combustible material.

The second type of lighting was produced by the kalikukui. This was made of kukui nuts first roasted in the shell and then hulled, or merely shelled and allowed to dry in the sun. These kernels were then strung usually on a short piece of midrib of a coconut leaflet, or on a long sliver of bamboo. Such a torch lighted and rested against a stone would illuminate the huts during the evenings. It was usually tended by one of the children in the family, who, as the uppermost kernel was beginning to burn away, would invert the torch so that the remaining flame should ignite the adjoining kernel. When this had been accomplished, the entire torch was righted again and the remains of the old, uppermost kernel knocked off with a short piece of wood. Each nut burned for two to three minutes.

An aulama, on the contrary, consisted of half a dozen or more kalikukui wound up parallel together with dry banana leaves into a cylinder about three to six inches in diameter and from two to four feet long. Such a torch produced a bright light convenient for a nocturnal dance, or religious service in the heiau. Besides the light and an odor akin to roasting peanuts, such a torch gave off abundant smoke which made its use within huts objectionable.

The highest type of Hawaiian illumination was the stone lamp, called pohokamoa pōhaku kukui, of which various examples are pictured in fig. . These resembled the early lamps

R

of the Caucasian. The Hawaiian lamps were filled with kukui nut oil or more rarely with the oil of the cocoanut ( ) or kamani (Calophyllum inophyllum), or with some animal fat. The kukui oil was gained in one of two ways: entire, single torches were lighted at one time for illumination while the heat would cause much of the oil to run out of the kernels and drop into a container placed below; or the oil would be expressed from the kernels in a stone mortar. For light a strip of twisted kapa, placed over the rim of the filled lamp, was ignited as wick. If more light were needed, additional wicks were simply added to the rim of the lamp.

The trunk of the kukui tree, though composed of extremely soft and easily decaying wood, was in some cases hollowed out and fashioned into canoes. The wooden floats, kikoi, for fish nets were also made of kukui ~~is one~~ the superior wood of the hau ( ) ~~were~~ not available.

The kernels of the kukui nut, or the meat of the cocoanut, were chewed by the Hawaiian fisherman and then blown out of the mouth over the sea. Sufficient oil from these nuts would thus be spread over the water to quiet its ripples. The oil was probably not first derived from the kernels and then spat over the water as ~~is~~ intimated ~~by Andrews and Parker's Hawaiian Dictionary~~ has been by others.

For fish nets, the oloma (Touchardia latifolia Gaud.) was used in preference to the related mamake ( ). Its fiber was stronger and more resistant in water. To tan such a net in order to strengthen it and hinder decay, it was treated with an infusion of kukui bark. The inner bark would be taken from an old tree, pounded and then put into a trough with water. After stirring, the bark would be strained out. The new nets would be dipped into this liquid and allowed to dry, and thereafter dipped and dried a second time. This would preserve them as well as stain them a reddish color. If such a net is frequently being used, it should be dipped at least once every month or six weeks in such a bark infusion as the effect of the treatment seems to become lost by long immersion in the ocean. Nets thus treated have been known to be serviceable for fifteen years.

R

The kukui furnished several dyes. The bark of the root was pounded to form a stain which was mixed with the finely chewed kernels of the nuts. This oily dye was then used to stain kapa ( ) a copper color. At times, a dye would be made from the male inflorescence of the breadfruit ( ) and the bark of the kukui. Another dye was made from the broken shell of the kukui fruit and of the bark of the tree trunk. The bark of the root, on the other hand, mixed with charcoal, was used in coloring canoes black. Another black dye was prepared from the acrid juice derived from the hard, green covering of the nut. A far superior black, however, was produced from the soot that collected on smooth, clean pebbles under which kukui nuts had been burned. This was even used for tattooing. A yellow dye for tattooing was prepared from the fleshy covering of the green fruit.

From wounds made in the bark of the kukui, a dark, resinous gum, called pilali by the Hawaiians, exuded. After dissolving this in water for a day or two, the liquid was used as an adhesive or painted on kapa with a brush, called huluanai, made from part of a coconut husk or hala (( ) fruit. This protected the dye and made the cloth more durable and water proof. Pilali was also eaten.

The oily flesh of the kukui nuts is somewhat poisonous to eat in the raw state as one might expect from the fruit of a member of the Euphorbiaceae. After eating two or more nuts, one is likely to become ill. This poisonous quality is largely changed by roasting. In that state the kernels are prepared by the Hawaiians to make various edible dishes called inimona. They may be merely pounded up in a stone mortar with sea salt to be eaten as a relish. Or they may be mashed, mixed with salt and the fruits of the red pepper (Capsicum frutescens L.), or sometimes with the dried ink bag of the squid. It is advisible for the visitor to partake sparingly of inimona until he has observed how this dish agrees with him.

The plant also furnished the Hawaiians with various medicines. Waiki, a remedy for a skin disease, consisted of the core of a green calabash gourd fruit and the sap of the kukui tree. A purge, akukanihe or kukanihe, was made from the bark of a native, small leaved euphorbia called koko and the sap, called waikea, of the green kukui fruit. A medicinal drink, called

piikua was derived from the sap of the tree. For the infants' disease called ea, the kukui was used in several ways. The fresh juice seeping from the broken stem of the young kukui fruit was put on the finger and allowed to become partly dry. This was then rubbed over the infected area in the child's mouth. Or the patient ate the flowers of the kukui pounded together with boiled sweet potatoes. Yet another remedy for ea was made by allowing the kukui nut to burn to charcoal and then rubbing this on the infected area.

For their precious feather cloaks, helmets and certain idols, the Hawaiians caught various forest birds, especially the mamo, oo, iiwi and apapane for their plumage. The mamo was black in color but possessed a small tuft of yellow feathers under each wing, not two feathers only as so many relate. The oo was also black and yellow while the iiwi and apapane are black and red. The yellow feathers of the mamo, a bird now extinct, were especially prized. The royal bird catchers would ensnare these birds by smearing the sticky juice called kia or kepau of the breadfruit, endemic lobelias ( ) or fruit of the pisonia on long, baited poles, laaukia, or on posts, pokia. These were thickly scattered about their haunts. Birds alighting upon them would thus become caught by their feet. The hunters were instructed by Kamehameha to liberate the birds after plucking their choice feathers so that they might grow a new supply. They were freed after their feet had been washed with kukui nut oil, or with sugar cane juice, to clean them of the adhering sticky mass of bird-lime.

The hard shell of the ripe kukui, after its ridges had been rubbed away with a stone, was buried in a marsh to season and blacken. Then it was carefully polished with the large stipules of the breadfruit tree and oiled. These nuts when strung into a necklace remarkably resemble one made of jet.

The kukui even aided in the detection of crime in the early days. If an object had been stolen, the priests, or kahunas, were often asked to discover ~~who was~~ the offender. The complainant usually paid the kahuna a pig before the following ceremony was performed: Two sticks of green wood were rubbed together until the friction produced a smoldering powder, which, when

blown upon would ignite some dried grass. With this, a pile of wood was kindled. Three kukui nuts were then broken, and one of the kernels thrown into the fire. While this was burning, a prayer was uttered, accompanied with the anathema that the thief should be killed. If the thief appeared and made restitution, which generally followed, he was merely punished with a heavy fine. If the culprit did not make himself known, the ceremony was repeated with the remaining nuts. A proclamation was then made throughout the island by the king that a theft had been committed and the guilty prayed to death. Nothing more was done as the thief's death was considered inevitable. So firm was their belief in the power of these prayers to arouse the avenging diety, that the guilty one usually pined away and actually died of fright. This is not surprising when one recalls with what fear the European regarded papal interdicts not many centuries ago.

With the coming of the white man, the importance of the kukui in the economy of the Hawaiian gradually declined. Kukui lamps persisted in use in the country districts until about 1865. The nuts, rich in their oil which was a good substitute for linseed oil, were formerly gathered in large quantities and sold to the Russians for use in their settlements on the north-west coast of America. At one time as much as 10,000 gallons of kukui oil was exported from these islands in a single year. As the pay of labor steadily increased, however, the cost of picking up the fallen nuts left no profit from their sale, and the industry ended. Today, the polished shells of the nuts may be seen occasionally in curio shops in the form of leis, watch-fobs, rings and necktie claspa.

DODONAEA or AALII

Several kinds of dodonaea, known as aalii in Hawaiian, are found in these islands. All, except possibly one kind, are endemic. Some botanists consider these plants, and about 50 very close relatives, members of the Sapindaceae or Soapberry Family; others maintain that they constitute a distinct family of their own which they call the Dodonaeaceae or Dodonaea Family.

Dodonaea spathulata Smith is the shrub growing so commonly in the vicinity of Kilauea and on the slopes of Mauna Loa, Mauna Kea and Hualalai of the Island of Hawaii. These plants are one to rarely six feet high. They are either "male" or staminate, bearing flowers with numerous pollen-filled stamens and no pistils, or they are "female" or pistillate, bearing flowers having pistils but lacking stamens. A large twig of the former plant fills the greater part of Plate , while a flower cluster from a typical pistillate plant is shown in the upper right hand corner. Below are two different diagrammatic views of a capsular fruit that had developed from a pollinated pistillate flower. These capsules are always borne in open clusters and are either yellowish or bright red, imparting a very ornamental effect to the shrub. The capsules are either two- or more commonly three-winged. They are smooth, and are neither sticky nor inflated like those of other kinds of dodonaea.

Dodonaea eriocarpa Smith is known in several varieties. It is found on the islands of Hawaii, Maui and Kauai. On the Island of Hawaii it may be seen to best advantage in the aa lava flows near the little village of Punaluu, less than miles from the Kau Entrance of the Kilauea Section of the Park. This plant differs from D. spathulata growing near Kilauea in having distinctly hairy leaves, and in having its capsules three- or four-winged, somewhat hairy, slightly inflated, yellow but never red, and borne in compact, almost spherical clusters. The plants known as D. eriocarpa growing on the Island of Maui on the slopes of Haleakala and within the crater itself, are quite different. Their capsules are a brilliant red.

The dodonaeas were sacred to Laka and to Kapo, the goddesses of the hula. ( ). Various parts of the plant were used by the old Hawaiians. Because of the extremely hard, durable wood, the dodonaeas when found of sufficient size were sometimes cut into timbers for building houses, or fashioned into spears and other weapons. ~~The leaves of the plant were made into the medicine pasili which was used~~

The brilliant red capsules were also gathered, placed in a calabash with water and brought to a boil by dropping hot stones among them. The liquid, becoming as red as ink, was strained and then used for dyeing kapa ( ) and other articles.

53

SOAPBERRY TREE, AE or MANELE

The Soapberry tree, called Ae or Manele by the Hawaiians, is botanically known as Sapindus saponaria L. It is native in various slightly different forms to certain regions in tropical and subtropical America as well as in the Orient. It is also native to the Island of Hawaii but not to the other islands of this group. With the aalii ( ), it belongs to the Sapindaceae or Soapberry Family.

Some Soapberry trees almost 80 feet high may be seen in the Kipuka Puaulu near Kilauea. They have compound leaves and clusters of small, yellowish flowers that secrete abundant nectar. These flowers are apparently evolving into completely unisexual structures as ~~XXXX~~ are those of the Broussaisia ( ) and Pelea ( ) previously described. Although all the flowers bear stamens, only those lacking pistils have stamens that ever produce good pollen (fig.). These are consequently true staminate, or "male", flowers. The other type of flower, which may be termed the pistillate, or "female", flower is peculiar. It not only bears worthless stamens but usually two of the seed-producing organs, called carpels, that constitute the compound pistil, have degenerated also. Consequently when they have matured into fruit, the result of this abortion is greatly magnified. Instead of consisting of three equal spheres mutually united to one another, the fruit consists, as fig. c shows, of one that is almost an inch in diameter and two that are about one fourth as large. Of these three only the large sphere contains the seed. The ~~only~~ logical explanation for the occurrence of these two aborted structures is that the ancestors of the Soapberry tree originally bore fruit containing three viable seeds.

When the fruit of the soapberry tree dried, the flesh shrinks away from the seed, thereby forming a cavity filled with air. In this state every seed could float. When removed from the fruit, however, about half of the seeds will sink in fresh water and one fourth in sea water. Whether the plant owes its wide distribution to the floating ability of all of its fruits and at least half of its seeds is not definitely known.

No particular Hawaiian use for this tree is known. The fleshy fruit is

rich in the chemical, saponin, which has the property of making a lather. It therefore can be used as a substitute for soap. As saponin is somewhat poisonous, the fruit is unfit to eat. The black, spherical seed, which is about half an inch in diameter, has been used extensively in the manufacture of rosaries.

R