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where is either human birth control or a Third World War that will wipe out centers of human population. It would be paradise regained for so many species on the verge of extinction.

Just as over 98 per cent of the native Flowering Plants (Phanerogams) of the

PLANTS

The plants described in the following pages are arranged, where convenient, in the order of their complexity, the primitive in structure preceding those that are more advanced: Algae, Fungi, Lichens, Mosses, Psilotums, Lycopods, Ferns and Flowering Plants. Among the Flowering Plants or Angiosperms are two groups: the Monocotyledoneae, nicknamed "Monocots" for brevity; and the Dicotyledoneae, nicknamed "Dicots." As visitors to the Parks will note especially the Flowering Plants, a brief explanation may be helpful.

The monocots, in contrast to the dicots, typically have stems with strands of wood, associated with some other tissue, scattered in a pithy matrix. They bear leaves with parallel veins, have flowers with parts usually in threes or multiples of three, and seem to have an embryo in the seed with but a single cotyledon or "seed leaf." Evidently ancient ancestors bore two of equal size. Today the plants have the second cotyledon modified into an organ (called scutellum in grasses, and prominent to any muncher of corn on the cob) to absorb nourishment from food of parental origin stored in the seed. Other monocots have the second cotyledon more or less aborted, while in still others it has disappeared altogether. The seedling produces a root that soon becomes functionless and disappears as adventitious roots sprout out from various parts of the stem to replace it. The most primitive in flower structure are such plants as the Astolia (p. --), belonging to the Lily Family; while the most evolved in flower structure are the orchids (p. ..). In regard to the vegetative part of the plant, the monocots are more evolved than the dicots by, paradoxically, "degeneration." Instead of retaining

a main stem and leafy branches like their venerable ancestors, these so often have dwindled over the ages to become herbs possessing underground stems and branches, called rhizomes. Still other monocots have reduced their stems to such an extent that the plant consists of little but a bulb or corm. Yet others, like XXX typical palms (p. ..), have remained large as their ancestors or become large. These, with few exceptions, have lost their former ability to produce branches from the axil of each leaf. About the only time for branching is the time they prepare to burst into flower. Evidently the present monocots have evolved from an ancient dicotyledonous ancestor.

Dicots may be herbs, shrubs or trees. The herbs have a solid or broken cylinder, associated with some other tissue, surrounding a small pith. Most of them obviously are more complicated anatomically than trees, and can be shown to have evolved from them. The trees have a solid cylinder, associated with some other tissue, surrounding a small pith that usually is obliterated in time by crushing. The cylinder consists of a thin layer of cambium cells that actively produce cells of wood, or xylem, on the inner side, and phloem on the outer. As the cambium ever moves outward from the center of the tree by the continuous formation of wood, massive tree trunks and branches are formed. Magnificent examples of such growth, as exemplified by an endemic acacia, flourished on the Island of Hawaii until the tourist demand for koa (p. ...) bowls and curios speeded their destruction except in the Kipuka Puaulu of Hawaii Volcanoes National Park.

Life processes are always accompanied by waste products requiring excretion. The methods in the Animal Kingdom are familiar to us all. Phanerogams rid themselves of waste products by depositing them in old wood, old phloem and old leaves. Such excretory products impart to the "heart wood" and to old phloem many perfumes (as in sandalwood, p. ---), dyes, medicines and other complicated substances of value in industry.

The cambium and the phloem areas of cambium-like cells which form the phellodern, always lie outside the wood in dicots. These form cork cells.

The result is various, depending on the particular species of plant. In some cases, the bark remains long attached to protect tree trunk and branches; while in others, as in the ohia-lehua (p.), it sloughs off with the old, dead phloem. The stem of shrubs is fundamentally that of trees with, however, various features common to herbs.

Dicots bear leaves with netted veins, and have flowers with parts usually in multiples of five or more rarely four. The embryo in the seed bears typically two cotyledons or "seed leaves" of equal size. The seedling has a root which continues to grow in length and /breadth, producing innumerable lateral roots and rootlets.

For readers more technically interested how Flowering Plants in the Hawaiian Islands are modified from two fundamental, ancestral structures, a number in (parenthesis) is added to the caption of each plant. These numbers correspond to the Plant Families appearing in our "Flora Hawaiiensis or New Illustrated Flora of the Hawaiian Islands," of which six volumes (3) have appeared to date.

ALGAE, FUNGI, LICHENS AND MOSSES (4)

Many kinds of algae exist, both in the oceans as well as on the continents and islands. They are aquatic and less often terrestrial. The more advanced kinds we know as "seaweeds," such as fucus, kelp and sargassum. The most primitive, however, with not even a differentiated nucleus in the cell, are called blue-green algae (Cyanophyta). They are microscopic, unicellular organisms or colonies loosely held together in slimy filaments or in gobs of jelly. Though all about us, we are hardly aware of these plants unless they disfigure a swimming pool wall with a blue-green film or cause us to slip and fall when walking on the slimy colonies growing on damp, shaded sidewalks. Some will grow in the ocean or in fresh water; others on the trunks of trees alternately drenched by ocean spray and baked by the tropical sun like Scytonema hoffmannii Ag., (Deg. & Deg. No. 31,416) at Wahaula's heiau, or o/on in painfully hot fumeroles like Stigonema hor-

moides (Kütz.) B. & F., (Deg. & Deg. No. 31,412) about Kilauea and the Chain-of-Craters Road! Such plants could have reached the Hawaiian Islands like dust by wind currents or by adhering to a migratory bird in flight.

Fungi vary all the way from molds, mushrooms, rusts and smuts to yeasts. Their spores are adapted mainly for air dispersal. Many are parasitic on plants and more rarely on animals; but by far the greatest number are said to be saprophytic, living off dead organisms and thus helping break their tissues down into the simpler elements from which they had been formed. In a way, they are soil and air formers. Without fungi and bacteria the earth would be cluttered with plant debris and animal carcasses. Forests would be like piles of enormous jackstraws - dead tree trunks, branches and leaves lying helterskelter one upon the other and interspersed with long-dead animals. This beneficial scavenging by fungi, however, does not concern us here.

Where extremes of temperature, lack of food or water, poisons, etc., would kill algae and fungi growing alone, each can withstand such adverse conditions when associated with one another. In the dry state, they in combination are more resistant to environmental abuse than seeds. In a way, like man, certain kinds have formed a partnership or corporation. They live in so-called symbiotic relationship, the alga and fungus together for life for mutual advantage. The alga, with aid of sunlight, synthesizes food for itself and the fungus; whereas the fungus not only protects the alga but furnishes it with salts and acids for the processes of life and growth. Such plant "corporations" can reproduce as independent algae and as independent fungi. Moreover, they can even "reproduce" most efficiently as "corporations." Fragments containing at least one algal cell and several fungal strands, or hyphae, simply break off to be carried by wind, by splashing rain or by animals to colonize new places. These different kinds of fragments, or propagules, are so complicated that experts have given them distinctive names.

(21) Such plant "corporations" are all about us; on almost every tree, rock and even on the bare ground, excepting perhaps in air-polluted cities. Though few people except botanists realize their remarkable structure, every one is familar with them. THEY ARE THE LICHENS! Such a strange dual relationship between two distinct kinds of plants is so remarkable that few believed Simon Schwendener when he announced it in 1886. Gaston Eugène Marie Bonnier (1853-1922) in 1889 prepared a dish with a nutrient jelly. On the one side he placed a mold (a kind of fungus); on the other a blue-green alga. Both plants grew, spreading ever nearer to one another at the center of the dish. Where they eventually met, they produced a lichen! This vindicated Schwendener as it proved that a lichen consisted of two different kinds of plants which, nevertheless, act like a single one. For convenience, botanists classify the different kinds of lichens as though they were single plants.

In general, according to appearance, three main kinds of lichens exist: fruticose lichens (fig. .), which are branched somewhat like miniature bushes; foliose lichens (fig. -), which are superficially leaf-like; and crustose lichens (fig. .), which form a crust on the material on which they grow and, furthermore, may be more or less combined with it.

The commonest and earliest lichen invader of new lava flows is Stereocaulon vulcani (Bory) Ach. It is a grayish white, erect, scurfy, irregularly branched structure up to an inch or so high. Moistened by fog or wetted by rain it grows, bends and trembles in the slightest breeze; but when exposed to hot sunshine it becomes inactive, rigid and brittle. In such a state the slightest touch will break off fragments that can grow with coming moisture into independent lichens. It will grow on bare lava, ash and cinders as well as between scattered ohelo)p. ...) and aalii (p. ...) bushes, sedges (p. ..) and ohia-lehua (p. ...) or mamani (p. ...) trees. Thus it imparts to the landscape the appearance of being covered with a thin blanket of not very white snow. This lichen and its close relatives are, on the one hand, particularly tolerant of sulphur dioxide, a gas given off by volcanic

(32) vents and fumeroles world wide; and are, on the other hand, dependent on high humidity. Hence many areas of the Hawaii park are just about ideal. One of the more conspicuous kinds, less tolerant of abuse, is S. skottsbergii H. Magn. It resembles an Afro hair-do and is closely related to the "reindeer moss" of the Continents. It may be seen to good advantage snuggled in inch-high masses at the base of bushes and trees in the ash and cinder covered area about Keanakakoi Crater, flanking Kilauea; and in open shrubby areas about Haleakala, Maui. Where a dead twig lies on bare ground, it may even begin to cover it. In somewhat less barren areas S. vulcani may be gradually displaced by various kinds of Cladonia.

Some of the Cladonia lichens are miniature, erect trees in shape; others are like goblets; but the most beautiful are bluntly branched and bear their thick, flattened apothecia, or spore-bearing structures, at their tips. These are bright red, and either of C. coniocraea (Flk.) Sprengel., or of C. vulcanica Zoll., depending on which particular acid each contains. In truth, the identification of many lichens in the Islands and elsewhere is in a state of flux until each kind has been subjected to chemical analysis best performed in a laboratory. This is the latest refinement, some workers believe fad, in their study.

The above fruticose lichens are more or less erect and usually terrestrial. A large group, however, is more or less arborescent. Among those are the "beard mosses" of the genus Usnea. The gray-green U. poliothrix Mot., and the yellow-green U. hawaiiensis Mot., are at their very best festooning old branches of the koa (p. ...) in Kipuka Puaulu, Hawaii; and a bit depauperate on old telephone and other wires between Hilo and Kilauea. Similar, but smaller, lichens are the bright yellow U. lutea Mot., and the dirty yellow U. boreomelleri Steiner.

Foliose lichens are chiefly on rocks and tree trunks. They are usually flat on the substratum or somewhat loosely attached. They branch dichotomously from the center and, if furnished with abundant room, spread to form

a circular plaque. Often the central part of the lichen, due to a combination of age and perhaps depletion of nourishment from below, will die to expose the rock surface beneath. Thus the old lichen will form a more or less irregular ring. One of the most conspicuous of these foliose lichens because of its pale color on dark lava along the sun-scorched coast, is Parmelia conspersa var. isidiata (Ansi) Stitz. A coarser one, favoring tree trunks, as near the Administration Building of the park on Hawaii, is P. perlata (Huds.) Ach. A lichen provisionally called "P. margaritata Huc" until precisely identified, is a coarse, gray one pitch black beneath. It is common about Kipuka Ki, Hawaii. Pannaria mariana (Fr.) Muell.-Arg., an olive one with a black border, favors tree trunks. These few examples indicate the diversity of foliose lichens in shape without even going into their chemical constituents.

A nice adaptation occurs on rather barren aa flows wherein some isolated chunks of lava stick out like some sore thumb. Atop these, unexpectedly, are found especially abundant growths of Parmelia conspersa mentioned above, intermixed with crustose kinds in spite of the fact that they are especially exposed to the elements. Quiet observation from a distance for a considerable length of time may solve the riddle. Such exposed areas are the preferred lookout and roosting places of the golden plover and other birds. Their occasional droppings on such a rock act like applications of nitrogen- and phosphate-rich fertilizer, stimulating the lichens to profuse growth. The specialist Sernander named such lovers of guano "ornithocoprophilous lichens."

Some crustose lichens are so firmly united with bark or rock that they are often overlooked. Buella maunakeaensis Zahlbr., is almost as somber as the lava upon which it grows; while Caloplaca inconstans Zahlbr., on arid lava near the sea, is first noticed because of the apothecia. These are little dark orange spots. Toward the end of the Mauna Loa Strip Road, Hawaii, is the strange Diploschistes subfarinaceus H. Magn. It is a brittle, milk

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colored crust on dusty earth between lava blocks. It is so delicate that the splashing of raindrops breaks up the thallus and efficiently distributes the lichen from place to place. Megalospora papillifera H. Magn., is a a pale lichen with fruiting bodies resembling black pinheads.

*Klement, Oscar. Zur Kenntnis der Flechtenflora und -Vegetation des Hawaii-Archipels. Zeitschrift für Kryptogamenkunde. 11:243-283. 1966.

Though barely 10% of the lichen flora of the Hawaiian Islands is as yet known, the lichenologist *Klement has come to interesting, tentative statistics: So far as known 31% are pantropic, 30% are endemic to our Archipelago, 19% are native also to tropical America, less than 7% are native to Malaysia, and the rest have a scattered distribution. That the Hawaiian lichen flora is so closely related to America, when the Phanerogam flora is so closely related to Malaysia is indeed surprising. What can the reasons be?

Lichens, particularly the crustose ones, are unusually important the World over in the formation of soil and in the preparation of rocky terrain for higher types of plants. The hyphae of the lichen not only grow firmly on the rock but penetrate its finest crevices. Prying particles loose and exuding certain dissoling acids, lichens are important in the rock's decay.

As the lava flows on the Island of Hawaii are often precisely dated, ecologists have been fascinated in the problem of how quickly plants will invade them to form ultimately a climax forest. Test plots have been laid out, measured and minutely studied as to the extent and kind of floral composition, such studies being repeated on the same plots specified years later. According to our observations, contrary to popular opinion and the findings of workers in foreign lands, lichens in the Hawaiian Islands are not necessarily the first and only early invaders of lava flows. In fact, blue-greens as well as lichens can invade fresh aa and pahoehoe flows even before they have completely cooled. Certain of the blue-greens, as well as [illegible] phytes of Lycopodium cernuum (p. ..), as noted d[illegible]out the fumeroles,

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even thrive best with volcanic heat inimical to lichens. Provided there is sufficient moisture in the air, they will invade aa flows mainly in the depressions of broken gas bubbles and, particularly the blue-greens, under loose lava fragments. On pahoehoe flows, on the contrary, blue-greens and lichens will invade crevices and the wrinkles on the ropy lava, gaining but a precarious foothold on the iridescent film of volcanic glass known as obsidian. Though such areas of concentrated blue-green algae and lichens are supposed to prepare the way for the colonization of ferns and flowering plants, we noted that the endemic fern Sadleria cyatheoides (p. ..) is an equally efficient pioneer invader. Not long after, ohia-lehua seeds will sprout, preferably on the fern, and slowly take up a scraggly existence. How quickly a lava flow becomes covered with jungle is dependent more upon even the supply of moisture than upon its age. Water is the bottleneck. In fact, a fresh flow in the rain or fog belt can appear just about as bare of vegetation as a similarly appearing flow in the desert a hundred or more years old. Moreover, this same flow in the moisture belt, in spite of the absence of arable soil, will be a lush jungle, though difficult to traverse because of jagged blocks, holes and perhaps crevices, in twenty five to fifty years.

Other factors being equal, newer aa flows in contrast to pahoehoe ones are first more uniformly and quickly covered with plants; albeit, microscopic and small like blue-green algae and lichens. Newer pahoehoe flows are relatively devoid of life except in their few crevices and wrinkles where even higher plants, like the ohia-lehua, will find sufficient soil to germinate and strike root. As these young trees are so conspicuous, the prevalent but wrong opinion prevails that pahoehoe flows are the first to be covered by vegetation. AA, already in brittle fragments with a huge surface exposed to the elements due to broken gas bubbles and jagged edges, breaks down more rapidly than pahoehoe. It therefore overtakes pahoehoe in supporting a far denser growth of plants. As both types of flow, however, increase

in age, break up and accumulate layers of humus and duff, it is impossible to ascertain whether the covering of forest is growing on an ancient aa or an ancient pahoehoe flow without using a shovel to dig down to it. Contrast in abundance of plants between aa and pahoehoe flows of similar ages is apparent in the Wahaula Heiau area and elsewhere in Hawaii Volcanoes National Park. Since the introduction by Europeans of cattle and horses, and to a lesser extent of goats and sheep, the vegetation of jagged aa flows is more protected from browsing by these hungry herbivores than is that of smooth pahoehoe flows. Cattle and horses are not nimble enough to enjoy walking over aa.

Many groups of mosses and their allies grow in our Parks. One type belonging to the liverwort group is Riccia. R. rechingeri Steph., prefers earth embankments of dried rivulets within Halemaumau, the sides of crevices near Keanakakoi east of Kilauea, and the almost bare ground about Hilina Pali beyond Kipuka Nene due south of Kilauea. It is like a pale green ribbon firmly fastened by threads to the earth. It branches profusely but, being primitive like many seaweeds, both branches are of equal importance. Thus, surprisingly, there is no main stem. Such branching is said to be dichotomous. Reproduction occurs near the upper surface. Anthoceros and related genera, on the contrary, favor rain- and fog-drenched soil and decaying logs. They resemble dark green, flat algae or seaweeds with erect bristles growing out of them. Everything is actually quite complicated. The flat structure is a plant termed a gametophyte, having a definite number of chromosomes in each cell, as it produces gametes of two kinds. These are eggs and sperm. The latter are single cells able to swim in rain or in a film of dew to the egg in the body of the parent or to that of a neighboring plant. This accomplished, the fertilized egg grows into the erect bristle. Though green and able to manufacture its own food with the aid of sunlight, it nevertheless remains attached by its base throughout its life to the parent from which it continues to derive additional sustenance. As this young

plant ~~moss~~, it splits open lengthwise by four valves to liberate innumerable, sexual, reproductive cells called spores. Being a spore-bearer, this ~~fern~~, partly parasitic on its parent, is called a sporophyte. It differs ~~from~~ the gametophyte in bearing twice as many chromosomes per cell. Spores ~~blown~~ to a favorable locality germinate to grow into the sexual plant again. Thus an alternation of generation ensues, the sexual or gametophyte generation alternating with the sporophyte or asexual generation ad infinitum. Obvious in these lowly kinds of plants, such alternation prevails all the way up through the Plant Kingdom to the highest types of plants as represented in the dicots by a plant such as the silversword (p. ...) and in the monocots by the orchids (p. ..). Though here no longer visible with the naked eye as in Anthoceros, the male and the female gametophytes can be seen only with the aid of a microscope, both hidden away as complete parasites within the flower.

Another group of liverworts is represented by fantastic, little, bright green plants with prominent networks of cells. They are Marchantia crenata and M. ~~pumilidisciformis~~. Marchantia may be found within Haleakala and about Kilauea on the sides of washout and earthquake crevices in open, drier regions; also on muddy ground in dark rainforests. Like Riccia, Marchantia is so primitive that it has not yet evolved a main stem with side branches. Whenever it branches, it does so dichotomously. Unlike Riccia, where the same gametophyte produces both sperm and eggs, Marchantia has definite male plants producing sperm and definite female plants producing eggs. Both sexes produce, ~~at~~ erect, miniature "umbrellas." Those of the male plant, called antheridial branches, are somewhat rounded. When a raindrop falls on a flat-tened male umbrella, sperm are splashed about the neighborhood. Perhaps one of very many will eventually land close enough to an egg to fertilize it so that the union of the two can develop into a sporophyte.

Acrocarpous mosses belonging to about fifty genera grow on tree trunks and branches in the rain- and fog-belt. These plants vary from pale green

through beautiful claret to practically black. They can be flat and firmly attached to the bark or form massive, loose, rain- and fog-drenched tufts and cushions in which moa (p. ..), psilotums, ferns, lilies, orchids and other flowering plants take root, making veritable hanging gardens. Unlike Riccia, Anthoceros with its bristles and Marchantia with its umbrellas, they can produce a delicate, transparent filament with a spore-filled sphere at the top (fig. ..). When ready for their shedding, the sphere opens by four valves spreading out in the shape of a cross. The spores then are carried away by the slightest air current. This type of reproduction is not often seen. In so many cases, scale mosses reach new trees or rocks when these are dusted by the wind with living fragments.

Just as the true mosses (Plate ..) are abundant and the scale mosses scarce in temperate and cold regions of the Mainland, so are the true mosses scarce in our parks and the scale mosses abundant. The true mosses grow in areas of moderate to little rainfall locally. About 250 have been described from the Hawaiian Islands thus far, some of them strictly Hawaiian and known from no other place on Earth. One of the commonest and most resistant to cold; to alternate drying and wetting by fog, rain or slush, is the olive gray Rhacomitrium lanuginosum var. Lanuginosum Hook. & Wilson or, according to some specialists, var. Sandvicense Reichardt. It grows, for example, among the scrub without and within Haleakala and up to the summits of Mauna Loa and Mauna Kea. The related R. crispulum (E.D. Hook. & Wilson) Dixon is not quite that common. At higher elevations where pelted by fog, rain and sometimes snow, the former grows in massive, congested cushions fancifully resembling reclining sheep. There it is often first overlooked because it melts in so well with its surroundings. At the highest elevations, it survives as gray streaks in protected cracks and in depressions of lava flows. As both kinds of Rhacomitrium are native also to New Zealand, Tasmania and elsewhere in the Southern Hemisphere and as related species grow in Alaska and thereabouts, we suspect the ancestor of the western golden

plover is responsible for the distribution of these cold climate mosses. This plover migrates yearly from a summer home in the far North to a second summer home in the far South yearly, benefitting by stop-overs on high islands and low atolls in between. Such spores, as well as microscopic seeds, can adhere to oily *feathers or be glued in a smidge of New Zealand clay on a bird's scaly leg.

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*Degener, O., & I., & Ziegenspeck, H. Verk. Dres. angl. Naw. Semenv. D. Art. Naw. Eur. Apr. 21, 1956.

The upright psilotum, Psilotum nudum var. caluensis (Mueller) Deg. & Deg., (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 ~~XXXXXXX~~ falt-stemmed psilotum, P. complanatum forma fosbergii Deg. & Deg., (Plate ..), on the other hand, invariably grows on tree trunks, especially on those of the giant forms. It has flattened stems that grow a short distance out from the trunk of the tree before drooping sharply like a horse's tail.

The two psilotums, which live throughout the tropics in several varieties and forms, 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.

sperm. Such alternation of unlike generations occurs in all the plants, excepting the blue-green algae, described in this book. In the flowering plants, as mentioned before, the gametophyte generation has become so observed that only the botanist can recognize it.

The nodding clubmoss (Plate ..), botanically known as Lycopodium cernuum var. canaliculatum Spring, is the commonest representative of this group of plants in the Islands. It is found in the Kilauea area in great numbers,

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forming dense thick-

Abel Harris & Co., Honolulu merchants, accepted a few thousand pounds of pulu in 1851 as payment for a bad debt owing them. "Just what is pulu grass?" asked Abel's younger brother. "It is a kind of moss," Abel replied," "that soft, downy stuff like cotton which grows around the stalk of treeferns. We 'll send a batch to San Francisco." Three months later the two brothers received a letter from that city: "We are glad to get your shipment of so-called pulu-grass. Believe the market here will absorb all you can supply. ~~XXX~~ Enclosed is our draft [at 28 cents per pound] covering payment for your present shipment." The next year the company shipped 27,000 pounds to California, where it was prized for stuffing pillows and mattresses. This industry increased with leaps and bounds. In 1857 the rate of duty for exporting pulu from the Kingdom amounted to 1%. In 1859 a famine occurred in Hamakua, Hawaii, "in consequence of the people being all devoted to picking pulu." Many of the taller tree ferns were chopped down to gain this material. Even the smaller ones, left standing, suffered as the removal of the pulu exposed their tender buds to the elements. The industry collapsed about thirty years later when it was discovered that pulu disintegrated with use and time, and inhalation of the dust was injurious to the health of the sleeper.

Around 1920 the tree ferns were again threatened with destruction by the beginning of a fern-starch industry near Hilo. The trees were cut down for the 50 to 70 pounds of starch contained in their trunks. This was very good for both laundry and cooking purposes. After a short time, the concern that manufactured the starch suspended operations. During the latter part of this Century a more serious danger threatened these magnificent ferns. Bulldozers were used to destroy many square miles of fern forest to make place for the planting of tropical ash, Fraxinus uhdei (Wenzig) Lingelsh and other timber trees. Other extensive treefern areas of a kind deserv

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National Park status are now being sacrificed for a new, exotic orchid industry. Two separate tractors drag a heavy chain between them, thus mowing down flat the jungle. Then with chain saws, the middle part of the treefern is harvested. This is then used, because of its mass of fibrous, adventitious roots, for the cultivation of orchids. This explosive demand for orchids throughout the World will hardly subside like the tuliponania of Holland about the middle of the Seventeenth Century. Besides their beauty and interest, orchid plants and flowers can be transported to far distant markets so easily by 'plane.

ots in the more open woods with the uluhe (p. ..) form. 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 the exception of the root, is beset with innumerable, awl shaped leaves.

Insert 9 p 24

Doguer, O. The Gametophyte of Lycopodium Cernuum in Hawaii. Bot. Gaz. 80:2-16. 1925.

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known as Dicranopteris emarginata W.J. Robinson (Plate. ..) is native to the Islands of Hawaii and Oahu. It is especially abundant in the Hawaii Park.

Insert 10 p 25 etc

About half a dozen treeferns are endemic to our Islands. They flourish from almost sea level in the more rainy districts to an elevation of seven thousand feet or rarely more. All belong to the family Dicksoniaceae, according to some specialists and Cyatheaceae according to others. They can be readily recognized by their tall, erect trunks. The only plant the visitor may possibly confuse with the true treefern 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 treefern. 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.

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Chamisso's treefern, Cibotium chamissoi (Hook.) Kaulf., which is known to the Hawaiians as hapu-iii, is the largest of our ferns. Its trunk may become twenty five feet high, while the fronds spreading from its top may add another ten to fifteen feet to the plant's total height. The lower third of the stalks of these fronds is always covered with very dark brown (almost black toward Kohala) somewhat prickly hair. The glaucous treefern, C. glauca (Smith) Hook. & Arn., and its very close Oahu relative known as C. splendens (Gaud.) Kaj., are both called hapuu by the Hawaiians. These are usually about ten feet shorter and the stalks of the fronds lack this stiff hair (Plate).

On the under side of many of the fronds may be seen small marginal bead-like structures called sori (Plate , at left). They are much more complicated than the simple sori of the ulehe fern previously described (p. ..). A small part of the margin of the

The buds of all local treeferns are densely clothed

Three important animal enemies of the treefern exist. The

to place, no matter how small the fragment. The third animal is man himself. One of the few plants that sometimes destroys the treefern, as described on page , is the ohia-lehua tree

FILMY FERNS (12)

Eight species of filmy ferns, belonging to the Hymenophyllaceae, may be found in our parks, some only after considerable searching. The family may be characterized as being primitive in certain features and highly evolved by reduction, or "degeneration," in other features. Instead of producing spores that are more or less yellow, these are green, with chlorophyll and hence germinate quickly. Some species have an erect stem bearing roots concentrated toward the base and a tuft of fronds at the very top. Most species, however, creep by means of root-bearing rhizomes over earth, rocks, tree trunks under branches. Some rhizomatous species are extreme in lacking roots entirely. The blades of the fronds are mostly just one cell thick and devoid of stomata, useless structures unless

this condition. The veins, usually several cells thick, are simple and never nett

Macroglena toppiniii Deg. & Deg., (Plate ..) is a representative of the more primitive filmy fern. It becomes about six inches tall, and grows on the ground preferably in dark forests. Conocormus minutus (Hl.) v.d. Bosch (Plate ..), represents the more evolved type. This species is notorious for being the smallest of all ferns in the Hawaiian Islands. In contrast to Macroglena, Conocormus has thread-like rhizomes which usually creep over rocks to form a mat in dark forests even near sea level. With fronds a quarter to half an inch across, it is usually mistaken for a moss by the casual observer. Mecodium recurvum (Gaud.) Copel., is a creeping form with smooth, hairless, upright fronds. It almost approaches the local Macroglena in height. It grows in the dark rainforest on the ground and on larger tree trunks. Two of the most delightful filmy ferns indeed are Sphaerocionium lanceolatum (H. & A.) Copel., and S. obtusum (H. & A.) Copel. Both inhabit the rainforest, their thread-like rhizomes firmly attached to tree trunks and branches or boring through tufts of epiphytic mosses. Though both have drooping, hairy fronds an inch or so long, they can be easily distinguished from one another. In S. lanceolatum simple hairs grow on veins and leaf margin; while in S. obtusum star-shaped hairs are scattered throughout. These two ferns, so often growing on high branches are frequently subjected even in the rainforest to intense drying by wind and sunlight especially in summer. Though appearing frail, they do not die but simply deactivate. With the coming of rain, fog or even moist air, they absorb moisture throughout their entire surface to quickly resume their interrupted activity.

conditions of soil, temperature and moisture, or whether there are several kinds in these islands difficult to tell apart. We do know, however, that the form growing about the Volcano House of the Hawaii park is Polybotrya polymorpha var. volcanicum Skottsb.

Saffordia polypody, known scientifically as Polypodium pellucidum

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SPHENOMERIS (12)

Carl Linnaeus, considered the father of modern Taxonomy, named a certain Chinese fern "Adiantum chusanum" in 1753 in his book "Species Plantarum" on page 1095. He named another Chinese specimen "Trichomanes chinensis" on page 1099. The late pteridologist W.R. Maxon, realizing that Linnaeus had the latter fern in the wrong genus, renamed it in 1913 Sphenomeris chinensis (L.) Maxon. The late E.B. Copeland, a pteridologist long resident in the Philippines, convinced that Linnaeus had placed Adiantum chusanum in the wrong genus, renamed it Sphenomeris chusana (L.) Copel., in 1929. A dilemma occurs because Linnaeus had never realized that Adiantum chusanum and Trichomanes chinensis are the same species of fern. Hence some modern botanists, conscious of priority, follow Copeland in using the specific name on page 1095; while others, by complicated reasoning, follow Maxon in using the specific name on page 1099. Only one of these names can be correct. This fern is a member of the Pteridaceae.

This lacefern, pala'a or palapala'a of the Hawaiians, is common at lower elevations in somewhat sunny and open rocky situations. It belongs to the Pteridaceae or Bracken Family. Unlike our treeferns, it is not endemic to the Hawaiian Islands; it is native, growing here as well as thoughout the South Seas, in Japan and even in distant Madagascar. Unlike the treefern, it is not erect. Instead, its rhizome, or main stem, is a slender, creeping structure bearing a series of scattered fronds. As these seem to have been twisted to force them to grow upright from its upper surface, it is reasonable to surmise that the ancient ancestor of this fern bore an erect stem with spirally arranged fronds at the tip. The Hawaiians used the pala'a as a red dye. Moreover, according to their mythology Hiiaka, sister of the volcano goddess Pele, was wont to wear a skirt fashioned from its fronds.

PTERIS AND PTERIDIUM (13) Place Block P-4

Though five or six species of Pteris may be growing in our parks, the visitor will see probably only two naturalized ones, the bright green, Old

World Pteris vittata L., (Plate ..) was first collected in the Islands by one of the writers in 1922 near the steam crevices about Kilauea; while the more yellow, New World P. longifolia L., was growing on the wet cliffs about the Thurston Lava Tube. By now both species have become extensively naturalized. Their sori, as in all other species of the 250 known throughout the World, are protected by a flap of tissue, called the indusium. This is formed by the revolute margin of the frond.

The endemic bracken, Pteridium aquilinum var. decomposition (Gaud.) Tryon, known to the Hawaiians as paia and Kilauapuaa, prefers grassy situations, especially like the savanna interspersed with koa trees along the Mauna Loa Strip Road, Hawaii, from a medium elevation upward. In fact, this bracken is the last large fern to survive in volcanic cinders at high elevations. Though somewhat poisonous throughout, wild pigs nevertheless will wander to such inhospitable regions to root for the rhizomes which evidently are palatable to them.

Though related to Pteris, Pteridium has a sorus slightly more complicated. An obscure, secondary indusium faces the marginal one. As expected from their names, both genera belong to the Pteridaceae.

[illegible]

The cliffbrake (Plate ..), the kalamoho laulii of the Hawaiians, is known botanically as Pellaea ternifolia (Cav.) Link. It is another one of the Pteridaceae. Our plant is native both to the Hawaiian Islands and to warm and tropical America. This is not a true cliff plant as its name would indicate. It prefers to grow in very dry soil among ledges and embankments exposed to the full heat of the sun, as occurring within Haleakala; and on older, dusky, aa lava flows, as occurring from the Kau Desert up toward the summit of Mauna Loa.

SWORD FERNS

Three kinds of sword ferns may be found growing wild in the Hawaiian Islands. They belong according to some experts to the Polypodiaceae, to others

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to the Davalliaceae, and to still others to the Oleandroideae. Such differences of opinion ~~xxxxxxxxxxxxxx~~ indicates that Botany is an active science in which the serious student can help solve countless problems. They are characterized by an upright, scaly, short rootstalk 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 indusium. This structure is so typical of these plants that they have been placed in a ~~xxxxxxxxxx~~ genus named Nephrolepis, meaning kidney-scale. In addition to reproducing by spores, these plants produce long, slender runners at the end of which young plants develop. These in time become detached from the parent by decay of the intervening connection.

The typical native N. exaltata grows in dry to wet, somewhat sunny situations from sea level to medium elevations. It grows on the ground and on arid lava flows, its pale green fronds ~~xxxxxxxxx~~ growing out of crevices. It occasionally grows on trunks of trees. N. cordifolia (L.) Presl ~~xxxxxxxxxxxx~~ was introduced probably from Japan before 1875. It prefers mossy tree trunks. N. hirsutula (Forst.) Presl, a recently naturalized sword fern in the Hawaii park grows on the ground. These three species may be easily distinguished from one another. N. exaltata has broader and flatter fronds than N. cordifolia. Moreover, the former has runners that are slender throughout, while those of N. cordifolia produce ovoid, scaly tubers, as shown on Plate . N. hirsutula is the hairiest of them all; has the widest, most upright fronds; and lacks tubers.

Until recent research by experts, the identification of the different kinds of pandanus or screwpines, known to the Hawaiians as hala and lauhala, was in a chaotic ~~xxxxx~~ state. Based on the character of the leaves, crown stomata, staminate flowers, pistillate flowers and especially fruits, we find our Archipelago harbors Pandanus sharlssonis Gaud., P. douglasii Gaud., P. Monsiesii Gaud., P. odoratissimus var. laricatus Martelli and var. colu-

ensis Martelli, and H. tectorius var. sandvicensis Warb. Every one is endemic to the Islands. To be sure, some varieties and forms may be of aboriginal development.

Pandanus, Freycinetia, and the more primitive Sararanga extending from the Solomons through New Guinea to the Philippines, constitute the Pandanaceae or Screwpine Family. Our hala grow typically along the ocean or, where the chukai or ocean mist penetrates, farther inland. P. [illegible], prominent about the Wahaula area of the Hawaii park, may be considered a typical hala.

The Hawaiians attached great significance to the umbilical cord, or piko. Soon after the birth of a child, the piko was usually secreted or placed out of reach. According to Eric Knudsen of Kauai the cord might be placed in a hole in a cliff, the hole being plugged with a phalange or two to discourage insects or rats from reaching it. Though the following does not pertain to plants, we wish to add that on the Island of Maui within Haleakala is the famous "bottomless pit," about [illegible] feet deep, and Ke Piko Kaua, about ten feet deep. After wrapping the cord in a piece of tapa, or bark cloth (page), it was secreted in a crevice or thrown into one of these holes. Regarding the Island of Hawaii, David Konanui in 1911 related that at Puuloa, between Kealakomo and Apuki within the park, is a large pahochoe mound formerly used as a depository for umbilical cords at the birth of children: "A hole is made in the hard crust, the cord is put in, and a stone placed over it." Sam Konanui was more explicit. "When I was small, going with my papa to fish, my papa explained the meaning and the doings of Puuloa. 'Puuloa' means a long life, and that is why they chose Puuloa to deposit the piko of their children. You make a hole [illegible] by pounding with a stone, then in that wahi put in the piko, then there a stone in the place where the piko is placed. The reason for putting in that stone is to save the piko from the rats. My papa said that if a rat bit the piko,

that child would become a thief. Another thing that my papa said was that people on all the islands did the same thing. When they had babies, they saved all the piko in a ʻumeke [calabash] . When they had no more babies, they would get on a canoe and bring the piko to Puuloa. Because they like the connotation of the name Puuloa, which means 'long life,' they would bring the piko here from all the islands to Hawaii Nei. If they had ten children, they would make ten pukas. Each puka held one piko and a small stone was inserted in each. They made the holes round in a ring so they would know they belonged to one family."

In some parts of the Islands, such as the Kau Desert where water is scarce, "the natives," according to Ellis [1833], "have recourse to an ingenious method of procuring a more abundant supply. They fasten together the leaves of the pandanus, which are concave on the upper side, from the top of the tree to the lower branches, and thus form a kind of spout, along which the rain that falls on the tree descends into their calabashes or other vessels placed underneath these vegetable aqueducts for its reception. By this means, during a shower, they often procure a tolerable supply."

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elevations. It is not known elsewhere, but about 250 related species are fo[und] in the islands to the southwest of us and in the Orient. All belong to t[he] Pandanaceae or Screwpine Family.

The lolo is very conspicuous, growing not uncommonly in partly sunny forests at lower elevations. It just manages to extend upward into the Hawaii Volcanoes park in the Kilauea area. Some plants climb the trees and reach their very tops, the main stem enveloping the trunks with its slender aerial roots, while the branches curve out into the sun. Other individuals trail on the ground in great masses, forming impenetrable jungles.

All plants mentioned from here ... forward must have pollen, which is dusted in their stamens, conveyed to their stigmas in order to mature seed

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the pollen of one individual, in most cases, should [illegible] on the pistil of another of the same kind. Plants have therefore gradually evolved many often fascinating methods for insuring such cross-pollination. Some like the grasses, sedges, conifers (.) and plantains (P.), employ wind for this transfer and hence have inconspicuous, odorless and nectar-free flowers. Others, most of the kind here illustrated, depend on insects instead to effect this transfer. They therefore bear flowers that contain nectar as bait to lure the insect, and that are fragrant and conspicuously colored to enable the insect to find this bait with greater certainty. In fact, some of these colors are very conspicuous to certain groups of insects and not to others, nor visible, like ultraviolet, to [illegible]. The special method that the ieie has devised to insure cross-pollination is so unusual as to be worthy of more detailed discussion.

continue (?)

pistils of the "female" plant can be harmed by [illegible] the plants with flower clusters.

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*Rattus exulans Peale, native of the islands and spread by man to many islands of the Pacific as far south as New Zealand and as far north as Hawaii.

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Here we shall digress to consider why the Hawaiian woody vine ieie bears the Latin name Freycinetia arborea Gaud., translatable as "Gaudichaud's Tree-like Freycinetia." Almost every temperate and most boreal and tropical regions of the World have some plant blooming conspicuously in May, and consequently almost all people of the world using the Gregorian calendar have named some plant "mayflower" in their language or dialect. With [illegible] to a hundred "mayflowers" [illegible] the world and belonging to [illegible] as many different [illegible] of the Plant Kingdom, which [illegible] "mayflower" should be [illegible] it be the North American [illegible] or Epigaea repens L.; the [illegible] Gänseblümchen, [illegible] majalis L.; [illegible] Carl Linnaeus [illegible]

with the publication of his two volume Species Plantarum in 1753 cut through red tape. Favoring no modern language, he gave each plant in his monumental work simply a generic name and a specific name, both preferably derived from Latin. This was such an efficient solution to the past Babel of confusion that botanists have been following this method ever since. To be sure, they have modified and improved upon Linnaeus' system, publishing an International Code of Botanical Nomenclature for them to follow. One of these rules is that of priority of publication.

If Charles Gaudichaud-Beaupré (1789-1854) wanted to name a new genus of Pandanaceae for Captain Louis Claude de Saulces de Freycinet (1779-1842) of the exploring vessel "Uranie," a later name for the same group would have no validity unless an outstanding reason prevailed. Similarly, as Gaudichaud gave the Hawaiian vine the species name "arborea" in 1824, that name must stand even though he himself renamed the plant F. arnottii in 1841.

The specific name "arborea" for this vine is purely accidental. When the "Uranie" was shipwrecked, the vessel "La Physicienne" came to the rescue. The wet packages of specimens and accompanying explanatory notes were dried on the beach. As some notes were lost or misplaced in the confusion, the Hawaiian ieie was inappropriately named "Freycinetia arborea."