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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.

the middle of the 16th Century. It forms no viable seed. This was probably distributed from continent to continent by man and is now frequently found growing wild in the U.S., propagating asexually. The creeping rhizome of A. calamus especially in the cortex contains an aromatic bitter oil. The rhizomes are therfore used by c confectioners as a candy, by perfumers in the preparation of aromatic vinggar, and by rectifiers to improve the flavor of gin. According to Sturtevant they are seen for sale on the street corners of Boston and are frequently chewed to sweeten the breath. In some cases the plants have been poisonous. Engler-Prantl 2.2. 118

b. Caladium colocasia, the taro, is a succulent perennial with a starchy tuberous rootstock and unisexual flowers. Itis native thruoughout the East Indies and is thought to have been carried by the Polynesians throughout their migrations. It is not supposed to be native to Hawaii al although scores of varieties or rather forms grow here. Pliny mentions it as cultivated in ancient Egypt. There it is now eaten by the laborers and called qolqas. The taro is the most important food-plant of the Hawaiians, grown on all islands chiefly at the lower elevations and frequently escaping. The commonest forms are cultivated in marshes or flooded fields. They are propagated by cuttings or by the replanting of crowns of the plants just harvested. After about a year's growth has taken place, they are gathered for their palatable tuberous rootstocks. These are either boiled or baked and thus eaten, or cooked, mashed and mixed with water until of paste-like consistency. This nourishing substance,

after a few days' fermentation, is eaten as poi. The leave also can be eaten cooked. The plants are notably free from the ravages of insects. This immunity is due to the presence of innumerable minute cells scattered throughout the tissues, each one filled with scores of needle-shaped crystals of calcium oxalate called raphides. As soon as these cells are wetted by the saliva, they forcibly expel their crystals, thus intensely irritating the linings of the mouth and throat. These crystals are dissolved by cooking. A variety known as " Dasheen" was introduced into the U.S. in 1905 from Porto Rico into which it had been brought from Trinidad. It probably came originally from China as its name indicates (de la Chine or da Chine). It grows well in the sandy Gulf States. Its many forms are eo cooked like a potato.

c. Zantedeschia aethiopia, native to South Africa, is the Calla Calla Lily, which is no lily at all. The yellow central column is merely the spadix while the White corolla-like structure is the spathe.

d. Symplocarpus foetidus is the skunk cabbage of marshes of the Eastern States. In early spring, even while snow is on the ground, a purplish mottled spathe with vile odor arises above the ground. This generates heat and because o of the odor and warmth early insects go there for protection from the cold and for food. Later in the season large leaves develop. The plant is poisonous. This plant is remarkable in that its seed has degenerated to such an extent that testa and tegmen are wanting. The outer part of the endosperm has become hard instead.
(Engler-Prantl 2.2:122.

e. Syngonium podophyllum of Mexico is a climber with compound leaves growing of the campus. (Engler-Prnatl 2.2:141

f. Scindapsus aureus of the East Indies is a climber with ~~cor~~ cordate yellow-blotched leaves. It is commonly allowed to grow up poles in Honolulu.

g. Philodendron, composed of over 200 American species is als planted in Hawaii against trees. It leaves are cordate but due to a normal death of certain tissues, they become lacerated.

h. Monstera deliciosa of Mexico is widely cultivated. It is a liane with theoretically cordate leaves but by the death of of certain tissues become pinnate (as in the palms) and the individual pinnae in turn have holes formed in them. The fruit is a large pineapple-like spadix about 2 dm. long which takes about 2 years to mature. They have a combined taste of pineapple and banana and are commonly sold in the Markets of Mexico. (Lotsy 521

i. Pistia stratiotes is a small free-floating plant with simple oblong leaves with a velevty surface to shed water and with long trailing roots. The plant is found throughout the tropics of the world and actively reproduces by stolons. The small white spathe bears a spadix with unisexual flowers. A many-ovuled pistillate flower with a long style is at the base. Above that are several staminate flowers. The lower have degenerated to form a collar while a single upper one has degenerated until only 2 stamens remain. These have grown together and thus appear as one. The floral formulae are is follows: P 0 A (2) G 0

P 0 A 0 G 1

Pistia, then is the most degenerated of the Araceae, possibly because of its aquatec habitat. This plant leads directly

over to the next family, the Lemnaceae, which are still more degenerated.(Engler & Prantl 2.2:153)

B. Lemnaceae--Duckweed Family.

1. Distribution: A family of 4 genera and about 30 species found thruout the world.

2. Affinities: Pistia would lead directly over into Sporodela, one of the Lemnaceae by--

   a. Decrease in size of plant as a whole.

   b. Branching roots reduced to unbranched roots.

   c. Spathe enclosing one pistillate flower, one fertile staminate flower and a few sterile staminate flowers reduced to one single pistillate flower and two fertile staminate flowers.

   d. Staminate flower with formula of P 0 A 2 G 0 reduced to P 0 A 1 G 0 while the pistillate flowers in both cases are the same.

3. Characteristics: They are the smallest flowering plants on ear earth and have no longer any distinct stem and leaves. The plant body is therefore termed a frond or thallus. All are aquatic, folating freely on or immediately below the surface o of the water. They reproduce very rapidly by vegetative means and are raely seen in flower. In fact, some have never been seen in flower. During unfavorable conditions, such as drying of the pond or its freezing, some species form resting fronds that are very resistant.

4. Genera.

   a. Spirodela consists of two species (and one variety), one of which has been collected only twice, both times at Terra del Fuego. The other, Spirodela polyrrhiza, is practically cosmopolitan and was lately delcovered in

Hawaii. The fronds are 3 to 8 mm. long, flat, green above, pu purplish beneath, and bear several rootlets each with a single fibrovascular strand. The plants reproduce asxually by forming three buds in a groove of the old frond. Each one of these then develops into a new frond, the central one usually developing first while one of the side buds develops faster than the other. These fronds remain connected foresome time t to form conlonies of several individuals. On rare occasions Spirodela produces a spathe in the groove of the frond which contians a single pistillate flower of P 0 A 0 G 1 and two staminate flowers of P 0 A 1 G 0.

b. Lemna consists of about 10 species of wide distribution. These different species in former years were not recognized so everyone practically lumped them under the name Lemna minor. L. minor was reported from Hawaii around 1900. Whether it is truly L. minor has not yet been ascertained. This genus differs form Spirodela in having smaller, entirely green frond and in having but a single rootlet lacking fibrovascular bundle. The inflorescence is practically the same.

c. Wolffia is the smallest flowering plant, being sometimes less than 1 mm. long. It was first found in 1927 near Waikiki. It is globular is shape, lacks rhaphides which Spirodela and Lemna possessed, has a pouch at one end from which axsecond frond arises, and may or may not have a few stomata on the upper surface. The inflorescence consists of a depression on the upper surface of the frond bearing one pistillate flower consisting of a single pistil and one staminate flower consisting of a single stamen.

d. Wolffiella, is composed of linear fronds almost 1 mm. long which bear a groovve at one end for the production of the new frond. About 7 species have been described, yet few have

flower are still unknown.

C. Cyclanthaceae.

1. Distribution: A small family of 6 genera found only in tropical America.

2. Affinities and characteristics: These plants are not derived from the Lemnaceae but like them are derived from the Araceae In general, they are intermediate between the Arum Family and the Palm Family as will be decribed under the genera.

3. Genera:

a. Evodianthus is a liane, thus resembling many Araceae. It has a thick compound spike surrounded not by one spathe as in the Araceae but by several fleshy spathes. The spike is covered with pistillate flowers, each surrounded by four staminate ones as follows:

S SS SS SS S
P P P P
S SS SS SS S
S S SS SS S
P P P P
S SS SS SS S

The pistillate flower bears 4 long strap-shaped structures which are most likely degenerated stamens, or staminodia. The formula is P2#2 Staminodia? 2#2G(4)

The staminate flowers have a single group of innumerable stamens and not even a trace of a pistil. Their formula would be P 2 # 2 A many G 0

b. Carludovica palmata has the appearance of a fan palm. Its spike has been incorrectly interpreted as being composed of perfect flowers composed of one pistil surrounded by four stamens. This flower-like structure, however, is composed of 4 highly degenerated staminate flowers surrounding a single degenerated pistillate one. Their diagrams are as follows: P 0 # 0 Staminodia 2 # 2 G (4)

P O # O A [illegible] G O

From the leaves of this plant, called jipijapa in South America the panama hats are made. This plant with its great number of stamens leads over to Phytelephas, one of the Palms.

D. Palmaceae--Palm Family.

1. Distribution: This is an enormous family consisting of about 150 genera and 1,200 species. All are tropical or subtropical and are found chiefly in Asia and America while only 11 ~~gene~~ genera are found in Africa and one species (Chamaerops humilis) in Europe. The genus Pritchardia is native to the Hawaiians Islands while more than 100 kinds of exotic palms are cultivated here.

2. Affinities: The anatomy of palms is essentially the same as that of Carludovica while the staminate flowers of Phytelephas with its 30-90 stamens might have been derived from that of Carludovica.

3. Characteristics: This is the great tree family of monocots, ranging in height from a 1 foot West Indian Thrinax to a 150 foot Date Palm. The palms with a few exceptions(Hyphaene of Africa) are unbranched. If their terminal bud is cut off they usually die. In many the stem is of uniform diameter thruout while in others limited growth in thickness occurs t towards the base either by the enlargemnet of the tissues al already present or more rarely by the formation of new tissue. The leaves, which are often of gigantic size, form a terminal crown. They are either pinnately or palmately divided, the divisions coming about by the death of definite portions of tissue in the young leaf while still in the bud, and its subsequent tearing along these lines(recall Monstera).

The inflorescence is enclosed by a massive wooden spathe. In a very few cases it is terminal, and then the individual palnt dies with the development of the fruits(Metroxylon), Usually, however, it is axillary. The inflorescence is simple or more commonly branched. The flowers are usually unisexual, having commonly the following formulae: P 3 # 3 A 3 # 3 G 0
P 3 # 3 A 0 # 0 G (5)

The ovary, though composed of 3 united carpels usually becomes one-seeded by the degeneration of the other two. During germination of the seed, one cotyledon remains with its apex in the seed to absorb food from the endosperm while the other appears free. This heterocotyly, of course , makes the plant a "monocot."

4. Genera.

a. Phytelephas is a genus of about 3 species found in swampy localities in tropical America. One species has the appearance of a cycad. Definite staminate and pistillate plants occur. The male inflorescence is a long unbranched, thick spike or almost spadix that breaks out from a sheath of 2 to 4 spathes. The female inflorescence os a large head resembling that of the Pandanus. The floral formulae of staminate and pistillate flowers are the following:

P rudimentary A 30 or usually its multiple on long filaments P 0

P rudimentary A rudimentary on short filaments P (4-9)

The inflorescence forms a collective fruit, each fruit containing 4-9 seeds. The seed is spherical, in different species varying from the size of a walnut to that of a potato. A minute embryo is embedded in the endosperm under a circular lid in the seed coat that lifts off at germination. The endo-

sperm is remarkable in consisting of cells with extremely thick cell walls of a carbohydrate called reserve cellulose which is digested and absorbed during germination by the embryo. The endosperm is so hard and white that it is called vegetable ivory and is used extensively as a substitute for ivory in the manufacture of buttons, piano keys, and even for roller-skate wheels. The seed does not soften when put in water for a day or so. But when it germinates, the endosperm suddenly becomes soft due to the formation of digestive enzymes by the embryo.

b. Phoenix is a genus of 11 or more African and Indian species, many of which are very closely related. About half a dozen are grown in Honolulu. The plants are usually tall trees bearing scars of fallen leaves on their trunks. The leaves are pinnate, the basal leaflets being reduced to spines. Stamainate and pistillate plants occur. The floral formulae, which are typical of the palms, is as follows:

P(3) # 3 A 3 # 3 G 0 or rudimentary

P (3) #3A3 staminodia or 6 G 3 but 2 degenerating at fruit.

P. dactylifera is the Date Palm, native of North Africa and Arabia, which has been cultivated since prehistoric times. It is one of the most valuable trees for the people of Asia and Africa who recognize over 75 cultivated varieties. The life of the wandering tribes of the desert, especially, centers around this plant. In fact, the Arabian poets ascribed such high importance to it that they maintain that the tree was not formed with other plants but from the clods which remained after the creation of Adam. The Orientals since earliest times have practised artificial pollination to insure abundant fruit. When they hear a noise similar to that of crubbed wetted flour upon pressing the unopened spathe of the staminate tree, they cut it off and hang it in the pistillate tree. Thus pollen is not wasted when the

staminate spathes open. The sweet fruit furnishes, fresh or drie the staple food of large regions. The large, succulent head cut from among the mass of leaves is also eaten. The sap is sweetish and may be used as a drink or distilled into a spirit. The seed is chiefly endosperm, the embryo being minute and lying at the s surface near the middle. At germination, the stone-like endosperm, becomes soft and is absorbed by the tip of the one cotyledon and the rest of the embryo bore into the soil. This is consequently a typical monocot with heterocotyledony.

c. Caryota urens, the Wine or Fishtail Palm, is native of India, and not uncommonly planted in Honolulu. The tree may become 40 feet high while the leaves may be 20 feet long. These are bipinnate, each segment having the shape of a fish's fin. When the plant has grown tomaturity, it begins to produce flowers on long dropping racemes near the top of the trunk. As these racemes mature, new ones are formed in succession below until the bottom is reached when the palm dies. The fruits are globose, reddish, and contain a sour juice that is irritating to the skin. In India this palm is much used in the formation of wine, a single tree yielding a hundred pints of juice in 24 hours and this flow of sap will continue for a month. The fresh or fermented juice is called toddy while after distillation it is known as arrack. The trees are tapped when they are twenty years old by cutting off the flower stalk and tying vessels below to catch the juice. This tapping is continued until the entire tree dies. This usually lasts for over a year. The pith contains starch and is manufactured into and inferior sago used locally in making bread and gruel.

d. Metroxylon Rumphii, the Sago Palm, is a large tree of the Molucca producing short runners at the base which are used by the natives to propagate the plant readily. The leaves are pinnate. The pith contains starch, a 15 year old tree producing 600-900 pounds of it when crushed and washed. This damp powdery starch is then p pressed through sieves into copper pans which are kept in motion. The starch thus forms round masses and this is sold as peral sago. Much of the sago is now made from potato starch, however, b by a similar process.

e. Raphia is a genus of about 6 species found in hot, humid regions of Africa while several varieties of an African species(R.vinifer are found in Brazil. This is almost the only case known in which a single genus of palms is found in two distinct floral regions. The leaves are enormous, being 60 feet long. These are probably t the largest leaves known for any plant. The upper epidermis with its bast fibers is stripped from the leaves and exported as raphia for weaving.

f. Calamus is a genus of climbing palms called rattans. At least 200 species are known from China, India and the Philippines. The berries are about the size of a hazelnut with brown scales and reddish flesh. They bear hooks on their pinnate leaves. They are usually modified leaflets situated at the very elongated tip of the leaf. Rattans may claimb to the top of tall trees and loop from one tree to another. Stems about 200 yards long with a diame diameter of only about an inch have been reported. The stems are extremely thin strong and are therefore used locally in the weavi ing of baskets and in the making of suspension bridges. Thye are extensively exported to Europe and America for the manufacture of wickerwork, chairs, seats of chairs, cordage, etc. Rattan canes are merely single internodes (usually of C. Scipionum). Calamus

draco furnishes Dragon' Blodd, a resin which exudes out of the ripened berries. This is used for coloring varnishes and other substances, and in engraving.

g. Pritchardia is a genus of about 35 species of which 75% are endemic to the Hawaiian Islands. These are the only native palms. The other Prichardias are found on Fiji, on the Dangerous Archipelago, and curiously enough, on Cuba. In these islands, no species is found on more than one island. The plants are rather rare and seem to be found in usually inaccessible places, as on high mountain ridges and palis. How they got there is a mystery since the seeds have no method of wind dispersal and are too large to be transpoted by animals. Possibly the original Pritchardias were scattered over the islands at a time previous to marked erosion. Then as the rolling mountains were gradually cut into precipitous ridges, the Pritchardias more or less remained in such isolated spots. Due to isolation for countless ages, they gradually diverged in characteristics to such an extent that we now recognize them as distinct species. The flowers are peculiar in that their perianth falls off at flowering. The Hawaiians the Pritchardias loulu. They ate the young seeds which resemble coconut while with the coming of the white race, they braded the leaves into hats. Many of the species are on the verge of extinction, chiefly due to man and his cattle.

h. Oreodoxa regia is the royal palm, native of tropical America. It is planted troughout the islands. Its trunk is swollenaat the base and near the center of the tree.

i. Oreodoza oleracea, the cabbage palm, differs from O. refia cheifly in having a straight and not swollen trunk. The plant is also more robust and will grow to a height of 150 feet. It is not as common

in Honolulu as the preceding species. The terminal bud, of a white color internally and of a delicate flavor, serves as a vegetable. The heart can be made into pickles while the pith contains a very inferior quality of sago.

j. Areca catechu, the betel-nut palm, resembles somewhat a royal palm though the trunk is straight and slender. It is probably native to the Sunda Islands but now widely grown in the Orient and in Hawaii In many countries the plant is grown for its orange-colored fruits which are grated, wrapped in the leaf of Piper betel with a pinch of quicklime, and chewed. This, as described previously, colors the lips brick-red, blackens, and corrodes the teeth, while the saliva during chewing turns blood red.

k. Elaeis guineesis, the oil palm, is native of Africa. The plant resembles a thick-set date palm. Its reddish fruits contain oil of the consistency of honey, which is widely used for cooking despite its flavor. It is chiefly used, however for soap. A fine group of trees grows along the Pleasanton Hotel driveway.

l. Cocos nucifera, the coconut palm, is indigenous to Hawaii and found thruout the Pacific due to its buoyant seeds enclosed in a fibrous husk. See Cook's Bulletin.

E. Pandanaceae.

1. Distribution: They are plants of the Old World tropics, especially common in Malaya. None are found in the New World. Only 3 genera exist

2. Affinities: These plants are not derived from the Palms but like them seem related to the Cyclanthaceae.

3. Genera:

a. Sararanga sinuosa is a monotypic genus recently discovered in the Solomon Islands. The plant is a tree 90 feet high without adventitious roots. It has staminate and pistillate flowers both with poorly formed perianth. Each flower stands in the axil of a

bract. (Wettstein 934)

b. Freycinetia is a genus of about 30 species, F. Arnotti being native of Hawaii. The plant is a liane, resembling many Araceae in that respect, and is found usually in the mountains where it climbs over trees, The leaves are frequently thorny-toothed on the edges and mid-rib. Staminate and pistillate plants occur. The spathes are a brilliant red in our species, fleshy and sweet at the base. In Java these bracts are greedily eaten by flying foxes while in Hawaii they are eaten by rats and earwigs. These probably effect cross-pollination. The spikes are several, terminal, oblong and surrounded by the spathes. The staminate flowers are very closely pressed together and consist of merely many stamens and usually of a very r rudimentary pistil. The pistillate flowers also are on oblong spikes. They consist of several staminodia surrounding a single pistil. These become fleshy at maturity. No floral bracts occur. The F Freycinetia (F. Banksii) of New Zealand bears flowers of a sweetish taste which are eagerly eaten by the natives. According to Curl (1880), the plant produces the best edible fruit of the country. (Wettstein 936); Lotsy 3:557)

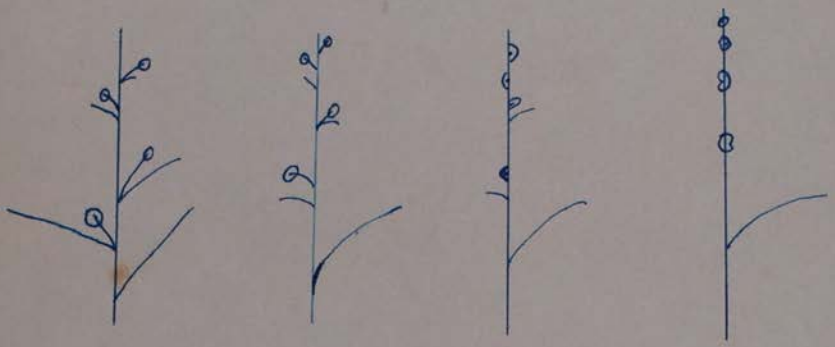
c. Pandanus is a large, little-known genus P. odoratissimus is native to Hawaii, especially along the coast. The plants are upright trees with stilt-like adventitious roots, and prickly lenticels. The staminate trees differ from the pistillate in appearance and in the nature of the wood. The staminate spikes are huge pendant structures bearing staminate flowers whose identity has been lost because they are so closely pressed together. The pistillate flowers at maturity produce an aggregate fruit the size of a child's head. This then breaks up into sections composed of about a dozen closely united carpels, each near the apex containing an air cavity

for floatation device. In each carpel is also a channel from the exterior to the seed lined with rather delicate cells. This is f for the escape of the embryo at germination. In Hawaii the fruit are strung into leis while the yellow basal part can be eaten although it contains very troublesome raphides. From the leaves, lauhala mats are woven. The terminal bud can be eaten as cabbage Most of the trees in Hawaii are pistillate while in India most of the trees in Hawaii are pistillate while in India most of the are said to be staminate. (Wettstein 936)

F. Sparganiaceae.

1. Distribution: A monogeneric family of about 15 species found in marshes of Asia, Africa, and North America.
2. Affinities: Sparganium, the only genus, probably came off early from the Pandanaceae. From these they differ as follows:
   a. More primitive features:
      1. Distinct staminate flowers and pistillate flowers found on one plant, not on two as in Pandanaceae.
      2. Retained the indefinite perianth as found in Sararanga and did not lose it as did Freycinetia and Pandanus.
      3. Each pistillate flower is in the axil of a bract, as in Sararanga but not in Freycinetia and Pandanus.
   b. More reduced features:
      1. From arboreal to herbaceous condition.
      2. From multiovulate condition of Freycinetia to one per carpel.
      3. From many stamens per staminate flower to usually 3.
3. Characteristics: All are small, upright marsh herbs, bearing densely globular heads of staminate and of pistillate flowers on leafy stems. The staminate heads are the upper. The heads appear to surround the stem but this theoretically is not true. They are actually borne on

side stems which have grown to the main stem. The flowers then practically encircle the main stem. This can be shown to be true by noticing that the leaves are alternate and that the first head above a leaf is partly bare on the same side as the leaf. This we would expect since the side opposite the bract or really spathe, here completely degenerated, would naturally be the portion which in such a distribution of flowers would be the last to reached. The following diagram explains this best:



The floral formulae are as follows:

P 3 A 3 G 0

P 3 (to 6) A 0 G 1

G. Typhaceae--Cat-tail Faimily.

1. Distribution: A monogeneric family of about 18 species found in marshes of tropical and temperate regions.

2. Affinities and characteristics: Typha, the only genus, is certainly derived from Sparganium by reduction, The plants are slender upright herbs about 5 feet high terminated by two candle-shaped spikes placed one above the other. The upper spike is staminate and is protected by a deciduous spathe. Below that is the pistillate spike, with or without an intermening sterile area according to the species, which is also protected by a caducous spathe. These spathes are found on opposite sides of the main axis. Typha is thus merely a tall sparganium in which 2 spathes failed to degenerated but in which the heads were reduced to a single oblong staminate one and to a single oblong pistillate one, or a single group of each. The flowers also have been reduced as the following formulae show: (Lotsy 3:563)

P 0 A 3 (2, or even 1 in T.minima) G 0

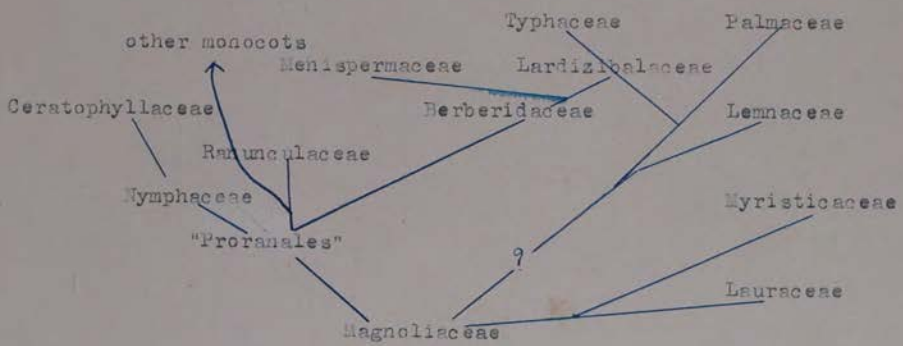
P 0 A 0 G 1 but in axil of bract.

The flowers have a gynophore beset with bristle which are either hairs or possibly degenerated floral members. This gynophore elongates much in fruit while the hairs act as a parachute for wind dissemination. The fruit thus sails upside down in the air. The pollen of Typha has been used as assubstitute for Lycopodium pwoder, while in one species (T. elephantina) of the Mediterranean it is even made in to bread. T. latifolia of Europe and America has starchy edible rhizomes and leaves, which when young and cooked, resemble asparagus.

IV. Summary and Proranales.

A. The most primitive Angiosperms were the most generalized as exemplified by Magnolia of the Anonales. Then by the gradual reduction of the Magnolia flower and by various modification of the result, the other plants arose. When we trace out their different evolutionary lines, we arrive at five cul-de-sacs or blind alleys, namely: Lauraceae, Myristicaceae, Palmaceae, Lemnaceae, and Typhaceae as th the chart illustrates.

B. So now we must return to the Magnoliaceae and see whether they may have given rise to some other group. The only other possible group consists of the Ranales which are chiefly herbaceous while the Anonales are arborescent. To make the relationship seem more correct, Lotsy believes that a transitional order of plants called by him "Proranales" existed which are now entirely extinct and of which we have no fossils. Then the phylogeny me be as follows:



V. Ranales--These are usually characterized by absence of ethereal oils, presence of berberin, tendency for the leaves to become divided into threes or multiples of three, perianth in threes or twos, embryo minute and endosperm copious.

A. Ranunculaceae..

1. Distribution: A faminly of about 30 genera and 1500 species found chiefly in North temperate and arctic regions. Only two species of Ranunculus are native to these islands.

2. Affinities: They show relationship to the Magnoliaceae and Anonaceae because both the floral members are in spiral arrangement on a more or less cone-shaped torus or receptacle. They do differ, however, in lack of aromatic oil and in pollen development.

3. General characteristics: They are chiefly herbs with all the floral parts present, regular, free and distinct. But to this discription we find many exceptions. The family seems to break up into two tribes rollows:

   a. HELLEBOREAE with 2 rows of seeds attached to suture of carpel.

   b. ANEMONEAE with one single seed attached to base of carpel (sometimes, however, additional rudimentary seeds occur indicating origin from Helleboreae)

4. Helleboreae, according to Schroedinger, have perianths composed of a spiral series of modified foliage leaves. Evidence for this is the frequently leaf-like outer perianth parts and their spiral arrangement continuous to that of the leaves below. Most of them have honigblaetter which are modified stamens.

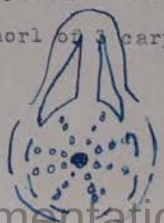
   a. Caltha consists of about 15 species, Those in Europe and America, called marsh marigolds, are swamp plants with

yellow flowers. These are the most primitive of the family, having a varible and large number of floral parts and showing easily the transition between leaves and perianth members. There is no differentiation between sepals and petals. Honibblaetter are lacking. This plant is interesting because the cotyledon stalks have grown together and have produced a tube from whose side the plumule breaks. In two other genera, (Erantus and ficaria), they a also fuse. This seems to prophecy the evolution of a secon group on monocots.

b. Coptis trifolia, the Gold Thread, is round in northern North America and Siberia. It is a small, creeping, woody, trifoliolate plant with yellow rhizomes rich in berberin. The flowers are small with about 6 sepals, an outer row of about 6 yellow stamens modified in spoon-shaped honigblaetter containg nectar, a large and variable number of stamens, and a few apocarpous pistils. Here in the honigblaetter do we find the beginning of a corolla in the Ranunculaceae, In Coptis, they can almost be called petals altho the sepals are white and function as petals in the attraction of insects. (Lotsy 573

c. Delphinium, the Larkspur, consists of about 125 species. Here the flower is zygomorphic. There are 5 colored sepals, the upper being large and spurred. There are, the most primitive species, 8 pe petals. The lower 4 remain latent or develop into small threadlike structures. The 4 upper become modified into two types. The 2 middle ones become spurred and these two spurs are enclosed by the spur of the single sepal. The two lateral are unspurred. There are 3-4 rows of 8 stamens and usually a single whorl of 3 carpels. The floral formula and diagram is as follows:

P 5 # 8 A 8 # 8 # 8 G 3



All the plants of this genus are very poisonous. D. staphisagria, the stavesacre, is native to the mediterranean region. Its seeds which contain in abundance the poisonous alkaloid, delphinine, is powdered and mostly used as a parasiticide to destroy vermin, especially against pediculi vestimentorum--inhabiting the garments next to the skin. Internally the drug acts like aconite as a depressant on the heart and respiration (Lotsy 3:580)

d. Aconitum, the Monkshood, consists of about 75 species chiefly of cold regions of North America and Europe, This plant is practically a Delphinium in which the upper sepal is not spurred but acts as a hood to enclose the two upper spurred petals. These are quite small but extremely long stalked. All of these plants are very poisonous. The tuber of A. napellus is used for the extraction of aconitine which is used in medicine as a heart and respiratory depressant. (Lotsy 3:579)

5. Anemoneae, with a single seed attached to base of carpel.

a. Ranunculus, the buttercup, composed of over 300 species is the most important genus of this tribe. The plants belong typically to cold regions of the northern hemisphere. They are annual or perennial, erect nor creeping, acrid herbs with usually primitive yellow flowers as follows: P 4-7 # 4-7 A many G many. Their leaves are entire or more commonly compound. Some aquatic species show leaf polymorphism. When growing submerged except for the flowers, their leaves are finely dissected while if they become exposed to the air their new leaves will become somewhat compound or even simple. Two species of Ranunculus are endemic to these islands in damp cold regions such as Kokee, while three others have been accidentally introduced in recent years.

B. Berberidaceae--Barberry Family.

1. Distribution: A small family of about 8 genera found chiefly in cold regions of the northern hemisphere.

2. Affinities: Related to the Ranunculaceae from whom they differ chiefly in having whorled floral parts instead of usually spiral, and in having a single carpel instead of a indefinite number. Theri anthers usually open by means of valves as in the Lauraceae.

3. Genera:

a. Berberis is the barberry plant so often planted for a headge in the United States and in Europe. This plant is one of the hosts for the wheat rust, Puccinia graminis. Its planting has therefore been discouraged and even prohibited in states where wheat is generally grown. The leaves are unifoliolate. The read berries are very acid and can be eaten cooked (E and P. 3.2:71)

b. Podophyllum is the mandrake of the Eastern States. The plant i is a fleshy herb about 2 feet high, bearing 2 one-sided 7-to-9-lobed peltate leaves with a large white nodding flower in the center. The fruit is deible but as all other parts are very poisonous, children have frequently died from accidentally eating more that the fruit . The plant is used medicinally as a drastic cathartic and becouse of its similr action to mercurous chloride (HgCl) is commonly called " vegetable calomel". (E. and P. 3.2:75)

C. Lardizabalaceae.

1. Distribution: A small family of 7 genera and about 20 species, all n native to Asia except Lardizabala which grows in Chile.

2. Affinities: They are practically Berberidaceae in which the flowers have become unsexual, although the organs of oppsite sexes usually persist in a rudimentary condition. They differ from the Berberidaceae however, in having a tricarpellary gynoecium, having extrorse anther usually bing lianes, and usually having palmately divided leaves. Lardizabala, a liane native to Chili, leads directly into Menispermaceae as its flora formulae show:

Sepals 3 # 3 Honigblaetter 3 # 3 A (3 # 3) G 3 rudimentary

Sepals 3 # 3 Honigblaetter 3 # 3 A 3 # 3 rudimentary G.5

D. Menispermaceae--Moonseed Family.

1. Distribution: About 60 genera occur chiefly in the Old World tropics
2. Affinities: The most primitive member, cocculus, of this family is practically a Lardizabala in which unisexuality became complete by the loss of the rudimentary sex organs. The more highly evolved Menispermaceae have variously modified this plan but since they lead to no other group of plants we need not discuss them. Most of the Menispermaceae are lianes.
3. Genera:
   a. Cocculus, the most primitive genus, is found in several species in Asia, Hawaii, Australia, Africa, and Mexico. The native Hawaiian name is "huehue". According to Hillebran, 4 endemic species are found here but these according to another botanist have been lumped recently into C. Ferandianus. The plant in Hawaii is a pale olive-green vine creeping over rocks and arid clay soil. The fruit is a dark purple berry, containing crescen shaped seeds. This plant and its relatives are often employed to stupify fish so that they may be picked out of the water. The floral formulae of this " reduced Lardizala" are:
   Sepals 3 # 3 Petals 3 # 3 A 0 # G $\underline{3}$
   Sepals 3 # 3 Petals 3 # 3 A 3 # 3 G 0
   The Menispermaceae lead to no higher group of plants. We must therefore return to the Proranales for the next groups. (E and P 3.2:81)

E. Nymphaeaceae.

1. Distribution: Water or swamp plants found chiefly in warm regions and especially in tropical South America.

2. Affinities: These plants we had better attach to the hypothetical Proranles for want of a better link. And since we believe the Proran ales gave rise to many other families as well, the Nymphaeaceae should possess at least a few characteristics in common with them. Thus the nymphaeaeceae possibly show a certain relationship to the Berberidaceae as follows:

   a. Both have arils.

   b. Both have fibrovascular bundles in their pith.

   c. The nymphaeaceous genera Nelumbo and cabomba have free floral parts as have the Berberidaceous genera Podophyllum, Jeffersonia and Diphylleia.

   The Nymphaeaceae possibly show a certain relationship to the Papaveraceae or Poppy Family as follows:

   a. They have fibrovascular bundles in their pith as have a few Papaveraceous genera.

   b. Both have their seeds attached to the entire surface of the septa of the carpels,

   c. Both have latex.

   The Nymphaeaceae in the tribe Cabombeae possibly show a certain relationship to the aquatic Ranunculus species in having free floral parts, small flowers , and small finely divided submerged leaves.

3. General characteristics: Water or marsh plants with submerged, floating, or even emerged leaves. I floating leaves the stomata occur only on the upper surface. Usually the floral parts are many and indefinite in number with the carpels united, but in a few gen genera like Brasenia the floral parts are few and more definite in number with the carpels free.

4. Genera:

   a. Brasenia is a monospecific genus growing everywhere except in Europe. Its roots and rhizomes are buried in the mud and its flowers and peltate leaves float to the surface of the water. The young parts of the leaves, excepting the upper surface of the leaves, is covered with a remarkable transparent slime that is 2 to 3 times as thick as the plant itself. This is secreted by special glandular hairs probably to protect the growing parts from the water until the cuticle should form. After its formation the secretory hairs and slime gradually fa fall off. The flower is purplish in color and in respect to apocarpy resembles the buttercups. The formula is as follows: P 3 - 4 # 3 - 4 A 12 -: 18 G.$\underline{4}$ - $\underline{18}$ It is apparently more primitive in respect to its gynoecium and more highly advanced in respect to perianth and androecium and more than other Nymphaeaeceae. (Lotsy 3:602)

   b. Nelumbo is a genus of 2 species, N. lutea having yellow flower and growing in the Mississippi drainage basin, and N. Nelumbo having pink flowers and growing in the Orient. The Asiatic species is the Indian Lotus, not the true Lotus of the Egyptians, It seems to have been brought by the early Persians into Egypt where it has now almost killed out the true Egyptain Lotus, N. Nelumbo has numerous sepals and petals which intergrade into each other, numerous hypogynous stamens with sterile tips, and a remarkable inverted cone-shaped torus in

in which about 15 apocarpous pistils are embedded except for their stigmas. The leaves are peltate, about 5 dm. in diameter, and project several inches above the surface of the water. They have stomata only on the upper surface, proving that they evolved from floating leaves such as are found in the waterlilies. When water lies on the peltat leaf in bright sunlight, it will appear as though it were boiling. In 25 minutes one leaf will give off 1 liter of air. This is not due to phoyosoynthesis but to the expansion of gases throughout the plant, especially in the warmth of sunlight. This exchange of gases must be beneficial because water plants must get air into rhizomes and roots that are buried in oxygen-free mud. The rhizome of Nelumbo appears like a string of thich yellow sausages. They contain about 8 large air channels. The starchy rhizomes are extensively eaten cooked in the Orient and in Haw Hawaii. They also furnish a starch called "gaou fun" in China The seeds, not unlike small acorns in shape, are also eaten. According to Pickering who wrote in 1879, the stems are eaten in Japan. (Lotsy 3:604)

c. Castalia, often called Nymphaea, is the Waterlily of which about 40 species exist. Castalia odorata, the common white fragrant American species, has floating leaves about 1 dm. wide which are round but have a deep sinus. The flower floats but the fruit matures under water. There are 4 sepals, a large and indefinite number of petals that have originated from stamens and show all possible transitions between true petals and stamens and many stamens inserted on the ovary. This is 15-to35-celled, with the concave summit tipped by a globular projection at the center around which are the united stigmas. Nymphaea lotus is the true white lotus of Egypt. It is

depicted on most of the Egyptian monuments. N. caerulea, a smal smaller flowered but blue species, is also found in Egypt and d depicted on monuments. These must not be confused with other plants going by the same name. Thus Nelumbo is the Indian Lotus Zizyphus lotus (Rhamnaceae), a jujube tree, produces fruit whi which served as food to the Lotophagi or lotus-eaters of Greek history. The genus Lotus consists of legumes commonly used for fodder in Europe, one of which was mentioned in Iliad as affording food for horses. Most, if not all Castalias, have starchy e deible rhizomes. Castalias usually grown for ornment are hybrid. The ovules are attached to the entire surface of the septa of the gynoecium. This condition is similar to that found in the poppies. (Lotsy 3:610)

d. Victoria consists of about 3 South American species. They are perennials with floating leaves that are prickly on the under side, and large flowers with prickly sepals. The leaves are 3 to 6 feet in diameter, have an upturned margin 3 to 8 inches high to act as a border possibly to keep the water off the leaf and great bars and cross-ribs beneath. These leaves are so strong that htey will easily hold a 5 year old child. The flowers are 6 to 18 inches in diameter, have 4 sepals or more, over 50 petals, over 150 stamens, and about 50 carpels. The flower is similar to that of Castalia. The plant was named after Queen Victoria. The seeds are eaten in South America where they are called "mais del aqua" or water corn. The Amazon is covered for miles by this plant where the water is not more that 2 meters deep. The best known species grown for ornament is V. regia but in North America V. Cruziana, named after Gen. Stanta Cruz is grown altho incorrectly dnown as V. regia. (France 6: 193--519, E. and P.)

F. Ceratophyllaceae

1. Distribution: Found throughout the world in standing water except in the arctic and antarctic.

2. Affinities: Because of their aquatic habit these plants are very much reduced and were with difficulty recognized as one of the Ranales. In fact, they have been considered at various times Gymnosperms, Monocots, relatives of the Nettle Family, and relatives of the Halorrhagidaceae. According to Asa Gray's studies, they are without doubt derivatives of Cabomba, a close relative of Brasenia which has finely dissected submerged leaves. Namely, they have a ma many-leaved perianth, innumerable stamens on a convex torus, free carpels, and an embryology similar to that of the Nymphaeaceae.

3. Caracteristics and genera: The family contains only Ceratophyllum, a genus of only 3 species. The plants are submerged, and have finely dissected leaves. Definite staminate and pistillate flowers are found sessile in the axils of different leaves. The pistillate flower consists of 9 to 10 greenish perianth parts surrounding a single carpel having a pistil extending 4 to 5 times beyond the perianth. The entire pistil secretes a sticky substance and functions as a stigma. The staminate flower consists of 9 to 10 perianth part and 10-20 large almost sessile stamens having 2 air cavities at the apex. The stamens at anthesis float to the top, shedding their pollen which slowly sinks in the water and occasionally pollinates the female flower. The fruit of Ceratophyllum demersum has 2 large projections at base to anchor the plant. The seed is very large and contains 2 thick cotyledons and well developed plumule. At germination the cotyledon tips remains in the seed while from the base arise the next pair of leaves which also seem to aid as anchorage organs. Roots are never formed and the plants merely float freely in the water at considerable depths. The floral formulae are:

P 9 - 10 A ∞ G $\underline{1}$

P 9 - 10 A 10 - 20 G $\underline{0}$

or dioecious. This unsexuality is due to reduction. The carpels are very numerous, are arranged over a globular torus, and form a compact head at maturity. Two species are found introduced in these islands. Sagittaria sagittifolia, a Eurasian species, was no doubt introduced by the Orientals around 1880 Its first leaves are merely linear petioles, round in cross-section. The later leaves are hastate. Its corms become an inch or more in diameter and are an important article of food to the Orientals. They are somewhat bitter and probably should be boiled bor a long time. The second species found so locally has not yet been reported nor identified. Its early leaves are hastate like its later ones. The Sagittarias, like several other marsh plants, introduce us to DeCandolles Theory on the Origin of Monocot leaves. Sagittarias have polumorphic leaves. The young leaves are blade-less while older ones show all transitions to a fully bladed condition. Furthermore, plants growing in deep water have linear blade-less leaves while those leaves that can easily reach the top have well developed blades. According to DeCandolles and Arber, all plants originally had net-veined leaves with prominent blades. Some of them then gradually reduced their blades until they became lost, possibly due to increased dryness of the environment. Later, however, conditions changed so that more photosynthetic area was desirable. But since the net-veined blade was gone and could not be recalled because of Dollo's Law of the Irriversibility of Evolution, the plant was forced to adapt some remaining structure into a bla blade. It therefore flattened out its petiole into a new type of blade. Since the fibrovascular bundles naturally ran parallel in the petiole, they would likewise run parallel

VI Helobiales: These are monocots apparently easily derived from the Ranales of Proranales. They are water or marsh plants with usually apocarpous pistils, numerous stamens, 3 petals, 3 sepals, and frequent resemblance to Ranunculus. These flowers, however, are frequently greatly modified by reduction. All, except one family(Aponogetonaceae) have strange microscopic scale-like or hair-like organs called squamulae intravaginales in the axils of their leaves which secrete slime(cf. Brasenia?).

A. Alismaceae--Water Plantain Family.

1. Distribution: found practically throughout the world in temperate and tropical regions.
2. Affinities: Related to the Ranales as decribed above.
3. Characteristics: A family of 10 genera of marsh herbs with basal leaves and perfect or unisexual flowers composed of 3 persistent sepals and 3 deciduous white petals, 6 or more stamens, and numerous apocarpous carpels which become floating achenes at mat maturity. The vegetative organs contain latex and seem to be avoided by herbivorous animals. In a few species we find that self-pollination occurs if the plants are submerged to such an extent that the flowers cannot reach the surface of the water.
4. Genera:

a. Alisma plantago-aquatica of Europe and America is the water plantain. It has perfect flowers and its numerous carpels are arranged in one circle around the torus. With maturity, however the fruits press each other to such an extent that they no longer lie in one row. The typical leaves are long-petioled with an ovate blade. (Lotsy 3: 626)

b. Sagittaria, the Arrow-head, consists of about 15 species, all but one or two found in America. Here the plants are monoecious with the staminate flowers above the pistillate, o

when flattened. The monocot blade thus is homologous to flattened dicot petiole. (Lotsy 628)

B. Butomaceae--Water Poppy Family.

1. Distribution: About 10 species in 4 genera found in the tropics.
2. Affinities: They show some relationship to the Alismacrar in gener floral structure but their carpels contain many ovules attached to their entire side surface as in the Nymphaeaceae. It is therefore best to consider them, not as derivatives of the Alismaceae but as derivatives of the Proranales along a line somewhat parallel to the Alismaceae.
3. Genera:
   a. Hydrocleis nymphoides (incorrectly known by florists as Limnocharis Humboldtii) is the Water Poppy of tropical America, which was growing near the roadside spring in Nuuanu Valley. It is an aquatic with floating leaves and large yellow flowers. The outer stamens are staminodia.(Lotsy 3: 632)

C. Hydrocharitaceae.

1. Distribution: About 15 genera consisting of fresh water plants while others are strictly marine--a rather habitat for plants higher than Thallophytes.
2. Affinities and characteristics: These may best be considered Butomaceae in which the gynoecium became syncarpous and inferior. Many variations of this general plan naturall occur. Another characteristic is that the inflorescence while young is enclosed by a sheath composed of 1 or 2 bracts.
3. Genera:
   a. Vallisneria spiralis is the Fresh-Water Eel-Grass of warmer regions of America and Europe. It is planted in aquaria in H Hawaii and may be found escaping in the future. The plant grows entirely submerged in streams and lakes. Its leaves are linear, and arise from near the buried base. Long creeping rhizomes

form for asexual reproduction. The plants are dioecious. The staminate plants produce short stalked inflorescences surrounded by two closely investing transparent bracts. Within is a short raceme bearing innumerable staminate flowers, having the formula P 3 # (3 rudimentary) A 2 G 0. These flowers while still closed brake from their pedicels and float to the surface because of air enclosed by the sepals. Then they open and the 2 stamens with rip pollen are blown around on the water like boats. The pistillate f flowers are larger, single, enclosed by two bracts, and attached to a very long spirally wound peduncle. At maturity they come to the top and open. Their formula is P 3 # (3 rudimentary) A 0 G (3). The stigmas are then so arranged that the floating staminate flow flowers should touch their anthers to them. The pistiliate flower after pollination is drawn under water to ripen its seeds. Such pollination is called hydrophilous pollination.

b. Elodea consists of about 5 species native to America. Pistillate plants of E. canadensis were accidentally introduced in Europe in 1836 where it has become such a troublesome pest that it is called the Amerikanische Wasserpest by the Germans. It has spread widely by growing along canals from one part of the country to another. The plant has a long stem beset with small leaves. It rarely flowers and seeds. Instead, it easily breaks into pieces which then float around and produce adventitious roots for anchorage. The staminate flowers are practically the same as those of Vallisneria except that the tricarpellary gynoecium has united into one cell yet gives a hint of its original structure. The peduncle of the staminate flower is an inch or so in lenght. The male flowers float to the top as in Vallisneria. This plant is c commonly used in Botany classes to show move ment of Chloroplasts The staminate flowers shed their pollen at the surface. The grains

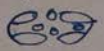
cohere in tetrads and, though heavier than water, float at the surface because of long spines that entangle air. The pistillate flowers may produce a corolla tube that is 30 cm. long and only 3 mm. wide, namely 1000 times as long as wide. It produces a depres depression on the water surface into which the polen grains slip. They then touch the projecting stigmas and effect pollination.

c. Halophila is a little-known marine genus of which one unreported and possibly new species grows off Kaimuki. This plant in flower structure is greatly reduced and difficult to connect with other forms. Its floral formulas are: P 3 # 0 A 3 G 0 and P 3 # 0 A 0 G 3 with filiform stigmas. The pollen occurs in multicellular filiform threads and pollination is under water. (Lotsy III:648)

D. Potamogetonaceae--Pondweed Family.

1. Distribution: About 10 genera and many species, found practically throughout the world in fresh and salt water.
2. Relationship: They may possibly be related somewhere near the Alismaceae but their floral structure is built on the 4-plan instead of on the 3-plan,
3. Characteristics: Water plants with submerged or floating leaves, with greenish flowers which are perfect or imperfect and typically built on the 4-plan.
4. Genera:
   a. Potamogeton, the Pondweed, consists of over 50 species of fresh or mere rarely brackish water throughout the world. They are herbs woth jointed rooting stems and 2-ranked leaves. The floating ones are firmer and have usually a dilated blade while the submerged leaves are very thin and usually linear. This is another genus that exemplifies DeCandolle and Miss Arber' Theory. The inflorescence is a spike that projects above the water for wind pollination. The flower is peculiar. There are 4 one-seeded carpels,

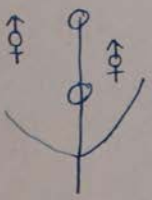
4 stamens, and 4 sepal-like lobes whose structure is not certainly known. They areceither sepals united to the stamens or sepal-like projections of the connectives. The fruit matures under water. If the unripe fruits are picked and placed in distilled water they will germinate immediately, while if they are allowed to ripen they will never germinate in distilled water. This is because the unripe seedcoat is permeable to water while the ripe one is not until has at least partially decayed. Two species grow in Hawaii. Many species become encrusted with calcium carbonate and are then used as a fertilizer.

b. Ruppia maritima, the only species of the genus, is found thruout the world in salt and brackish water in many different forms. It has a similar habit to that of Potamogeton but its leaves are filiform. The inflorescence, too, is a filiform peduncle bearing usually 2 flowers on opposite sides of the peduncle. This consists of usually 4. separate carpels with one sessile stamen on each side thus: 

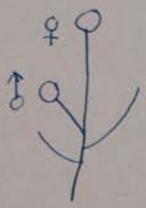
The inflorescence in diagram will show how the next genus may have evolved. The flowers usually reach the surface of the water for pollination by means of a long spirally coiled peduncle. After fertilization the stamens drop off while the carpels then ~~or~~ are raised by the formation of a gynophore. The entire inflorescence at the same time is drawn under water by the spiral winding of the peduncle. Dr, Britton and others interpret the Ruppia inflorescence as composed of two groups of greatly reduced flowers, each flower being composed of either a single stamen or a single pistil. Ruppia is very common in brackish ditches and ponds in Hawaii.

c. Zan ichellia palustris, in many forms, is found in fresh and brackish water throughout the world. It is entirely submerged and re-

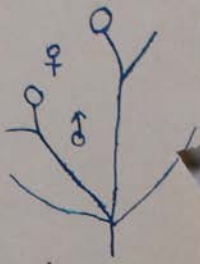
sembles Ruppia superficially. Here again we do not know whether we are dealing with an inflorescence or single flowers. All we can say is that Zannichellia might have been derived from Ruppia as the following diagram shows:



Ruppia



theoretical Ruppia that has become unisexual.



Zannechellia

E. Najadaceae.

1. Distribution: Only the genus Najas exists of which N. marina is the commonest, being almost cosmopolitan.

2. Affinities and characteristics: These are possibly derived from a plant like Zannichellia by further reduction. Dioecious and monoecious species occur. They are almost solely fresh water plants and a are completely submerged. A species was found on Oahu in the early d days but has not been found since.

3. Genera:

a. Najas marina L. seems to be a fresh water species like almost all others. Linnaeus found it first at the head of a fiord in Sweden and thinking the water was salty gave to the plant the specific name marina. It is probable, however, that the localities in the bays in which N. marina lives are filled not with sea water but with fresh water from the mountain torrents. The pistillate flowers consist of a single carpel with usually 3 stigmas. The staminate flowers consist of a single stamen enclosed by a sheath appearing like a carpel. It has been observed that the pollen sometimes germinates while still in the anther to produce a long tube. Such germinated pollen grains would be caught much easier by the stigma that if they were merely spherical. If this type of pollination really occurs, then it stimulates that of Halophila in which the pollen is filamentous. Quite a number of other families belong in the Helobiales (most of them aquatic butoone parasitic and terrestrial) but are unimportant

orescent, transmitting light red and reflecting it more or less orange. All fluorescent materials change the length of light rays and it may be the object of this pigment to make the light useful for photosynthesis, especially for the reds that live at the greater depths to which blue and ultra-violet rays may penetrate but not the red. (The chemistry of the substance was worked out by Kylin in Zeitschrift Phys. Chemie. 69. 1910.) It is a globulin that can be chrystalized out with 5% NaCl and with ammonium sulphate.)

D. Common or noteworthy species:

1. Nemalion.

a. General characteristics: This appears like a sparsely branching slimy thread attached at one end to somecsubstratum like a stick or stone. When magnified, we see that the thallus is composed of loosely intertwining filaments of two general types The axial filaments are in the center, run lengthwise, and are colorless. The assimilating filaments which arise from them and run at right angles to them are red. These produce the sexual organs. This plant is consequently the gametophyte.

b. Male organs: Minute antheridia are produced in clusters at the tips of branching filaments. Each contains a cell called a sperm, although since it encloses two nuclei, it theoretically contains two sperm nuclei. This sperm is finally liberated and passively floats in the water and may hit against the female organs.

c. Female organs: At the tips of branching filaments occur two cells which collectively constitute the procarp. The lower cell, which corresponds to the oogonium of other algae, is the carpogonium containing a female nucleus. The upper cell, which

is elongated, constitutes the trichogyne. When a sperm comes in contact with the trichogyne, the two intervening walls become resorbed, and through the perforation one of the nuclei reaches the female nucleus in the carpogonium to accomplish fertilization.

d. Sporophyte: The fertilized egg or oospore grows to produce numerous short filaments, actually the sporophyte generation. At the tip of each filament a carpospore is formed. The entire structure composed of carpospores, filaments, carpogonium and decaying trichogyne is termed the cystocarp. The carpospores then germinate directly into a new sexual plant.

2. Liagora: This alga is not rare on the reef. It is very much like Nemalion except that it is more extensively branched and has a chalky appearance. In cross-section we find that lime has been deposited among the axial filaments. Little is known about its life history, but from general appearance we may assume that it is practically the same as that of Nemalion.

3. Grinellia americana is a red alga of the general habit of the green sea lettus, Ulva lactuca. Its cystocarps can be seen with the naked eye as red dots scattered over the thallus.

4. Corallina: Many undescribed species grow along the reef of these islands. This plant is heavily encrusted with lime. Definite uncalcified joints appear, as inn Halimeda, one of the Greens, which allows the plant to sway with the currents and not be broken into pieces.

5. Lithothamnion is a very calcareous red which is usually mistaken for a true coral. It forms the greater part of the reef between the Zoology Laboratory and the Elk's Club.

6. Polysiphonia is typical of the more complex red algae.

a. General characteristics: This is a branched polysiphonous plant consisting of a central row of elongated cells called the axial siphon, surrounded by peripheral cortical cells.

b. Male plant: Certain branches produce erect grape-like clusters of antheridia. These do not discharge their contents as in the case of Nemalion. Instead the entire antheridium is cast off bodily from the parent plant and functions as a sperm.

c. Female plant: Certain branches produce a rather complicated procarp composed of trichogyne, carpogonium, pericentral cell, and auxilliary cells.

d. Carposporic plant: When the sperm nucleus unites with the egg, the resulting nucleus actively divides. Then many of the cells fuse to produce an irregular chamber filled with many nuclei derived from the fertilized egg. This chamber then buds out 60 or so cells into each one of which one of the nuclei migrates. These then develop into carpospores. Later cell cells from the female plant grow around the entire structure to protect it.

e. Tetrasporic plant: After the carpospores are disseminated they germinate to produce a plant similar to the sexual plant. This, however, produces sporangia from the axial filament which develop into 4 tetraspores each. These tetraspores then give rise to the two sexual plants. Polysiphonia thus has a distinct male generation, female generation, a very reduced carposporic generation more or less parasitic upon the female and a tetrasporic generation.

E. Economic importance.

1. The well-known edible "Irish Moss" or "Carrageen" is merely

the dried and bleached red alga, Chondrus crispus.

2. Several genera (Gracilaria lichenoides in Ceylon, Eucheuma spinosum in Java, Gelidium corneum and G. cartilagineum in Japan) are used to form agar-agar, a substance used in bacteriology and as a medicine.

3. Several reds (Porphyra) were eaten by the Hawaiians.

X. Fungi.

A. General characteristics.

1. Lack chlorophyll and must therefore live either as parasites on plants or animals or as saprophytes upon decaying plant or animal products.

2. The vegetative part of the fungus is termed the mycelium and consists of threads called hyphae which may be either free and delicate or variously interwoven to form a compact structure.

3. The asexual reproduction is accomplished by spores variously produced.

4. The sexual reproduction is extremely variable, often obscure, and possibly in certain groups entirely missing.

B. Relationship.

1. Probably of polyphyletic origin: Since the fungi include three great groups which have little in common except that of living a parasitic or saprophytic life, it is probable that they evolved from several unrelated algae that lost their chlorophyll and not from a single alga. Thusvtheir probable origin is polyphyletic and not monophyletic.

2. The three great groups are as follows:

a. Phycomycetes or Algal Fungi seem to have evolved from a Green Alga like Vaucheria, as we will describe later.

b. Ascomycetes or Sac Fungi produce usually eight spores inside of a single cell. They probably originated from the Red Algae.

c. Basidiomycetes or Club Fungi bear usually four spores at the tip of special cells. They possibly originated from some primitive Ascomycetes.

C. Geographical distribution and habitat: Fungi live on land or in

water, excepting the ocean, wherever living or dead organisms occur.

D. Phycomycetes or Algal Fungi.

1. Origin of the group from a siphonalian Green Alga is evident by the following comparison.

a. Vaucheria, one of the Green Algae previously described is a coenocyte. For sexual reproduction a round branch develops and forms a cross-wall at the base. The structure then becomes an oogonium containing an oosphere. On the same filament or on another plant a more slender branch develops which is frequently coiled. It also forms a cross wall at the base, but develops into an antheridium containing sperm. These are finally liberated, enter the oogonium and fuse with the oosphere to produce an oospore.

b. Saprolegnia, the water mould.

1. General characteristics: Common species live on drowned insects and form radiating whitish masses around them. These are composed of Vaucheria-like coenocytic hyphae. A few species are very harmful to the fish industry. The spores, for example, come to rest upon a fish and form tubular outgrowths, especially where a scale has been rubbed off. The fungus grows in size and finally kills the fish.

2. Asexual reproduction: The tip of a filament is cut off from the rest of the plant by a cross wall as in Vaucheria. The nuclei contained in the resulting zoosporangium then develop into zoospores. These finally escape through a terminal pore and after swimming around for a while, settle down on a drowned insect to produce a new plant. The empty zoosporangium may then later be filled with a second zoosporangium that grows into it by pushing through the old cross wall.

3. Sexual reproduction:

a. Antheridia are produced in a manner similar to that of Vaucheria. Instead of the sperm being liberated into the water, however, prolongations of the antheridium grow into the oogonium and then the sperm enters it for fertil ization.

b. Oogonium is similar to that of Vaucheria except that that instead of the formation of a single oosphere, u-sually several are formed.

2. Other common or noteworthy species.

a. Albugo candida, the downy mildew.

1. General characteristics: This plant is not aquatic but lives as a parasite upon various species of the mustard family. The mycelium ramifies throughout the tissues of the host, individual hyphae sending haustoria into the cells for food.

2. Asexual reproduction: Hyphae under the epidermis of the host become conidiophores and by abstriction or pinching off at the tip form conidia. The production of these conidia pushes up the epidermis of the host so that it appears like a blister called a pustule. Finally the spores are liberated by the breaking of the pustule and are blown to another plant. If this plant is wet with dew or rain, the conidium germinates to produce numerous laterally biciliated zoo-spores. After swimming around for a brief time, they pro-duce a hypha which penetrates the host tissue to start a new infection.

3. Sexual reproduction is similar to that of Vaucheria ex-cept that antheridia and oogonia are formed on separate

hyphae and that this occurs deep within the host tissue.

b. Rhizopus nigricans, the common bread mold.

1. General characteristics: This mold is commonly found growing on stale bread and more rarely on fruits and other organic matter. The mycelium consists of hyphae that grow on the surface of the substratum, producing ramifying haustoria at short intervals.

2. Asexual reproduction: Wherever the plant produces a group of haustoria we find several upright hyphae have formed which are termed sporangiophores. Near the tip a cross wall develops to form a sporangium. As the spores within the sporangium develop, the terminal wall at the tip of the sporangiophore bulges into the sporangium to form the columella. Finally the sporangial wall becomes mucilaginous and thus the spores are liberated to grow into a new plant.

3. Sexual reproduction: On very rare occasions sexual reproduction occurs when two suitable individuals are brought together. These have been called the plus and the minus strains, which apparently correspond to female and male plants although these cannotbbe recognized by sight but only by their behavior. When plants of these two strains come together, each sends out special hyphae called suspensors. These grow together, and each cuts off a terminal cell or gametangium by the formation of a cross wall. Usually these gametangia differ in size, the larger being the plus strain corresponding to a female plant, and the smaller being the minus strain. These gametangia finally dissolve their cross-walls, the contents fuse, and a thick walled zygospore develops. This then germinates to produce a new plant. Here

then we either find the origin of the differentiation of sex or the gradual degeneration of a heterogamous plant to isogamy.

E. Ascomycetes or Sac Fungi.

1. Origin of this group is not definitely known but in many of them a spore case called the ascocarp is developed in connection with the asci which is comparable to the cystocarp enclosing the carpospores in the Red Algae. More than 20,000 species are known.

2. General characteristics: The mycelium is septate and not coenocytic as in the Phycomycetes. The sexual method of reproduction is much reduced or even entirely wanting. The common asexual method of reproduction is by a sac-like cell called the ascus which encloses usually 8 ascospores.

3. Common or noteworthy species.

a. Saccharomyces or yeast.

1. General characteristics: These are unicellular plants lacking mycelial growth possibly due to degeneration. They multiply rapidly by budding new cells from the old which gradually break apart to form an independent plant.

2. Asexual reproduction: occurs most often when the plants are allowed to dry gradually in the presence of oxygen. Usually 4 but sometimes a greater or lesser number of resistant spores called ascospores develop within the old cell wall which is consequently termed an ascus. The ascospores are finally liberated by the decay of the ascus and then bud off new yeast cells. Whether the yeasts actually are degenerated Ascomycetes producing true asci and ascospores is not definitely known.

3. Sexual reproduction has been observed in a very few species. It consists of the conjugation of two cells accompanied by nuclear fusion.

4. Economic importance:

a. Various species of yeast are extremely important to man. Their importance is due to the fact that they actively decompose sugars upon which they feed into CO_2 and alcohol, a change called fermentation. This fermentation $C_6H_{12}O_6 = 2CO_2 + 2C_2H_5OH$ is accomplished by the presence of an enzyme which has been called zymase by Buchner.

b. As far as the United States is concerned, the most important use of the yeast plant is its application in the "raising" of bread. Flour contains, in addition to starch a little sugar, and this amount is increased in bread-making by a ferment called diastase in the flour which changes starch into sugar. The flour is mixed with water containing yeast into a dough and placed in a warm place. Soon it begins to rise. This means that the yeast plants begin to grow and decompose the sugar into CO_2 and alcohol. Especially the gluten in the dough prevents the escape of the gas which collects in bubbles, causing the dough to swell. Baking further expands the gas and also drives off the water and alcohol, leaving the bread light and porous.

c. Beer is usually made out of barley which is allowed to germinate. During the process of germination the starch held as a reserve food in the seed is changed into sugar by diastase so that the seedling can absorb it. This sug-

ar is later washed out of the barley and the resulting solution placed in large vats with yeast where it is allowed to ferment and produce beer.

d. Whiskies and brandies are obtained by removing a part of the water by distillation from the fermented mass. Such liqueurs contain 15 to 20 or more per cent of alcohol and are correspondingly poisonous. Alcohol used on wounds is a stimulant and local anaesthetic. When placed on surfaces of the broken skin, it causes cooling and contraction of the superficial blood vessels. Internally it causes a secretion of saliva and the heart is stimulated by the irritative action of the drug. The primary stimulating effects of alcohol in man causes increased mental activity and apparent brilliancy, but reasoning powers and judgment are decreased, and in many cases almost immediate mental confusion and drowsiness is induced In general alcohol affects the nervous system like most anaesthetics, namely stimulation, followed by depression, and if severe by paralysis.

e. Wines and cider are weak alcoholic liquids formed by the yeast plant from the sugars expressed from grapes and apples. In this case the yeast is generally allowed to find its own way naturally into the fluids, the ascospores occurring regularly in the soil of vineyards. When these fermented beverages are bottled before the decomposition of the sugar is complete, a further generation of CO_2 sets up a pressure in the bottle or cask that causes the popping of the cork when the bottle is opened and the sparkling of the fluid owing to the escaping gas.

b. Microthyrium, one of the mildews.

1. General characteristics: This fungus and its relatives are superficial parasites on the higher plants such as grape rose, lilac, etc., causing great economic losses. The mycelium usually ramifies over the leaves of various plants, sending out small haustoria into the epidermal cells. The presence of the fungus gives the leaf a dusty white appearance.

2. Asexual reproduction: From the mycelium arise many upright conidiophores which abstrict conidia. These then are blown around to other plants to increase the infection.

3. Sexual reproduction: Oogonia and antheridia are produced at the tips of hyphae. These grow together and then the nucleus in the antheridium enters the oogonium to fertilize the oosphere, producing an oospore. This then produces either a single ascus containing ascospores or it produces ascogenous filaments which develop many asci and sterile paraphyses. While this is occurring, filaments are produced from the oogoniophore and sometimes even from the antheridium to surround the asci. The entire structure is called an ascocarp or perithecium. Here we notice a resemblance to the Red Algae with their cystocarp containing carpospores

c. Xylaria.

1. General characteristics: These fungi are common on dead trees, through whose wood the mycelium ramifies and feeds. At length it comes to the surface of the log to produce a black charcoal-like mass called the sclerotium.

2. Asexual reproduction: This occurs by the abstriction of

conidia from conidiophores which are borne on the sclerotium.

3. Sexual reproduction: Apparently sexual reproductive bodies are formed in the sclerotium. From them arises a long club-shaped structure called the stroma (pl.stromata). The upper part, which is a little more swollen, contains over its surface many minute cavities that are similar in appearance to the conceptacles of Turbinaria. Each cavity is called a perithecium while the opening at the tip is commonly termed the ostiole. The perithecium is lined with the hymenium composed of narrow club-shaped paraphyses and thicker asci containing 8 ascospores each.

d. Claviceps purpurea or ergot.

1. This fungus attacks the flowers of different grasses and finally replaces the grain. When bread is made from ergotized grain, epidemics may occur. Such epidemics have been recorded ever since the time of Caesar around 150 B.C. They were common in France in the 13th Century and were called plagues for which they were mistaken. For more than 500 years many thousands of people in Europe have suffered the most terrible torture by eating bread made of infected grain, not suspecting that the infected kernels were the cause of their suffering. Barely 4% of the people affected survived, and these were either crazy or terribly mutilated by the loss of fingers, toes, noses or ears. Now that the Plant Pathologists have discovered the cause of the disease, the infected kernels are carefully removed before flour is made. Ergot contains many poisonous alkaloids which affect animals and man in two general ways:

a. Nervous Ergotism: In this form of the disease the blood vessels of the brain contract, thus producing dullness and depression, the patient refusing food and gradually wasting away or dying suddenly in dilirium.

b. Gangrenous Ergotism: In this form of the disease the checking of the blood, resulting from the contraction of the small blood vessels, causes a loss of a part or of all the limb below the knee or hock, the tail, or the ears. This usually begins by the formation of ulcers at the top of the hoof or between the toes, and a toe may be lost or the entire hoof shed. The affected part dries, a small furrow or line of separation appears, completely surrounding the limb, dividing the living from the dead mummified tissue.

2. Asexual reproduction: If a spore of Claviceps reaches the flower of a grass, especially rye or wheat, it germinates to produce a mycelium which spreads overythe outer part of the pistil. It soon exudes a sweet slimy disagreeable juice and forms conidia. This liquid is eagerly eaten by flies and thus the spores are disseminated from one plant to another. The mycelium finally completely absorbs the substance of the grain and grows into a hard blue-black body called the sclerotium, several times larger than the grain. Even today there are still many persons who believe ergot is a degenerated kernel of rye or wheat.

3. Sexual reproduction: No changes occur when the sclerotium remains in the head of grass but in spring if it has lain on damp earth it seems to produce the sexual stage. At various points in the sclerotium arise groups of hyphae which

grow out into rose-colored stalks terminating in globular heads. These are the stromata bearing perithecia at the tips containing paraphyses and asci with filiform or thread-like ascospores. These finally escape, blow around, and thus infect new grasses.

e. Tuber sps: The mycelium of these fungi live in symbiotic relationship with the rootlets of the beech and other forest trees. Such a fungus growing in intimate contact with a root is called a mycorrhiza. The fleshy tuber-like ascocarp, commonly called truffle, is about as large as a walnut and lives underground. It is a highly prized delicacy in Europe where dogs and pigs are trained to locate the truffles by smell for their master. About 10 years ago, the truffle industry of France and Italy amounted to more than 1,000,000 Francs yearly.

f. Penicillium is the common blue-mould found on spoiled jellies, stale bread, wet shoes, etc. Penicillium Roquefortii is a common species in the French town of Roquefort, the center of the Roquefort Cheese industry. Stale breadcrumbs upon which P. Roquefortii usually grows, although the cheese manufacturers never knew about it, is mixed with the milk of ewes. This contaminated milk is then made into cheese. The Penicillium grows and feeds on the ripening cheese. This changes the chemical nature of the curds and thus imparts to the finished cheese the peculiar taste and aroma characteristic of Roquefort. The fungus produces greenish-blue conidia wherever gas cavities occur in the cheese, and these areas are plainly visible with the naked eye. They are the cause of the marble-like appearance of Roquefort Cheese.

F. Basidiomycetes or Club Fungi.

1. Origin of this group is very uncertain, Some botanists venture to say that they may have been derived from some primitive Basi~~diomycete~~ Ascomycete.

2. General characteristics: The mycelium produces club-like hyphae called basidia at whose tips usually arise 4 projections called sterigmata (sing. sterigma) from which the basidiospores develop. Sexual reproduction seems to be entirely wanting.

3. Common or noteworthy species.

a. Auricularia, the Pepeau of the Hawaiians, or the Jew's Ear of the Europeans which merely seems to be a corruption of Judas' Ear: This fungus lives preferably on the hau tree in these islands, feeding on the wood. Finally the mycelium grows out to the surface and forms gradually a small structure which at the first rain swells enormously to form an ear-shaped sporocarp. The underside of the sporocarp is covered with a fine layer called the hymenium composed of sterile paraphyses and basidia producing basidiospores at the tips of sterigmata. This sporocarp, in comparison to those to be mentioned later, is rather primitive.

b. Polyporus, the bracket fungus: The mycelium of this fungus lives in trees, frequently causing their death. The sporocarp is produced at the surface as hoof-shaped structures. The hymenium is situated on the underside and consists of narrow tubes lined with paraphyses and basidia bearing usually 4 basidiospores at the tips of sterigmata. Each season a new hymenial layer grows over the old, thus enlarging the original sporocarp. A related plant, Merulius lacrymans, or the dry rot fungus, is extremely harmful, attacking and destroying

especially the coniferous timber of damp houses. The best way to combat it is to expose the infected structure to good ventilation and dryness.

c. Polystictus: This fungus is similar to Polyporus except that the sporocarp has the shape of a toadstool. The stalk is called the stipe while the expanded part is called the pileus. The under surface of the pileus is covered over with the pore-like hymenium. The color of Polystictus is technically termed isabelline, a color very common among fungi. The word has a historical significance. Ferdinand and Isabella were king and qu queen of Spain and Portugal in the time of Columbus. Ferdinand was at war with the Moors. Queen Isabella was so incensed when the Moors pressed into European Spain that she swore she would not change her linen until Ferdinand had driven them beyond Gibraltar into Africa. Isabella was better at keeping her vow than Ferdinand was at conquering the Moors. Hence the technical definition of isabelline is the color of soiled linen.

d. Agaricus is a large genus to which most toadstools and mushrooms belong. The mycelium ramifies throughout humous soil, in trees or other damp substances rich in organic matter to feed upon them. At length nearly spherical mass or buttons of interwoven hyphae develop in which stalk and pileus soon become differentiated. Then at the first rain, these buttons soak up the moisture and swell rapidly to form the mushrooms which seem to spring up over night. The sporocarp of the Agarics and related genera consists of stipe and pileus. From the under side of the latter arise lamellae or gills which radiate from the center. These are covered over by the hymenium while the subhymenium lies underneath.

Sometimes so-called fairy rings occur which consist of mushrooms growing in a regular ring. According to old superstitious ideas such a ring was the dancing place of fairies, who visited blindness or sickness upon anyone who trod upon it. Now we know that it is merely caused by the mycelium of a fungus radiating out from a common center and then producing sporocarps which naturally then arise in the form of a ring.

Agaricus campestris, the common edible mushroom,

e. Lycoperdon or puffball: The fungi belonging to this genus are usually saprophytes living in the ground. The sporocarp is usually of circular shape, consisting of one or two outer sterile layers of hyphae called the periderm and an inner sporogenous area called the gleba. The gleba is composed of chambers which are either lined with a layers of hymenium or irregularly filled with a hymenium. While the sporocarp is young, it is white, creamy, and in many species edible. At maturity the gleba changes into a mass of dark spores and capillitial threads. Then the sporocarp is no longer edible and in some species may even be poisonous. The periderm finally ruptures at the tip and the spores are disseminated especially when the sporocarp is touched. A related species, Geaster, the earth-star, has two distinct periderm layers. The outer at maturity splits ~~upon~~ open into several segments to give the appearance of a star to the sporocarp. During rain these segments unroll, while upon drying they come together and thus squeeze the inner periderm, thus aiding in the liberation ofbthe spores.

f. Nidularia or bird's nest fungus: This rare fungus is merely a highly evolved puffball. When immature, the sporocarp is spherical and contains a dozen or so hymenial chambers in the gleba. As it matures, the periderm opens up to form a nest-like receptacle in which egg-like structures called peridiola lie. These are merely the hymenial chambers surrounded by a hard resistant covering of sterile hyphae.

g. Ustilago zeae or Corn Smut: The damage to the United States alone from this plant exceeds $2,000,000 yearly. The mycelium

may infect any part of the corn plant. At the time of flowering for the corn, the ovary may become packed with mycelium, which causes a distorted, swollen, tumor-like growth. Later this mycelium is transformed into a mass of black, thick-walled greasy chlamydospores. These spores fall to the ground and pass the winter. Upon germination in spring, each spore produces a short filament or promycelium of 3 to 4 cells. This filament is saprophytic, and each cell buds off a single basidiospore. If abundant food is at hand, the promycelium may keep on producing basidiospores while the basidiospores themselves may even bud off additional basidiospores similar to the budding of yeast. The basidiospores blow around and then finally develop a mycelium that penetrates the young host plant and grows in its tissues without much external evidence until the corn is maturing. Then it forms its tumor-like fructifications.

h. Puccinia graminis, the wheat rust: In the United States there are more than 2,000 species of rust, many of them extremely harmful parasites on crops and timber. The yearly loss from wheat rust alone in this country is more than $18,000,000. The wheat rust has a very complicated life history consisting of five distinct stages:

1. Aecial stage occurs on the barberry, a common cultivated hedge plant of the United States. The mycelium grows in the barberry leaves and finally on the under side produces a yellow pustule or blister called an aecium (or aecidium) that bursts open to expose the aeciospores (or aecidiospores The sterile outer layer of this aecium is called peridium.

2. Pycnial stage occurs also on the barberry leaf but always on the upper surface. The pycnia (or pycnidia) are similar to the aecia but smaller. The pycnospores (or pycnidiospores) do not germinate. It is probable that the aeciospores are really female gametes and that the pycnospores are really male gametes, but that the plant has done away with sex entirely. If this is correct, the pycnial stage is merely a worthless relic of the past.

3. Uredial Stage: If an aeciospore falls upon a wheat plant, it germinates to produce a mycelium which penetrates the ho host and feeds upon it. If it were to fall on a barberry leaf, on the other hand, it would finally die. The mycelium at length forms uredial pustules on the wheat plant composed of uredospores (or urediniospores).

4. Telial Stage: The uredospores are disseminated by the wind and finally infect other wheat plants. Toward autumn the mycelium produces telial pustules containing two-celled teliospores (or teleutospores). These pass the winter on the ground.

5. Basidial Stage: The teliospores germinate in spring to produce a four-celled promycelium. Each cell then produces a basidiospore at the tip of a ~~stigma~~ sterigma which is capable of infecting the barberry again. The method of irradicating the wheat rust is therefore comparatively simple - kill all the barberry plants.

XI. Lichens.

A. Relationship: Lichens are not distinct plants.

1. They consist of two plants growing together in symbiotic relationship.

2. The one plant is, with a few exceptions, an Ascomycete and the other is either a Blue-green Alga or one of the more primitive Green Algae. The best-known lichen which is not composed of an Ascomycete but a Basidiomycete is the tropical Cora pavonia.

3. The logical method of classifying lichens is by classifying the fungus into its respective genus without considering the alga, and to classify the alga into its genus and ignoring the fungus. But since in lichens the fungus and alga are so closely related, for convenience sake the lichen is classified as though it were actually a single plant.

B. General characteristics.

1. As far as form is concerned, three general types of lichens occur:

a. Crustose lichens are those which are firmly attached to a substratum like a rock or tree, similar to a incrustation.

b. Foliose lichens are those which have a definite Anthoceros-like thallus which has marginal growth and rhizoids.

c. Fruticose lichens are those which are erect and often branching.

2. As far as stfucture is concerned, two general types of lichens occur:

a. Homoiomerous lichens are those in which the algae are found irregularly scattered among the fungus.

b. Heteromerous lichens are those in which the algae are found

in a definite layer, called the gonidial layer, in the lichen. A cross-section of this type shows an upper cortical layer of fungus hyphae, a gonidial layer of looser texture in which the algae occur, and a lower cortical layer of hyphae.

3 ø. Consortium is the compound lichen structure composed of the fungus thallus and the alga thallus composing the lichen.

4 d. Gonidium is the old-fashioned name still applied to the Green or Blue-green Alga found in a lichen. Because the alga was formerly mistaken for a gonidium or resting spore, this term unfortunately still sticks to it.

5 g. Soredia are the asexual reproductive bodies of the lichen, as a lichen, consisting of a group of algal cells surrounded by a few fungal hyphae. These soredia are frequently formed at a definite place and can blow around like a powder to disseminate the lichen as a lichen.

6 f. The alga, as an alga, has no special reproductive bodies.

7 g. Sexual reproduction of the Ascomycetes in a lichen reminds you of the sexual reproduction of the Red Algae. The female reproductive organ consists of a multicellular thread-like carpogonium and a trichogyne imbedded in the consortium or thallus of the lichen. The antheridia occur on branching hyphae within a conceptacle-like chamber called the spermogonium. They are abstricted and if they happen to come in contact with a trichogyne, send their nucleus down into the carpogonium which then swells and divides to produce an ascogonium. The ascogonium then produces ascogenous hyphae which in turn produce the apothecium composed of paraphyses and asci containing ascospores.

h. Apothecia are disc-shaped reproductive bodies of the fungus as a fungus consisting of a hymenial layer composed of paraphyses and asci producing ascospores. An apothecium is merely an opened perithecium as seen in Xylaria. When the ascospores are shed, they will produce a fungal hypha which, if it happens to touch the right kind of alga, will produce a new lichen by growing around it. If it fails to come in contact with the alga, it may either live on as a fungus or more likely die because it has become too dependent during the ages on a symbiotic method of existence.

C. Geographical distribution and habitat: Lichens are terrestrial and very resistant to unfavorable conditions such as heat and dessication. Thus they can live on bare rocks and treetrunks where neither the alga alone nor the fungus alone could exist. Because of their great resistance, we find them growing farther north and farther south than any other plants, and on the highest alpine mountains where other plants would die.

D. History and uses.

1. The Scotch botanist Morison in 1700 thought lichens were excrementitious matter produced by the earth, rocks and trees.

2. Around that time and until 1868, practically everyone took for granted that lichens were distinct plants just as Brown Algae or Mosses are distinct plants.

3. In 1868 Schwendener announced that a lichen was not a distinct plant but consisted of two distinct groups of plants growing together in intimate symbiotic relationship. Few people believed Schwendener.

4. In 1889 Bonnier took certain free-living algae and certain free-

living fungi and grew them together, thus synthesizing artificial lichens. This of course proved the true nature of lichens.

E. Past and present uses of lichens.

1. Rocella tinctoria was used in the process of dyeing even before the time of Pliny. The blue and purple of the Old Testament (Ezekiel 27:7) probably refers to the dye made from this lichen. These dyes were for a long time an important article of commerce. The art of making them was forgotten and lost after the fall of the Roman Empire. In 1300 Federigo, a Florentine of German parentage, accidentally rediscovered the method of preparing and using it. He is said to have achieved such success in his commercial transactions with this substance that in time he became the head of a distinguished family, the Oricellarii, who were later known as Rucellarii and Rucellai. From these names are derived orseille, the name of the coloring substance, and Rocella, the genus of lichens from which orseille is prepared. For more than a century Italy supplied the market with orseille derived mainly from lichens collected on the islands of the Mediterranean. After the discovery of the Canary Islands in 1402 much of the orseille was derived from those islands, and later from the Cape Verde islands. Later orseille was collected from other islands and countries. Cudbear is a form of archil discovered by Dr. Cuthbert Gordon of Scotland. Cudbear is a corruption of Cuthbert, the discoverer's first name.

The dye is made by finely grinding the lichen and soaking it in a solution of potash and ammonia until the mass becomes purple. The reason for this is as follows: Most lichens contain colorless acids free from nitrogen which readily change into colorless crystals of orcin having the formula $C_7H_6(H_2O)$. In the presence

* Litmus is a special preparation of orcin which changes to red in the presence of acids and blue in the presence of alkalies; for this reason it is extensively used in making chemical tests. Litmus papers being ordinary bleached paper dipped in a solution of litmus

8. Lecanora esculenta is supposed to have been the "miraculously supplied manna of the Israelites." The lichen is very plentiful in Algeria as well as in mountainous districts of other countries. The plant seems to grow and spread rapidly and, being loosely attached, the wind readily carries it down the mountain sides into the valleys, where the ignorant inhabitants suppose it to have "rained from heaven." Travelers in the above countries have reported several noteworthy and extensive "rains of manna". The Kirghis Tartars eat this lichen, under the name of "earth-bread."

of ammonia, these colorless crystals dissolve to form the purple dye archil. *

2. Sticta pulmonaria, a lichen that resembled the human lung, was used as a remedy for consuption because of the belief in the Doctrine of Signatures.

3. Peltigera canina, dried and finely powdered and mixed with finely powdered red pepper formed the noted "pulvis antilyssus" or antihydrophobia powder of the London Pharmacopoeia of 1721 to 1788. In the history of the Royal Society it isrecorded that several mad dogs, belonging to the Duke of York, were saved by this powder. For the sake of the premedical students I will give Dr. Mead's treatment in the case of hydrophobia: "The patient is bled and ordered to take a dose of powder in warm milk for four consecutive mornings; thereafter he must take a cold bath every morning for a month, and for two weeks subsequently three times a week."

4. Usnea barbata was a favorite remedy for whooping cough and it was supposed to promote the growth of hair because it has the appearance of hair.

5. Xanthoria parietina,wa yellow lichen, was recommended for jaundice.

6. Cetraria Islandica, of Iceland, has long been used for food by man and animals.

7. Cladonia rangiferina, the famous reindeer moss, is the main food of reindeer and caribou. It forms endless arctic wastes into useful pasturage.

VI in Syl.

XII. Atracheata, Bryophyta, or Mosses Plants.

A. Relationship: These obviously originated from some filamentous Green Alga that crawled out of the water onto land and then became highly modified to meet the radically changed conditions of its environment.

B. Geographical distribution and habitat: A few primitive forms are aquatic while practically all the rest are terrestrial, though usually growing best in damp localities.

C. General characteristics:

1. They always have a definite alternation of generations consisting of a sexual plant producing eggs and sperm alternating with a non-sexual plant producing asexual spores. The sexual plant is called the gametophyte because it produces the gametes called egg and sperm. The fertilized egg then develops into the asexual plant called the sporophyte because it produces asexual reproductive bodies called spores. Of a definite species of plant, the egg and sperm each have a definite number of chromosomes. This number we will designate as the N number. At fertilization, egg and sperm fuse their nuclei so that the resulting fertilized egg contains the 2N number of chromosomes or is said to be in the diploid condition. The sporophyte developing from this fertilized egg naturally is also diploid. This diploid sporophyte finally forms spore-mother-cells in the diploid condition which divide once by meiosis or the reduction division to form two cells in the haploid or N condition. These two cells divide by ordinary mitosis to form 4 cells called spores or a tetrad of spores, each spore being in the haploid or N condition. These spores upon germination then produce the gametophyte which is in the haploid or N

ceptible to the disease. But the old-fashioned idea that "night-air" transmits disease is a fallacy. We know now that the origin of this belief was the prevalence of nocturnal mosquitoes that transmit malaria, yellow fever, and possibly other diseases. Instead of blaming the nocturnal mosquito for causing the disease, the night air was suspected.

b. Flies, since they breed in filth and sometimes feed on it, are the most dangerous animal carriers of disease. During the Spanish-American War more soldiers were killed of typhoid carried by the common housefly than by Spanish bullets.

c. Fomites (sing. fomes) are substances capable of absorbing, retaining, and transporting infectious bacteria.

1. Bait forvfieldmice has been smeared over with a bacillus (B. typhi murium) that only produces a disease in mice and then scattered in certain regions in Europe where the mice are troublesome. A few mice eat the bait, catch the disease, and spread it among their kind thus starting a mouse epidemic which holds the rodents in check.

2. Unscrupulous early Spanish conquistadors hung clothing of people that had died of infectious diseases on trees so that the unsuspecting Indians should take them and be killed off.

D. General characteristics.

1. None of the bacteria possess chlorophyll and therefore photosynthesize food for themselves. Most of them are saprophytes and parasites although a few can even chemosynthesize food for themselves, being independent of all light. ~~People therefore thought that the bacteria must have been derived from the blue-greens by reduction and degeneration. But nowxwe know that some bacteria can synthesize food for themselves chemically so that now we conclude that they are the simplest plants from which the blue-greens were probably derived.~~

2. Most bacteria are 0.5 to 5 micra in length although some are so small that they cannot be seen with the highest power of the microscope and others are even 100 micra long.

3. Cell wall is a firm membrane which sometimes is enclosed by a prominent gelatinous sheath. Masses of bacteria with this jelly sometimes form gelatinous films like "mother of vinegar" in decaying liquids. This is called the zoogloea stage.

4. Protoplasm is quite homogeneous and not even as differentiated as in blue-greens.

5. No definite nucleus exists although often granules are present which apparently absorb nuclear stains.

6. Movement occurs in some forms due usually to one or more flagella. To see these, special methods of staining are necessary.

7. No sexual method of reproduction occurs in bacteria according to the standard textbooks (although a book on Agri. Bact., by Loehnis and Fred printed in 1923 denies this. Verification needed).

8. Endospores, which are extremely resistant to unfavorable conditions form in some species by the shrinking of the protoplast and its secretion of a new cell wall inside the old. Since but a single spore is formed in a cell, this is not a method of reproduction but merely a method of living over unfavorable conditions.

9. Spherical spores called conidia are found in highly evolved filamentous bacteria. They arise by the pinching off of flagellated cells at tip of filament.

10. Reproduction is extremely rapid, a bacterium dividing possibly every 20 to 30 minutes. If this bacterial multiplication went unchecked, the descendants of one bacterium in 8 hours would number 60,000 while in 1.5 days the mass would fill 200 trucks of 5 tons capacity each.

E. Classification.

1. According to morphology, or shape.

a. This method is very commonly used, especially in Europe, although it has its limitations:

1. Cells mostly globular, rarely rod-like,

a. Single, in pairs, tetrads, clumps, but never in chains: MICROCOCCUS

b. In pairs or in chains: STREPTOCOCCUS

c. In regular bundles of 8, 16, or more cells: SARCINA

2. Cells mostly rod-like, rarely globular or curved,

a. Without endospores: BACTERIUM

b. With endospores: BACILLUS

3. Cells mostly curved or spiral, rarely globular or rod-like,

a. Of comma-shape: VIBRIO

b. Of rigid spiral shape: SPIRILLUM

c. Of flexible spiral shape: SPIROCHAETA

b. The bacteria are so small and so simple in structure that we do not know how to classify them conveniently. For instance a very common kind of bacterium is the coccus. Since all cocci are round we can distinguish one from the other only by size. But obviously many different kinds of cocci are of the same size so as far as their morphology or shape is concerned, we cannot identify them. Thus we must resort to physiology - namely how they react toward definite media or how animals react if they are injected into them. Thus B. coli and B. typhi are practically the same in size and shape yet one is harmless and the other produces typhoid. The method of distinguishing

Farinales (Enantioblastae): These have perfect or unisexual flowers with usually a double perianth differentiated into calyx and corolla. stamens are either of equal number as perianth parts or fewer. The ecium is typically tricarpellary, syncarpous, superior. Endosperm present and mealy.

A. Commelinaceae.

1. Distribution: A tropical and subtropical family of 25 genera and 100 species.

2. Affinities: These are Alismaceae in which the gynoecium has become syncarpous. Of course all kinds of modifications have arisen.

3. Characteristics: Annual or perennial, often succulent herbs with swollen nodes and leaves with sheating bases.

4. Genera:

a. Tradescantia geniculata is a creeping fleshy plant rooting at the nodes. Its flowers are white, actinomorphic, and possess 6 perfect stamens. The plant was introduced accidentally from Mexico into Pauoa Valley by Marin, a Portuguese, over 50 years ago. It is still found in that locality and apparently has not spread.

b. Rhoea discolor, the only species, is a large upright fleshy plant native of Mexico with green leaves purple beneath. The inflorescence is enclosed by large bracts and only 1 or 2 white flowers barely project beyond them at any one time. The flowers are very ephemeral, wilting around noon. The plant is frequently cultivated in Honolulu. The stamen hairs are excellent for demonstrating protoplasmic movement.

c. Commelina is a genus of about 100 species. The plants are fleshy and creep over the ground. The flowers are usually blue

and enclosed by a single cup-shaped bract. They are zygomorphic , the upper sepals being smaller than the other two and the two side petals being much larger than the lower one. The three upper stamens have been modified into conspicuous yellow staminodia while the three fertile onesmmay be of two different shapes. At least three species are found in Hawaii. C. nudiflora is the common species incorrectly called "honohono grass." Another species, not yet recorded nor identified, has large blue flowers. C. benghalensis, not yet recorded from here, has purplish flowers. The flowering of this species has been studied. The inflorescence is scorpioid, as in probably all , and enclosed by a cup-shaped bract in which water and slime has been secreted by hairs. The immature flowers are curved downward on their pedicels in the fluid of the cup. On the day of flowering, they stand erect and project beyond the cup. The following day the pedicel has bent down in the opposite direction and the fruit then matures protected by the liquid. C. benghalensis is remarkable in producing colorless cleistogamous flowers on subterranean branches. A few species of Commelina produce edible rhizomes.

d. Zebrina pendula, the only species, is a creeping plant with leaves that are striped in two shades of green above and that are purple below. The flowers are pink, have 6 stamens and a tubular corolla. It is often grown in Hawaii for a border plant An upright plant of another genus is also grown here but has not yet been identified.

B. Xyridaceae - Yellow-Eyed Grass Family.

1. Distribution: A small family of 2 genera and about 50 species chiefly growing in marshes in America.

2. Affinities: Apparently related to the ~~Sagittaria~~Commelinaceae from which they differ chiefly in having grass-like leaves arising from a shortened stem, frequent zygomorphy, and flowers solitary and sessile in imbricated scale-like bracts to form a compact globose head.

3. Genera.

a. Xyris flexuosa is a grass-like plant of marshes along the Atlantic coast. Its inflorescence produces 2 or 3 small, bright yellow, slightly zygomorphic flowers at a time. The formula is P 3 # 3 A 3 # 3staminodia G (3).

C. Eriocaulaceae - Pipewort Family.

1. Distribution: A family of about 5 genera and 500 species chiefly of warm regions of America in swamps and along shores of lakes especially.

2. Affinities: They are related to the Xyridaceae, differing chiefly in having unisexual flowers.

3. Genera:

a. Eriocaulon, one of the largest genera, has short tufted grass-like leaves. The plants, in the Eastern States at least, grow submerged along the sandy shores of lakes. Then in summer when the water recedes, they send up their scapes bearing dense heads of inconspicuous white flowers. These monocots have practically modified their inflorescence in the same way as have the dicot Compositae. Namely, the basal bracts of the inflorescence have lost their flowers and thus have practically formed

an involucre. The other bracts bear unisexual flowers, in some species the pistillate being near the center andvthe staminate around them while in other species it is justtthe opposite. The flowers, which according to the species are actinomorphic or zygomorphic, have usually the following formula:

P 3 # 3 A 3 # 3 G rudimentary

P 3 # 3 A 0 # 0 G (3)

E. articulatum grows throughout the Eastern United States and in Ireland and adjacent islands. This is the only European representative of the family. How it got there is a mystery. E. oryzetorum is axweed in rice fields in the Orient.

D. Pontederiaceae - Pickerel-Weed Family.

1. Distribution: About 6 genera of 25 species found in fresh water or marshes of all warm regions of the world excepting Europe.

2. Affinities: These plants are not related to the Eriocaulaceae. They are probably either related to the Lilies or more likely to the Commelinaceae since both have mealy endosperm and a spathe-like bract subtending the inflorescence.

3. Characteristics: Swamp, submerged, or freely floating plants with more or less irregular flowers composed of 6 perianth parts, 6 o r 3 stamens, and usually a 3-celled ovary. Sympodial growth, to be described later, occurs.

4. Genera:

a. Monochoria consisting of 3 species of Australasia is the most primitive genus. One unreported species (probably M. vaginalis) grows in a taro swamp near Hauula, Oahu. The plant grows partly submerged, the cordate leaves projecting out of the water. The spike bears blue flowers in which the sepals and petals are very slightly united at base. The one middle

upper stamen is larger than the others. The ovary is 3-celled. The spike after fertilization bends to allow the seeds to mature under water. The leaves of M. vaginalis can be eaten cooked while the rhizomes are used in medicine in Japan.

b. Piaropus (often called Eichhornia) consists of 5 South American species. These usually float freely in the water, the inflated petioles acting as floats. The spikes have blue flowers which mature their seed under water. P. crassipes was introduced by Surtevant, a waterlily specialist, into Florida as an ornamental plant. It escaped and now fills the St. John's River and many other rivers throughout the south to such an extent that it impedes navigation. The half-starved almost wild cattle of certain districts of Florida (Green Cove Springs) for want of better food walk into the river sometimes up to their shoulders to feed upon it. When riding through the Everglades from New Orleans one will see barely on the plants that are floating in deep water. But where the water is presumably shallow enough for the roots to reach the muddy bottom, practically every single plant forms a cluster of flowers producing a magnificent sight. The flowers are similar to those of Monocharia except that they have a distinct perianth tube. They are trimorphic. These plants have sympodial branching, the main axis being shifted to the side by the secondary axis which assumes the chief growth of the plant. Two unreported species grow in Hawaii.

c. Pontederia is the Pickerel Weed of America. It grows 1 to 4 feet tall in shallow water and has long lanceolate leaves and large spikes of blue flowers. Here the sepals and petals are united about half way their length. The upper 3 perianth lobes are more closely united, the central one being the largest. The

lower 3 lobes likewise are more closely united but equal in size. The 6 stamens are attached to the perianth tube at different levels. The ovary is really 3-celled but 2 of these abort before maturity. The flowers are trimorphous.

VI. Liliales: Plants usually with perfect actinomorphic flowers having 3 sepals and 3 petals which are similar in appearance, 2 whorls of 3 stamens each, and 3 united superior carpels. The embryo is surrounded by copious fleshy endosperm containing oil and albumin, rarely with mealy endosperm as in the Farinales.

A. Liliaceae - Lily Family.

1. Distribution: A huge family found especially in temperate and subtropical regions, composed of over 200 genera and 2000 species.

2. Affinities: It is difficult to determine from which group this family has been derived because its floral formula of P 3 # 3 A 3 # 3 G (3) is such a common one in the plant kingdom and because this group is so stereotyped in floral structure that we get no satisfactory clue as to their possible derivation from something else. Nevertheless, the following are the chief suggestions as to their relationship:

a. Wettstein thinks they are derived from one of the Helobiales such as the Alismaceae.

b. Miss Sargent on anatominal evidence derived from studying seedlings believes they are derived from the Ranunculaceae.

c. Hallier because of resemblance and leaf nervature of certain Liliaceae (Philesia) to certain Berberis species would derive them from the Berberidaceae.

d. Lotsy, in reviewing the above opinions, notices that all these plants are derivatives of the hypothetical Proranales and then concludes that it is best to consider the Liliales merely an additional Proranalian derivative.

The Liliaceae of recent years are being split up into separate families, but since no two taxonomists seem to agree as to the divisions, we will retain the old Liliaceae concept.

3. Characteristics, if we follow the old concept, are those of the family. In addition, they are usually perennial herbs, dying down after flowering to a bulb or crown of fleshy rootstocks. In a few cases they are woody, tree-like, or even vines.

4. Genera:

a. Veratrum has perfect or imperfect usually greenish flowers which mature into capsules. The stem is 2 to 6 feet high, bears large leaves, and a large greenish panicle. About 10 species exist, the common European one is V. album while the American is V. viride, commonly called American Hellebore. This has no connection with the genus Helleborus which belongs to the Ranunculaceae. The generic name is a combination of vere and atrum meaning truly black in allusion to its very poisonous qualities. Both species are used in medicine. The drug is bitter, very acrid, causing a tingling benumbing sensation in the tongue. Its action resembles that of aconite, being a powerful cardiac depressant and spinal paralyzant, but in addition it has a strong emetocathartic action, and overdoses therefore are less likely to prove fatal. An overdose will cause death by paralysis of the heart. The powdered root is commonly used as an insecticide.

b. Gloriosa consists of about 6 African and Asiatic species that climb by means of tendril-like leaf apices. The drooping flowers are red or yellow and very ornamental. The style at the ovary is bent abruptly upward so as to be in a horizontal position. Dr. Harold Lyon is growing one of these species in Honolulu.

c. Colchicum

c. Dianella is a genus of about 12 species found in Hawaii, Northern Australia, and China. The plants are upright herbs with distichous linear leaves and creping rhizomes. The flowers are panicled and inconspicuous. The anthers open by terminal pores. The Dianellas found in these islands have been called D. odorata but this is incorrect as D. odorata is a slightly different species found in the Philippines. The Hawaiian plants are very variable but nevertheless belong to at least two species. The common one should go by the name D. sandwicensis Hook. & Arn. This has berries that are as dark blue as ink. The other plant is a typical desert species of the Kau District of Hawaii. Its berries are sky blue. The species has not yet been described.

d. Hemerocallis fulva is the Orange Day Lily. The generic name really means "beautiful for a day" since the flowers are short lived. The plant is now found wild in America and from France to Japan. We know it was introduced into America and we suspect that it was introduced into Europe from Asia in early times. It was introduced a long time into Hawaii where it is now one of the commonest lilies offered for sale. The leaves are about 2 feet long and the 5- to 10-flowered scapes are somewhat longer. The flowers are large and resemble those of a Tiger Lily. The plant rarely sets seed. Since the perianth is slightly tubular because of zonal growth, a plant like this may have given rise to the following genus.

e. Aloe is a genus of about 100 species chiefly of arid districts of Africa. Not a single one is native to America. They are fleshy-leaved rosette plants or even trees usually producing erect many-flowered racemes. The flowers have their peri-

anth very much united to form a straight or partly curved tube. This is usually reddish-yellow and striped with green. They are usually pollinated by birds. The tree Aloes usually branch dichotomously until a flower cluster arises. This is then pushed aside by sympodial growth. Certain species fold up their rosettes during dry seasons to conserve moisture. Others have "windows" in their leaves to allow rays of light to enter. The drug Aloes is derived from any one of 3 or 4 species (A. Perryi, A. vera, A. ferox). It is collected at any season by the natives who dig a small hole in the ground near some plants. They then take a goat skin and lay it over this depression so that the center is dished. The aloe leaves are then gathered and placed in a circle 2 to 3 layers thick with their cut ends over the depression. The yellowish sweetish sap which flows from the leaves for about 3 hours is then collected. This juice is then exported to Arabia from where it is shipped throughout the world after evaporating down to a dough-like or resin-like consistency. The drug is a drastic cathartic, acting especially on the large intestine. It is also a valuable insecticide and therefore used in the Orient for the embalming of corpses. In former years aloes were mixed with potassium nitrate to produce dyes. The so-called American Aloe is no aloe at all. This is a misnomer for the Yucca or Spanish Bayonet to be described later. At least 2 species of Aloe are grown in Hawaii, one of which is A. vera.

f. Allium is a northern genus of 300 species characterized chiefly by usually having bulbs and an umbel of flowers protected by 2 spathes. The perianth segments are free. The most important species are:

1. A. sativum, Garlic, is a small plant with flat leaves and a bulb of several parts or cloves. The flowers are frequently sterile and replaced by bulblets. This plant seems native to the plains of western Tartary but at a very early period was transported over all of Asia (except Japan), north Africa, and Europe. It was ranked by the Egyptians among gods in taking an oath, according to Pliny. The want of garlic was lamented to Moses by the Israelites in the wilderness, and they seem to be partial to garlic and its relatives ever since. The Romans are said to have disliked it on account of the strong scent but fed it to their laborers to strengthen them and to their soldiers to excite courage. Garlic is said to have been introduced in China 140 - 86 B.C. In many parts of Europe, the peasantry eat their brown bread with slices of garlic which imparts a flavor agreeable to them. In seed catalogues, the sets or bulblets produced in the umbels are listed while seed is rarely offered.

2. A. porrum, Leek, is a large plant with equitant (overlapping) leaves having flat halves and a simple bulb which is not much enlarged. This according to Bailey is a sport that arose in cultivation from A. ampeloprasum. Others say that it grows wild in Algiers, while still others maintain it is a native of Switzerland. At any rate, it was cultivated from the earliest times and known probably throughout the greater part of Eurasia. Pliny states that the best leeks were brought from Egypt. Leeks were brought into great notice by the fondness of them of the Emperor Nero who used to eat then for several days in every month to

clear his voice, which practice led the people to nickname him Porrophagus. Leeks must have been cultivated in England from time immemorial as they are on the badge of Welshmen ever since the sixth century when they won a victory over the Saxons which they attributed to the leeks they wore by the order of St. David to distinguish them in the battle. The Jews complained to Moses about the absence of Egyptian leeks during their wanderings.

3. A. fistulosum, Spring or Welsh Onion, is a biennial with fistulose leaves (cylindrical and hollow) which are large but few in number and a bulb which is little thicker than its neck. It is native to Siberia but introduced into England in 1629. The Welsh Onion acquired its name not from Welsh but from the old German walsch, meaning foreign. It never forms a bulb like the common onion and so it is grown for its leaves which are used in salads. According to Targioni-Tozzetti it is probably the parent species of the onion.

4. A. cepa, Onion, is a biennial with fistulose leaves which are large but few in number and a very prominent bulb. Its native country is unknown. At the present time it is no longer found growing wild but botanists usually maintain that its native country was in the East. According to Targioni-Tozzetti it will probably prove identical with A. fistulosum, the Welsh Onion, a species having a rather extended range in the mountains of South Russia. The Jews again complained to Moses for lack of them in the wilderness. Herodotus says there was an inscription on the Great Pyramid stating the sum expended for onions, radishes and

garlic, which had been consumed by the laborers during the progress of its erection, as 1600 talents. A variety was cultivated,,so excellent that it received worship as a divinity, to the great amusement of the Romans, if Juvenal can be trusted. Egyptian monuments frequently show priests holding them in their hands or covering an altar with a bundle of their leaves and roots. The onions of Egypt were mild and of excellent flavor and were eaten raw as well as cooked by persons of all classes. Hippocrates says that onions were commonly eaten 430 B.C. There is a tradition in the East that when Satan stepped out of the Garden of Eden after the fall of man, onions sprang up from the spot where he placed his right foot and garlic from that where his left foot touched.

5. A. ascalonicum, Shallot, differs from A.cepa in its small stature, slender awl-shaped leaves and small gray angular bulbs that break up,into distinct parts or cloves that cohere at the base. The flowers are white to violet when they occur which is very rare. It is not known in the wild state and DeCandolle thinks it is a sport early derived from A. A. cepa. It is mentioned by Theophrastus and Pliny. The latter says that it came from Ascalon, a town in Syria from which the plant got its common name. Michaud, in his "History of the Crusades"(1853) , says that shallots were introduced into Europe by the returning Crusaders.

6. A. schoenoprasum, Chive, is a tufted perennial growing in mats with fistulose leaves but practically no bulbs. Chives are much used in Scotch families and are considered almost indispensable in omèèettes. The flowers are invariably sterile (according to Vilmorin).

Tulipa, Tulip, is a genus ofaabout 50 species of Eurasia. The word is derived from the Oriental for turban. These are lowbplants having a tunicated bulb and very showy regular flowers with free perianth segments flowering in spring. Although quite a number of wild species are native to Europe, the cultivated ones are derived from Asia. In 1554 Augerius Ghislenium Busbequius, representative of King Ferdinand, saw tulips growing in the Sultan's garden near Constantinople. Seeds were sent to Vienna and the plant later named T. Gesneriana, although it is probably merely a cultivated form of the wild T. suaveolens which the Turks probably brought with them from the steppes of Turkestan. The year 1570 is honored in Holland history as the year when the first tulip flowered there. This is the beginning of the tulip craze or tulipomania described in the "Tulip Noire" by Dumas By 1630 over 500 horticultural varieties were known. Then people began speculating in new varieties. The single bulb of the kind called Admiral Liefkien was s sold for 7400 mark. In 1640 the bubble burst with such misery to the investors that the government passed a law to prevent speculation. Now even the best fofms can be bought for a dollar or two. When grown from seed, it takes 7 years before the plants will flower. Every season for the first 6 years only a single leaf is produced and a "dropper". This is a special structure to burry the new bulb at the correct depth in the soil. This "dropper" consists of a downward projection of the main stem which unite unites intimately with the basal leaf sheath. At the base, the following year's bulb is produced which will absorb

all the nourishment from the bulb that gave rise to it.

8. Erythronium consists of about 20 species of the northern hemisphere. The plants resemble tulips except that the perianth parts are reflexed. Here belongs the Dog's Tooth Violet of the Eastern States and the Glacier Lily of the Rockies. Because the European species has red flowers, Linnaeus named the genus Erythronium, meaning red. Most of the species of Erythronium, however, have white or yellow flowers.

9. Hyacinthus, consisting of 30 species, is found along the the Mediterranean chiefly. H. orientalis is the plant which has given rise to over 500 different cultivated forms of Hyacinth. The great center for their growth is Haarlem, Holland, and Berlin.

10. Yucca, Spanish Bayonet, consists of about 30 bayonet-leaved showy xerophytes of America, chiefly on the Mexican plateau. They are woody low shrubs or even trees with terminal panicles of drooping usually waxy flowers. Y. gloriosa is said to have been introduced in Hawaii. The unitedcstigmas of the Yuccas produce a cup. A moth called Pronuba yuccatella flies to the flower and collects a ball of pollen. Then she flies to another flower and stings the ovary to lay eggs in it. When that is done, she crawls up the style and pokes the ball of pollen into the cup formed by the stigmas. Thus the plant is pollinated and will produce seed. The eggs of the moth hatch and feed on most of the seeds, a few escaping and thus reproducing the plant. The yucca consequently gains even if it does sacrifice most of its seeds.

k. Cordyline consists of about 10 species, chiefly of the Old World tropics. They are usually shrubs which emit shoots from the base. The leaves are long and tufted at the ends of upright branches. Each loculus of the ovary is many-seeded. C. terminalis is the Hawaiian ti which is found from Hawaii to China. The Hawaiians formerly made a kind of beer from the rhizomes while later they learned to ferment a liquor from it. The leaves are stilluused for the wrapping of food. A few horticultural varieties with ornamental foliage are also grown in Hawaii.

l. Dracaena consists of about 50 species of the Old World tropics, most of which are shrubby or tree-like with a few upright stems. In general, they resemble the genus Cordyline except that each loculus of the ovary contains a single seed. D. aurea aurea is the Halapepe, native to the Hawaiian Islands especially in arid districts. The name Halapepe really means <u>baby hala</u> in allusion to its resemblance to the Hala or Pandanus. It is 25 to 35 feet high and has a straight trunk 1 to 3 feet in diameter. The branches are erect and stiff, bearing terminal whorls of linear leaves. The berries are red but turn brown on drying. The wood is extremely soft and was therefore used by the Hawaiians for the carving of idols. D. draco is the is the Dragon Tree native to the Canary Islands, famous for the great age and size itcattains. One tree is famous and so described and pictured in many botanical books. It was 70 feet high with a trunk 45 feet in circumference, and was reputed to be 6000 years old, a figure possibly exaggerated. It grew in Orotava on the Island of Tenerffff and was destroyed by a hurricane in 1868. The dried resin of this plant is Dragon's

Blood, which is formed into a brilliant red powder. (Juice of Calamus draco also was called Dragon's Blood.)

m. Astelia, composed of about 10 species, is found in the Old World tropics growing especially on moist tree trunks. A. veratroides, or Painiu of the Hawaiians, is the common endemic species here which varies considerably. The flowers are unisexual by abortion and the berries are orange in color.

n. Asparagus is a genus of 150 species of dry regions of the Old World. These are erect or climbing, sometimes woody, plant plants. A. officinalis, the Asparagus, is native to the seashores and sandy areas from Great Brittain to Central Asia. The plant was known to the Romans about 200 B.C., the wild and cultivated being eaten indiscriminately as a delicacy, proving that cultivated varieties had not yet originated. The Asparagus is a dioecious perennial whose tops die down yearly. Only after the third year do the plants produce their nodding greenish-yellow flowers. The plants increase in size until they are about 10 years old when the size ofvthe shoots diminishes rapidly. Nevertheless under exceptionally favorable conditions, asparagus beds 20 to 30 years old may produce profitable crops. In early spring the shoots are cut and marketed while later they are allowed to develop into branches that will manufacture food for the next seasons growth. The staminate plants produce one third more shoots than the pistillate. The shoots are covered with small scale-like leaves. In their axils arise green linear branches or cladodes that take the place of leaves. A common practice formerly was to add salt to Asparagus beds to kill the weeds and to act as a fertilizer. This was of course possible because the Asparagus is typically a coastal dune plant.

G. Iridaceae - Iris Family.

1. Distribution: There are 60 genera and 1000 species found chiefly at the Cape of Good Hope and in tropical and subtropical America.

2. Affinities: Their exact affinity is in doubt.

   a. Among the Amaryllids was a tendency to lose three of the stamens (Tecophilea) thus possibly getting to the Iridaceae in which the inner whorl has become entirely lost. Good evidence for this is shown in Heinricher's experiments with Iris to be described later.

   b. Lotsy thinks they may have been derived from the Liliaceae since Crocus, the most primitive Iridaceae genus, links up in habit and appearance with Colchicum even to the possession of corms.

3. Characteristics: Upright herbs with rhizomes or bulbs, distichous basal leaves and flowers with P 3 # 3 A 3 G $(\underline{3})$

4. Genera.

   a. Crocus consists of 75 species native to the Mediterranean region. Four or five species are commonly planted in gardens and flower soon after the snow is off the ground. The plants are small and acaulescent, and possess a corm. The flowers are white, yellow or lilac and have included stamens and a very long pistil. C. sativus comes originally from Asia Minor. This plant has been cultivated from the time of Homer and is now sterile unless pollinated by wild plants. Saffron is the deep orange-colored substance consisting of the aromatic pungent, dried stigmas. In medicine this was formerly used as a tea to promote eruption in measles, scarlet fever, etc., but now abandoned. It is at present chiefly used to

color confectionary, liquors, varnishes, etc., and occasionally as a flavoring extract in cookery. It is commonly used in coloring butter and cheese. One part of saffron in 1000 will give a distinct yellow tincture used in dyeing.

b. Marica gracilis, cultivated on the campus, has outspread white sepals brown-spotted at base, upright blue and brown petals and upright linear stamens grown to the pistil. It thus leads over to the genus Iris.

c. Iris is the big genusm, containing over 150 species.They are commonly called Iris or Fleur-de-lis while the lilac- and purple-flowered cultivated species are known as "blue flags". The Fresnch words fleur-de-lis mean literally "flower of the lily". The French emblem fleur-de-lis is a conventional flower often said to have been suggested by the iris. It is a very old emblem, having been borne in the crown of EmpresssTheodora in 527 A.D. The coat of arms of ancient France (1179) was a blue field sprinkled with fleur-de-lis. Their number was reduced to 3 in 1364. The Irises are rather specialized for entomophily. Their flowers are really highly evolved Marica flowers. The sepals are deflexed and usually called "falls". They are often bearded. Here insects alight. The petals are upright and called "standards" Each stamen is protected beneath an arching petal-like style. When an insect lands on a fall, it usually touches the deflexed stigma, thus pollinating the flower. Then it crawls under the stigma to collect nectar and is thus dusted with pollen. This method prevents self-pollination. Heinricher's work is interesting since it seems to prove that the Iris Family was derived from the Amaryllids. In 1878 in the Graz

Botanical Garden Heinricher noticed flowers of I.pallida with the typically missing whorl of inner stamens developed. This anomaly held for succeeding years in 10 ± 30% of the flowers. Not always were the stamens fully formed for sometimes only staminodia with or without anthers, and sometimes only style-like members were produced. Heinricher sought to fix the character in an atavistic race by breeding. In the second generation arose a still more atavistic type for not only were there 6 stamens but the 3 upright petals assumed the form of the other 3 - namely all were bearded and spreading. What makes this even more interesting is the fact that in the Section Euiris of the genus, there are two species; I. falcifolia and I. longiscapa which have the same condition normally. Thus they are primitive members of the genus. Several species (chiefly I. ensata but also I. japonica, I. setosa, etc.) are cultivated in the Orient for their rhizomes which furnish an edible starch. I. florentina (also I. pallida, I. germanica), native of northern Italy furnishes the scented orris root. "Orris" is merely a corruption of Iris while the "root" is really the rhizome. Powdered orris root is sparingly used in medicine. Now it is chiefly used in the manufacture of scented toothpowder and is the chief ingredient of sachet powder. Iris green of painters was obtained by treating any violet Iris flower with lime.

d. Sisyrinchium,- Blue-Eyed Grass, is composed of over 50 American species. The plants are grass-like and have fibrous roots. The flowers are small and usually bright blue,

and have equal perianth parts. S. acre isxa yellow-flowered species endemic to the high mountains of Hawaii and Maui. The Hawaiians used the acrid juice to give a blue stain to their tattoo marks.

e. Belamcanda chinensis, the only species, is the Blackberry Lily native to the Orient but long planted in Hawaii and in North America where it has gone wild. The plant in habit resembles an Iris but the flowers are about 1½ inches in diameter and yellow spotted with orange. At maturity, the capsule valves fall away and leave the black seeds in a blackberry-like cluster hanging to the peduncle. The plant is also called Leopard Flower because of the spotted perianth. This has been translated into the Latin "Pardanthus" by which the plant is usually known in the trade.

f. Gladiolus consists of 100 to 200 species according to different authorities. They are found around the Mediterranean and especially around the Cape of Good Hope. The name comes from the Latin and means a "small sword" in allusion to the shape of the leaves. The cultivated Gladioli are notorious hybrids and cannot be ascribed to any one species. They are commonly planted in Hawaii. The flowers are zygomorphic, the upper 3 perianth parts being larger than the lower.

H. Bromeliaceae.

1. Distribution: This family is named in honor of Olans Bromel, a Swedish botanist. It is composed of 40 exclusively American genera.

2. Affinities:

a. This family is not related to the Iridaceae since it has 6 stamens, not 3.

b. It is usually put in with the Farinales since it has mealy endosperm. This view is probably not as good as the next.

c. It seems to be related to the Agavaceae through Puya which has the same habits of a bromeliad and differs merely in having a half inferior ovary.

3. Characteristics:

a. The ovary is inferior or rarely superior. The flowers are often regular but in a one-sided inflorescence, are zygomorphic. The dividing walls of the ovary enclose a vertical slit whose walls secrete nextar that escapes through an opening at the base of the style. This structure is called a septal gland.

b. This is a tropical and subtropical family very often living among rocks or as epiphytes and but seldom on the earth. The epiphytes live in the rain forests, and have many curious adaptations for collecting water and humus. This water may become so abundant in the leaf axil that Utricularias will grow in it. These then send out stolons which reach other "fountains", thus looping from one Bromeliad to another. This water is absorbed by curious hairs, peltate in shape. Perhaps organic matter is also so obtained since fragments of rotting leaves and insects get into it. Thus Mez kept a Vriesia suspended for a year in good health by filling the sheath cavity with water containing inorganic nutrient solution.

c. The leaves possess strong xerophytic characters, having a strong cuticle and water storage parenchyma between epidermis and chlorenchyma. The leaf margins are often spiny with

ferocious appendages. Thus Puya chilensis has hooks used for fish-hooks by the natives. Sometimes the leaves are used for grasping, forming a rigid crook or being tendril-like. The primary root is short lived, but many adventitious roots develop. In epiphytes, the root is used for fixation or soon becomes lost. Some of these secrete an adhesive gum.

d. Some genera are very shy on flowers. Thus Cryptanthus reproduces almost wholly by stolons. The Bromeliad flowers are short lived, brilliant, and often associated with colored bracts. The floral axis is sometimes persisting for several years, becomes woody, and produces new flowers each season.

4. Genera:

a. Ananas ananas, the pineapple, is the most important. The name is derived from the native one. The whole inflorescence including axis, bracts and abortive flowers become succulent and produce a big syncarp. Furthermore, the axis proliferates and produces a crown of leaves. This plant contains citric and malic acids, a proteolytic enzyme bromelin which resembles trypsin, and also a milk-curdling ferment. Pineapples never contain the maggot of the fruit fly, because when the eggs are laid, they are digested before they have the opportunity to hatch. A spiny pineapple was early introduced in Hawaii and still persists in dry, rocky places. But with the introduction of a larger-fruited, almost spineless variety the former is no longer cultivated. The pineapple produces adventitious roots in the axils of its leaves to absorb the water and inorganic salts collected there. Thus it is similar to other bromeliads with an epiphytic habitat.

b. Billbergia consists of 30 - 40 species of ornamental plants. They are acaulescent and have long leaves that are funnel-shaped at the base to catch water and organic matter. The flowers are usually blue and showy and subtended by usually large showy red bracts. Two species are planted on the campus, one being B. Saundersii. (Aechmea fulgens, similar to a Billbergia is also reported as growing in these islands.)

c. Tillandsia usneoides (Dendropogon usneoides of American Code),,is the Spanish Moss, Hanging Moss, or Air Plant. It is a gray lichen-like plant which has no roots when adult but curls around a support. This bromeliad ranges farther north than any other. It festoons the trees in the Southern States, frequently smothering them. The seedling has a root which soon dies yet the horse-hair-like sclerenchymatous strand remains to keep it moored. It is a shy seeder but the wind drifts bits around and birds use it for nests which start growing. Since this plant appeared to shed water, Linnaeus named it after his friend Dr. Tillands who could not stand the water because of seasickness. The entire plant is covered with peltate hairs that absorb and hold rainwater for gradual assimilation. The plant possesses stomata but these have degenerated and never open. The dead plant, composed solely of woody tissue, is used as a substitute for horse hair in the stuffing of mattresses and auto cushions. The plant is commonly grown in Honolulu hanging from a suspended barrel hoop.

I. Dioscoreaceae - the Yam Family.

1. Distribution: There are about 10 genera found throughout the world in warm and tropical regions.

2. Affinities: This family seems best derived from the Smilaxes since they are both climbers and both generally produce berries. The flower is of the general lily type with the stamens all fertile or the three inner changed into staminodia (this also occurs in Amaryllids). The ovary isiinferior and tubular. Thus this family seems to be another lily derivative.

3. General characteristics: Some of these plants usually have odd tubers which develop from the first internode above the cotyledon. For the first one or two years only one or two leaves are produced while in the third year a twining stem develops. The old tuber gets to be half a yard long and is deeply buried and very brittle. From these, annual aerial shoots arise. The tubers grow by means of a cortical cambium as do the Dracaenas. Dioscorea prehensilis (Scott: Annals 11:327) has its tubers covered with long thorn-roots (similar condition in the palm, Ireartea ferox). Some species are monoecious while others are dioecious.

4. Genera:

   a. Dioscorea is a huge genus having capsular fruits. In many cases the species are only known from plants of one sex. These plants furnish the yams, substitutes for potatoes. The negro word "yam" means "to eat". There are two species in Hawaii: D. bulbifera which has cordate leaves and axillary tubers called "alaala", and D. pentaphylla, the piia of the Hawaiians. This has lobed leaves and no axillary tuber. Several species in the tropics are cultivated for the their starchy underground tubers, which may weigh 50 - 80 lbs.

b. Testudinaria contains two Cape species. T. elephantipes, the Hottentot Bread, has a tuber very rich in starch. It grows very slowly but may become 3 yards in circumference and 3 feet high.

J. Taccaceae.

1. Distribution: A family of 2 genera and about 10 species of the tropics, especially in eastern Asia.

2. Affinities: This is a puzzling group about whose relationship no one seems to agree. They seem to have both monocot and dicot affinities. I have placed them here so that we can study them at this time. Not because I believe that they are necessarily one of the Liliales. Their puzzling relationship is indicated by the following opinions held by Taxonomists:

a. Jussieu puts them near Narcissus.

b. R. Brown places them between the Araceae and the Aristolochiaceae. His idea of aracean affinity is based on the leaves of Tacca leontopetaloides which resemble those of Amorphophallus.

c. Reichenbach puts them with the Araceae.

d. Masters sees in them a relationship to the Aristolochiaceae, Santalaceae, and Araceae.

e. Baskerville thinks they are an annectant group between the Araceae and Pandanaceae.

f. Hooker places them with the Burmanniaceae since both are epigynous and have parietal placentation, many small anatropous bitegumented seeds, and endosperm. But the Taccaceae have only one loculus in the ovary.

g. Clark and Baillon place them with the Orchids.

h. Pax says they form a bridge from the Amaryllidaceae over the Dioscoriaceae to the Burmanniaceae.

i. Lotsy thinks they were derived from Aspidistra of the Liliaceae and gave rise to Thismia of the Burmanniaceae.

3. Genera.

a. Tacca pinnatifida, the Pia ofvthe Hawaiians, is widespread in the tropics, common in Polynesia, and native to Hawaii where it grows in open woods and grassy plains near the coast. (Gleason seems to think the Hawaiian species is T. oceanica while other Polynesian species is T. pinnatifida.) The plant is a coarse herb with large pinnatifid leaves and starchy tubers. The flowers are in umbels and from them arise numerous curious filiform bracts. It was formerly much cultivated in Hawaii for arrowroot but this industry has ended. In Tahiti and other places it is both wild and cultivated. When cultivated, the tubers tend to lose some of their acridity and bitterness. The roots are rasped and macerated for 4 to 5 days in water to wash out the starch which is then sold as Tahiti Arrowroot.

VIII. Scitaminales - We begin now to get into the extreme members of the monocots which show wild extravagances in floral structure. They may be characterized as follows: The whole flower is zygomorphic or wholly irregular. Their perianth is of 6 leaves which may or may not be differentiated into calyx and corolla. The stamens were originally 6 in 2 circles but usually only a part of them are fertile; sometimes only 1, the others forming corolla-like staminodia. The ovary is inferior and 1- to 3-celled. The seeds usually have an aril and also endosperm and perisperm. All in all, they represent the lily type gone wild over irregularity.

A. Musaceae - Banana Family.

1. Distribution: This is a family of 4 genera of which Heliconia species are practically the only ones thought to be native to the New World. But, according to DeCandolle, species of Musa or Banana were grown in America before its discovery by Columbus. They were probably introduced during the travels of primitive races from one continent to another.

2. Affinities: These are probably lily derivatives, the most primitive genus, Ravenala, having 3 equal sepals, 3 petals (1 of which is small), 6 stamens, and a style with 3 stigmas.

3. Genera:

a. Ravenala madagascariensis is the Travelers' Tree of Madagascar. This genus once had a wide distribution though now the only other species is R. guyanensis of Guinea and North Brazil. The former tree is a weird-looking growth, some 10 meters high with leaves growing in 2 rows, thus forming a perfect fan. When a cut is made into the thick, firm end of the petiole, a stream of pure clear water gushes out. There

is a kind of natural cavity, or cistern, at the base of the petiole, and the water collected on the broad and ribbed surface of the leaf, flows down a groove and is stored. The blade, as in the banana, has a strong midrib with many veins running to the margin, but no marginal vein. Thus is is easily split by the wind which, however, does not seem to harm the plant very much. The flowers are protected by great spathes in axillary inflorescences. The flower is only sligh tly zygomorphic. There are 3 pointed elongate sepals and the 2 lateral petals are like these but the median one is shorter. There are 6 fertile stamens and a style with 3 stigmas. The fruit is a capsule containing seeds with slitted splendidly sky-blue arils. The seeds are edible. The plant is not uncommonly planted in Hawaii.

b. Strelizia is closely related to Ravenala but is much more zygomorphic. The 2 lateral petals are fused and enclose the 5 stamens. The third petal is reduced to a 3-cornered broad short leaf. The style sticks out between the fused petals while the 2 lateral sepals are hollow and the third long pointed. S. reginae whose fused petals are blue and the other parts orange, is pollenated by birds. The grains are tied together in threads. This species is cultivated here.

c. Musa, the banana, has all its perianth leaves except the median inner one cohering. Often all 5 points can be seen but in M. ensete and allies the 2 lateral are reduced and so only 3 points are seen. The median posterior stamen is usually absent but may produce a staminodium. The flowers of this genus are unisexual, the upper clusters on the stem functioning as males, the lower fertile and giving rise to

the "hands" of fruit. Honey in secreted in the female flower from septal glands (as in Bromeliaceae) while in the male the ovary rudiment turns into a nectary. Bisexual flowers have been observed in the middle bracts. Tischler has made a study of pollen in bananas. The cultivated species produce no seed but the wild species have many, the fruits resembling Iris capsules. Tischler found that the bananas have different chromosome numbers. Thus in the haploid generation, M. sapientum "Dole" has 8, "Rajah of Siam" 16, and "Kladi" 24. There are then uni-, bi-, and tri-valent races. All undergo abnormal reduction division showing evidence of hybridization. They are native of the tropics of the Old World, but have now spread to the entire tropical zone. M. paradisiaca, the plantain, is usually eaten cooked. Over 50 varieties of native bananas were known to the Hawaiians before the time of Capt. Cook. Their name was Maia. Then in 1855 the Chinese Banana (M. Cavendishii) was introduced and since then has largely driven out the native varieties from cultivation. Many still persist, however, in ravines throughout the islands. The banana was cultivated in South America before the time of Columbus. In fact, leaves have been found in Peruvian tombs, and the Astecs offered bananas at the shrine of the goddess Centeotl. The banana is really acaulescent, the stem being reduded to form a bulb. The apparent stem-structure of the plant is due to the petioles that are wrapped one inside the other. Then at flowering, a terminal inflorescence with bracts is pushed through the sheathing leaves to the top. Here it remains upright in the wild Tahitian species (M. Fei) found wild on Tantalus, while in all others it droops because of

weight. The plant dies after fruiting. New bulbs, however, arise from the base of the old. M. textilis, endemic to the Philippines, produces Abaca or Manilla Hemp. Its fruit is not edible. This plant is now grown in Hawaii as well as

d innumerable ~~species~~ varieties of banana.

d. Heliconia is composed of 30 American species, probably 2 being now grown in Hawaii. The plant is grown as an ornamental because of its long-petioled banana-like leaves and s showy upright folded bracts that conceal inconspicuous flowers.

B. Cannaceae - Canna Family.

1. Distribution: This is a monogeneric family limited to tropical and subtropical America. The number of species according to one authority is 25 while according to another it is 66. This discrepancy is due to the fact that the Cannas readily hybridize and that these hybrids are frequently mistaken for distinct species.

2. Affinities: These plants are probably derived from the Musaceae.

3. Genera:

a. Canna has a free leaved 3-parted calyx and the corolla is also 3-parted although the petals are united at the base. The androecium is composed of 1 - 5 stamens borne on the corolla tube. These are all corolla-like but one, whose right half carries an anther with 2 pollen sacs while the left half is petal-like. Of these staminodia, the one which stands opposite the fertile stamen is downward rolled. This is falsely called the "labellum". The other 2 or 3 are call-side staminodia. The ovary is 3-celled with 2 rows of ovules

in each cell. The style is thickish and petal-like. The method of pollenation has not yet been studied. It is probably curious as the structure of the flower while in the bud indicates. Several cannas have long been naturalized in Hawaii. The common name for them is C. indica, a name probably embrasing many distinct yet unrecognized species in different parts of the world. The Hawaiian name is Aliipoe while the European is Indian Shot, in allusion to the size and shape of the spherical black hard seeds to swan shot. The testa is so resistant to water penetration that the seed will not germinate for many years. The best way to induce germination is by cracking them with a hammer, boiling them, or soaking them in acids. C. edulis is cultivated for its rootstocks which bear edible tubers. From these is made Queensland Arrowroot or tous les mois.

C. Zingiberaceae - Ginger Family.

1. Distribution: About 20 - 40 genera and over 400 species found chiefly in the tropics of the Old World.

2. Affinities: These are clearly derived from the Cannaceae.

3. Characteristics: They have long sheathing leaves and a ligule Many produce rhizomes like Canna. The flowers are zygomorphic. There are 3 sepals and 3 petals while only 1 stamen, the posterior of the inner circle, remains fertile. The other stamens have usually changed to staminodia. Thus the 2 upper of the outer circle become corolla-like or are lost; while the 2 lower of the inner circle together form the labellum. The anterior one of the outer circle fails entirely. Thus the labellum of the Zingiberaceae is composed of 2 fused staminodia while that of Canna is composed of but one. The ovary is trilocular and the seeds have aril, perisperm, and endosperm.

There are some curious insect adaptations. Thus in some species nectar is secreted by a pair of epigynous glands often very long and resembling staminodia, while in Roscoea purpurea there is a lever mechanism similar to that of Salvia.

4. Genera:

a. Zingiber zerumbet, the awapuhi of the Hawaiians, is occasionally very common in the more open forests of the lower zone, as on Tantalus. The plant is native to Hawaii but also found elsewhere. The vegetative stems are 1 - 2 feet high while the inflorescence is borne on a shorter stem. The inflorescence is terminal and composed of large imbricated bracts from which a few ephemeral whitish flowers at a time project. The inflorescence holds a large quantity of mucilaginous material which is locally used as a shampoo.

b. Zingiber zingiber, also found here but not native, is the ginger of commerce. Its flowers consist of 3 sepals, 3 petals, a labellum of 3 staminodia of which the central one is the largest, a stamen that has remained fertile and partly surrounded the pistil while the 2 remaining according to one view are missing while according to another have developed into 2 filiform nectaries. The rhizomes when merely dried are sold as Barbados Ginger while if peeled, as Jamaica Ginger. It is used as a tonic in medicine, as a spice in cooking, as a preserve in sugar, and in the manufacture of ginger ale and liquers.

c. Languas coronaria (Alpinia speciosa or nutans) is the shell-flower planted in all tropical regions. Here the perianth lobes are tinged with magenta while the large fleshy labellum is yellow with various reddish-brown markings. Well developed epigynous nectaries exist.

d. Curcuma longa, turmeric of the English and olena of the Hawaiians, is supposed to have been cultivated in India for such a long time that it no longer produces seed. It has escaped in Hawaii where it was used in coloring tapa yellow, hence the name olena from lena, meaning yellow. It differs chiefly from Zingiber in having the lateral staminodia petal like. The rhizomes are largely used in India as an ingredient of Curry Powder. It is now rarely used in medicine except in coloring ointments and tinctures. Paper soaked in the yellow dye is turmeric paper, used as a test for alkalin substances which turn it from yellow to brown, and for boric acid which turns it red-brown.

e. Elletaria cardamomum, native of Malabar, is possibly grown in Hawaii. From time immemorial, great numbers of the native of India have derived a livelihood from the cultivation of this plant. The fruit is used an an aromatic inmedicine and is largely consumed in the East as a condiment.

f. Mantisia saltatoria, the Dancing Girl, is one of the plants with the weirdest flowers. The floral shoots bearing only scales end in a panicle with great violet bracts and odd violet and yellow flowers. The calyx is elongate, top-shaped, constricted in the middle and blown out below the constriction. From the calyx the cylindric hairy corolla tube which ends in 3 points arises. The great labellum is turned back so that its under side covers part of the corolla tube. The two long side staminodia are grown to the filament of the fertile stamen for a short distance and then become free as filaments. The style lies in a hollow in the

fertile stamen filament, runs between the anthers and exposes the stigma beyond them. This plant is not grown in Hawaii but many others of the Ginger Family, too numerous to mention.

D. Marantaceae - Arrowroot Family

1. Distribution: This is a family of about 15 genera chiefly of the tropics of the New World while the Zingiberaceae were found chiefly in the tropics of the Old.

2. Affinities: These plants are undoubtedly derived from the Zingiberaceae.

3. Characteristics: This family has gone the limit in departure from the lilies and gave rise to nothing higher. The flower is very irregular and cannot be divided into equal parts. They are perennial herbs with rhizomes. The leaf has a sheath, and at the junction of blade and stem is a pulvinus. The perianth is composed of 2 trimerous whorls. Generally 2 or 1 member produces petaloid staminodia. The posterior stamen of the inner whorl has a half anther while the other half is a staminodium. The laterals of the inner whorl are petaloid; the one being hooded and enclosing the style and stigma while the other forms a broad, leathery and warted structure. The inferior ovary, which has axseptal nectary, is tri- or unilocular, each loculus having one ovule. Aril and perisperm are both present.

4. Genera:

a. Maranta arundinacea, the West Indian Arrowroot, has been n known in European gardens as far back as 1732.

IX. Microspermales (Orchidales): The flowers of this order are cyclic and derived from a pentacyclic trimerous type but often with great reduction in the androecium. The ovary is inferior, unilocular or trilocular, and with many small ovules. The fruit is a capsule containing many minute seeds with thin membranous testa and a small few celled undifferentiated embryo. The endosperm is either present or absent and upon this fact the two families Burmanniaceae (usually actinomorphic and endospermous) and Orchidaceae (usually zygomorphic and exendospermous) are made.

A. Burmanniaceae:

1. Distribution: This family consists of only 12 genera and 60 species but has a remarkably wide distribution in the tropics. (Of Burmannia there are 20 species in the tropics of both hemispheres. Gymnosiphon is found in the tropics of all 3 great continents; Dictyostegia is found in America and Africa; Thismia in Asia and America. But the great center of the family is the Malay Archipelago and Brazil.) Thus its distribution shows that it must be a very ancient family.

2. Affinities: This family is an interesting link between the epigynous Liliales such as the Amaryllids and the Orchids which they resemble in having many tiny seeds with undifferentiated embryo. All except certain Burmannia species are leafless saprophytes or rarely parasites.

3. Characteristics: Usually leafless saprophytes or rarely parasites with usually actinomorphic flowers and endospermous seeds.

4. Genera: Engler Prantl 2:6: 45 - 47

a. Thismia javanica grows on hills around Buitenzorg. It is a saprophyte with only the flower stalks above ground. The underground organs, which are roots, are peculiar white or brown-

ish threads 1 mm. in diameter, growing sometimes in knots or skeins. A few thicker and darker ones run horizontally and on these many adventitious shoots arise. They would seem at first sight to be rhizomes but they have no leaf scales, bear root caps and have root anatomy. Hence the plant is one which produces root sprouts. The shoots, which have 6 - 8 scales, are white and 1.4 - 2.5 cm. long. The vascular bundle is in a circle with excellent endodermis, which is as good as in the root. The stems produce 2 - 3 flowers that have a furrowed tube, white with orange stripes. Inside these are 12 ridges netted up with cross-beams. At the base is a ring. There are 3 calyx teeth while the 3 corolla teeth are remarkably long because of a great 1.3 cm. appendage. The 6 stamens, which have very well developed connectives, are on the tube.

B. Orchidaceae - Orchid Family.

1. Distribution: There are over 400 genera and 15,000 species known, and this number is constantly increasing. Thus in 1907 a New Guinea expedition brought back 1102 new species. Orchids usually are few in individuals but great in the number of different species in a tropical forest. They are found throughout the world, the extratropical species being terrestrial while the tropical ones are usually epiphytic.

2. Affinities: They are probably derived from the Burmanniaceae from whom they differ chiefly in having zygomorphic flowers and exendospermous seeds.

3. Characteristics:

a. General considerations: The flowers are hermaphroditic and medianly zygomorphic. The perianth is composed of 2 alternating trimerous whorls, with the median member differing from the laterals, particularly in the inner whorl where it pro-

duces the lip. Usually there are only 1 or 2 fertile stamens. There are 3 carpels and 3 stigmas, though usually only 2 are receptive. The ovary is usually unilocular with many minute ovules on parietal placentae. The fruit is a capsule while the seeds are many and small with a thin membrane around an undifferentiated embryo lacking endosperm. The distinctive mark of the orchids is the gynoecium, a structure formed by the union of pistil and stamens. This body is sometimes called the "column", although this term is also applied in other plants to an organ formed by the union of stamens alone. The gynandrium may be composed of 1 fertile stamen represented by an anther grown to the style, or (as in Cypripedium) of 2 stamens, and there may be staminodes also inasmuch as the stamens are morphologically or originally 6. Their habits are very various. They are terrestrial or epiphytic, autotropic or saprophytic, with flowers that are usually conspicuous because of size, brilliancy and oddity. The roots, rhizomes, and stem parts may thicken up as food making or storing organs. Sometimes the stem is reduced. Thus in Taeniophyllum scarcely anything but green roots are present. Air roots with velamen are common. Some are climbers, like Galeola, which reach 100 feet with their climbing roots and scale-like leaves. In 1903 Noel Bernard tried to grow seedlings under aseptic conditions. He found that the embryo only swelled and turned green, and then died. When he added an endophytic fungus isolated from old roots, however, the cotyledons and root-hairs developed. Thus it was discovered that the fungus invades the seed through the suspensor so that the cells of the lower part become full of gnarled hyphae some of which are digested. The in 3 - 4 months roots develop. Mycorrhiza are thus prerequisite to growth.

b. Special considerations: In some cases (Catasetum), when the leaves fall, the ends of the fibrovascular bundles act as thorns. In others,(Diacrium bicornutum), hollow pseudobulbs occur which serve as myrmecophilous domatia. The highest number of stamens in any archid is 5 (Arundina pentandra), but only one of the five is often well developed. Figures 1 - 4 represent bud conditions of different orchids while fig. 5 shows a mature flower diagram. Upon reaching maturity, each flower twists its ovary through 180° so that after resupination the single stamen lies opposite the bract. The infertile stamens may produce staminodia. These when small are often called stelidia. Very rarely do sporophylls sit directly on the torus. This does occur, however, on Diurus. But usually between perianth and sporophylls arises an elongation of the axis called a gynandrium which bears the sporophylls on the tip. In Corymbis veratrifolia the anthers stand upright on this gynandrium. If the next internode below elongates, the petals become raised above the sepals. Thus there may arise both a gynandrium and a gynandriophore. It may happen that 2 sepals and 1 petal get carried up on the gynandriophore (Drymoda), or 1 sepal and 2 petals. In some orchids, a third stigma is sterile and built into a rostellum around the pollinia. In certain orchids (Cephalanthera) this stigma remains rudimentary and the mealy pollen falls directly on the fertile stigmas and effects self-pollenation. In most orchids, however, the pollen is in waxy pollinia. In Dendrobium an insect merely knocks these out and it depends on chance whether they reach the stigma. Usually the pollinia form a stem-like process termed caudicle which comes into association with a stick

y mass of degenerated rostellar tissue; or a part of the rostellum itself forms a stem process called a stipe. Thus in either case, a stalk forms and bears on its end axsticky disc. If this stalk is attached to the tip of the pollinia, the orchid is called acrotont; if at base, basitont. When an insect touches the disc, it draws out the caudicle or stipe with the pollinia. The whole thing is called a pollinarium. The mucilage of the disc hardens and thereby quickly bends down the stalk to a horizontal position in place to touch the stigma of another flower. In Orchis mascula this takes about 30 seconds. When the insect enters another flower, part of the pollenmmass is torn off by the sticky stigma. The seeds of some orchids can be made to develop parthenogenetically if the stigma be stimulated by means of a brush. At time of pollination the ovules are undeveloped. The stimulus of pollination causes the ovary to increase in size, the placentae to become conspicuous, and minute anatropous ovules to develop. Theseeds are scattered by elator-like hygroscopic hairs developed on the interior of the capsule valves.

4. Genera:

a. Catasetum, a Bornean orchid, has 3 kinds of flowers on the same plant which have actually in times past been placed in 3 separate genera: Catasetum, Myanthus, and Monachanthus.

b. Renanthera Lowii, studied by Winkler, produces an inflorescence some 4 meters long bearing many flowers. The largest number of flowers found was 38, separated by internodes 5 - 6 cm. long. At the base of the inflorescence (above) there was a space of 17 cm. between flowers 2 and 3. The two lower

flowers differ from all the others in form and color; the petals being broader and shorter, and the color sulphur yellow strewn with red spots. The otherv flowers are pale yellow with many brown spots that have almost faded out. The labellum and the sex organs are alike. Only the two odd flowers are scented. This plant is then a biological analogy to the ray and disc florets of Compositae. The two strongly perfumed flowers remain fresh until all others have withered above.

c. Vanilla is the only economically valuable orchid outside of floricultural values. The flavoring, vanilla, is derived from its capsules. It was cultivated in England by Miller as early as 1759. It is introduced in Hawaii.

d. Liparis hawaiiensis is practically epiphytic. It has a large pseudobulb for water storage. The flowers are inconspicuous. It is endemic to the Hawaiian Islands.

e. Anoectochilus sandwicensis is another orchid endemic to the islands. It might be mistaken for a Commelina because of its creeping habit and leaf shape. It grows in shaded swampy places and has inconspicuous flowers.

f. Habenaria holochila is endemic to the high regions of Maui, Molokai and Kauai. It grows in bogs and has inconspicuous whitish flowers.

g. Hybrids: The first hybrid was Calanthe Dominii, a cross of C. mascula and C. furcata. Now about 3000 = 4000 hybrids have been produced, 2e being bigeneric. in the middle of the 19th Century there was a craze for striking floral species. In 1855 one plant of Aerides Schroederi brought $430, in 1875 a plant of Dendrobium Wardianum was sold at auction for $500, and the

same year a plant of Saccolabium guttatum was sold for $313. Collectors risked their lives all over the world to get new species.

Order Parietales

In the Wellstemiari system the Parietales are characterized by their usual parietal placentation, and tendency to sink carpels.

Weltstein says farther: The Parietales include families whose systematic association is seen thru a set of peculiarities but can't be brought into a common line. The Flacourtiaceae show some relations to the Capparids and go forward into Caricaceae, The violets thru zygomorphy lead in another direction. from Flacourtiaceae. All possess protein and oil. The other families starch (also come from Flacourtiaceae) and form families of Cistaceae; Bixaceae, on one side, and on another Tamaricaceae, Frankemaceae, Elatinaceae, Droseraceae. Doubtfully the Datiscaceae, Begoniaceae and Ancistrocladaceae are included. In this order too sympetaly begins to appear (Forquieriaceae Achanaceae and Caricaceae) This, as we shall see, leads to the sympetalous Ebenales.

Cistaceae: Shrubs or herbs with many stamens carpels 3-5 and with 1-many loculi Parietal plac. Warming says they are Violaceae with regular flowers numerous stamens and curved embryos. The many stamens arise thru chorisis.

Helianthemum is the rock-rose. It has 2 sorts of flowers, the vernal ones have large yellow petals and many stamens, later in summer have much smaller ones with petals small or none and 3-10 stamens--probably largely cleistogamous. H. canadence takes the name of frost weed - reason.

Hudconia is another genus which has 2 species. H. tomentosa is a shrub which has a close carpet, leaves oppressed pubescent, fls. brilliant yellow and sessile. The other H. ericoides has more obvious leaves and pediceled flowers. Grow more or less together from Virginia to Gulf of St. Lawrence and even Newfoundland. On coast of Maine grow on granite rocks. Other genus is Lechea the pin weed--ugly, weedy herbs of dry soils.

Family Bixaceae: Separated from preceding because of 2 carpels and 2 valved capsule, 180 trees and shrubs. Mention because the seeds have a brilliant red sarcotesta which contains the dye Arnalto used by natives of tropical America to color finger nails. Bixa Orellana is the species. Bixa is a name given by Aranco Indians. The color is used in the trade to color butter, cheese, chocolate and also for a varnish. Once used for silks and woolens. Coloring principle is Bixin $C_{28}H_{34}O_5$. Other genera also have colors.

Tamaricaceae: Trees or shrubs with needle-like or scale like leaves, whip-like branches. Sometimes cultivated for ornament often on salty soils of Meditteranean or Central Asia.

Tamarisk manna is produced by several species after being stung by the insect Coccus mannipanis. It is used by Arabs in food. In Persia cloths are spread under the bushes and trees are then shaken. It is made into cakes with flour, sugar or honey.

Droseraceae: Sometimes put with Sarraceniaceae but have strict parietal placentation Droseia, Dronaea, and Drosophyllum belong here. Also Aldroranda. Latter A. vesciculosa lives in southern and central Europe in shallow ditches where temperature rises to 30 degrees in summer and where no lime encrusts. Floats in water, no roots, stems filifoim--leaves in whorls. Forms hibernating buds which rest in winter filled with starch, in spring starch digests, axis elongates, lacunae fill with air and plant rises. Leaves resemble Dronaea; clavate petrole, rounded lamina with bristles projecting from junction of petrole and lamina--these are directed forward like spikes. Feeds much on pratoms and in same way as does Dronaea--also Cyclops, Daphnia, etc. Another sp. A. verticillata in tropical India, also A. australis in Australia.

Dro[illegible]
n dry[illegible]llum lusitanicum lives in Spain, Portugal and Morocco
ith hairy places. Leaves long and grass like and covered
ed by peasants in rooms to catch flies.

The larges[illegible] of all is Roridula from Cape of Good Hope which
ws three degrees to six degrees tall. Drosera is a gen[illegible]

of 90 species found everywhere except in Arctic.

Family Violaceae

Herbs on woody plants with flowers single or in inflorescences. ⊕ or ↑ ☉ P 5 + 5 a 5 and alternating with petals often with scale like elongated connective. The two lower when flower is often projections. Gynoec superios, 1 loculus with 2-5 laminal placentae. Fruit a capsule or berry. Seeds with oily endosp.

The spurred petal of the ordinary violet contains the appendices of 2 stamens--these are nectaries and secrete nectar into the spus. Viola is over the earth and much hybridized. The anthers have appendages which overlap laterally and embrace the style closely; pollen falls into the inner chamber around the style. In order to reach nectar an insect must lift the style--then pollen falls out of the chamber on to upper side of probosis. Stigma is always touched first.

Brainerd says "Besides these conspicuous blossoms, which appear in spring, others are produced later, on shorter peduncles or on runners, often concealed under the leaves; these never open nor develop petals, but are fertilized in the bud and are far more fruitful than the ordinary blossoms". Hybrids very common-effected by vernal flowers. A very difficult genus (viz. the blue violets) but well marked are: V. pedata a most beautiful species with pedate leaves, grows in sand, flowers pale blue, seeds copper colored. V. dacullata-commonest tall peduncled, swamp blue violet; fimbriatula, lanceoluta, pallens, blanda, rotundifolia; these are all acaulescent; caulescent types are pubescens, scabriuscula (intergrade), canadeusis, conspeisa, rostrata, and lor also escapes. Over 200 species of violet are described in sub-South American Andes seem to be a special center; a few five in Mawcal Brazil; Cape and tropical Africa; eight in Australia pecies are bush Islands. One group of Lignisceites of eight ation, etc) There some Violaceae are vines (leaves-Calyptrion; bulbosa of Himalayas has bulbs. is a bush V. arborescens of W. Meditteranean

laceae: Flower and scription of pollinat mechanism; cleis-ous flowers--Brainerd rk, few species natives; range, y and climbing species.

Family Flacouitiaceae

All woody plants often with discs in flowers. Stamens have Carpels 2-10 and 1 loculed with parietal placentation. Fr. a berry or capsule. Wholly tropical. The family starts with the Erythrospeimeae with spiral perianth; in Oncobeae it becomes cyclic but petals vary and are more than sepals. The disc of higher types (sometimes scales)may be derived from petals. Slowly the gynoecium begins to undergo pengyny, then flower becomes epigynous in Bembicia. We shall see that this progressive sinking leads Weinham to attach a group of Ebenales here.

In Phyllobotup flowers arise from the midnerve of the leaves on underside. Economics little. Flacourtia species edible sour fruits. F. inermis of the Moluccas is the looy-looy too tart to eat raw--reddish purple berry, size of a cherry F. ramouchi -- Madagascar plum.

Pangiuni gives an oil but fresh fruits are poisonous. Gynocardia odorata from India has the famous Chaulmosquos oil used in leprosy. The Guinea Barteria species have hollow myrmecophilous domatia.

Family Tuineraceae - 3 carpels partly sunken in receptacle. Arillate seeds. T. aphrodisiaca has Herba Damiana.

Family Malesherbraceae: This effects the transition from Tuineraceae to Passiflorales. It differs from former thru possession of a gynophore and lack of aril; from latter thru free styles.

There is only 1 genus Malesherbia and 18 species and [illegible] in western S. America from southern Peru to 36 degrees [illegible] in dry places. Shrubs with hairy stems.

Passifloraceae:

Sometimes raised to ordinal rank as Passiflorales. These are shrubs or vines and usually clomb by tendrils. Leaves often palinate. Flowers ⊕ and either perfect or imperfect. Calyx and corolla 5. Between corolla and stamens rises a "corona" Stames 5 often carried up on an androgynophoie. Ovary 1 cavity but 3-5 leaved with parietal placentae- often borne on gynophoie. Fruit a capsule or berry--seeds with sac like aril. Most Passiflorias are climbers yet Adenia globosa of west Africa has thick globose stems and thorny twigs. Echinothamnus Pechuelii has great columnar stems. The cornoa is very valuable--simple or multiple; of linear segments or of leaf like bodies or reduced to a ring. Evidence of evolution within the genus. This Tryphostemma lacks gynostemium.

Some Passifloras have edible fruit pedules; Pquadrangularis. Of. P.edulis Struter *Las*. The fruit is the size of an egg, green at first but plum color when ripe, pulp orange color with taste acid and like orange. Cultivated Queens land and New South Wales.

Passiflora Englenana

P. quadrangularis is the Granadilla of tropical America size of goose egg to middle sized watermelon. Greenish yellow with soft rind and succulent pulp with many black seeds. Sweet acid and pleasant. Many others are eaten. P. macrocarpa fruit of South America weighs eight pounds. Many cultivated as "Passion Flowers". Legend and superstitüon rampant. The ten colored parts represent the 10 apostles present at the cruxifixion--Peter and Judas being absent. The corona is an emblem used to [illegible]. The stamens are either 5 wounds or the hammers scourges. [illegible] the three nails (styles). The tendrils are [illegible] Folkard's "[illegible] leaves, hands of persecutors. Following flow[illegible] is a wild [illegible] Lore Legends and Lyrics": "The passion is said that the Sp[illegible] flower of the South American forests and it of this plant, as it hu[illegible]ards, when they first saw the lovely bloom the trees regarded the mag[illegible] in rich festoons from the branches of Indians should be converted to [illegible]icent blossom as a token that the [illegible]istianity.

In the year 1610 Jacomo Bosio, the author of an exhaustive treatise on the Cross of Calvary, was busily engaged on this work when there arrived in Rome an Augustinian friar named Emmanuel de Vuillegas a Mexican by birth. He brought with him and showed to Bosio the drawing of a flower so stupendously marvelous that he hesitated making any mention of it in his book. However, some other drawings and descriptions were sent to him by inhabitants of New Spain and certain Mexican Jesuits sojourning at Rome confirmed all the astonishing reports of this floral marvel--therefore Bosio conceived it to be his duty to present the Flos Passionis to the world as the most wondrous example of the Croce trionfante discovered in forest or field. The flower represents, he tells us, not so directly the Cross of our Lord as the past mysteries of the Passion. It is a native of the Indies, of Peru and of New Spain where the Spaniards call it the "Flower of the Five wounds" and it had clearly been designed by the Creator that it might, in due time, assist in the conversion of the heathen among whom it grows. Alluding to the bell like shape assumed by bud and fading flower he remarks: "And it may well be that in his infinite wisdom it pleased Him to create it thus shut up and protected as though to indicate that the wonderful mysteries of the Cross and of His Passion were to remain hidden from the heathen people of those countries until the time preordained by His Highest Majesty. Bosio figures the flower with a crown of thorns twisted and plaited, three nails and the column of the flagellations also finds evidence of the scourge, five spots of blood, lance shaped leaves and round marks of the thirty pieces of silver".

Family Caricaceae or (Papayceae)

These are trees with thick stems and trifling branchings. Leaves at end of stem and twigs--very large and palmate. Calyx 5, corolla sympetalous and of 5 petals--flowers unisex or perfect and inflorescencis often differ. St. 10---carpels 3-5 superior and united parietal plac. Fr. a berry. Seed with soft outer coat on testa. Milk in all parts.

Carica Papaya--Papan. Fruit run up to 15 lbs. weight and a tree bears 20-50. Fruit, salmon pink or yellow, has strong odor of muskmellon. Papain is a proteolytic enzyme so can be eaten in considerable quantities. Used widely to make tough meat tender. Leaves or green fruit boiled with meat. Williams says the Chinese are acquainted with this property and make use of it sometimes to soften the flesh of [illegible] and cooks [illegible]

killed birds in the tree or by feeding them upon the fruit beforehand. Indigenous to Brazil or West Indies--taken to Congo and East Indies. Come now to families whose relationship to other Parietales is obscure. Especially true of Begoniaceae and Datiscaceae.

Family Loasaceae: Shrubs or vines usually covered with climbing hairs or stinging hairs. Flowers remarkably varied. Basally pentamerous but stamens rise to 20 or many and often par turn into staminodial nectaries. Ovary wholly or partly inferior / loculed with 3-5 parietal plac.

In more detail: Corolla vary much from linear, rounded, flat, hollow or collar like, etc. Begins with 5 stamens in Cronovia, Cevalli a and Petalonyx; though in last some may have staminodia. Stamens are usually free. There is one significant genus Sympetalera--which again shows us where the Parietales are moving. In forms with many stamens there are bewildering variations.

In most Mentzelias they surround the pistil and all are fertile: in some however (sect Bumentzelia the outer become larger; while in still others the outer turn into tongue formed bodies--finally they become petaloid. Diagrams of above:

In many species the stamens before the sepals change into odd nectaries in groups--these runinto the Mentzelia state and transitions belong to Sclerothrix, and Klaprothia.

In Sclerothrix only the stamens before the petals are fertile. Klaprothra has undergone more extreme Chorisis and has many strange staminodia. In Loasa itself the staminodia become monadelphous and have 28-48 members of which 3-7 fertile one stand in front of petals. In Kissenia Loasa, Scyphanthiis, Cajophoia and Blumenbachia we find the staminodes united in groups of three to many scales often of odd shapes with ribs, flaps, etc.

We will describe one--Cajophoia

Family Begoniaceae.

U. herbs with watery stems; Begonia itself climbs by roots sometimes or by tendrils and is also epiphytic. Leaves often oblique, simple or palmate. Flowers monoecious. ♂ P 2-4 A often nonadelphous.
♀ P 2-5, G 2-6, and usually 3 winged. Ovules axial, laminal or parietal.
Fr. a capsule Seeds very small.

Many have tubes or rhizomes. In some Begonias the upper part of hypocotyl swells to a tuber and produces adventive roots while main root dies. Leaves often brilliant with red or silver. Most fromcallused areas can form abundant adventive shoots, even on leaves. In the hybrid between B. incarnata and B. lucida called B. phyllomaniaca they rise all over stem and leaf.

♂ Flowers have no rudiment of carpels - the perianth is colored and Wettstein raises the question whether it is primitive or reduced. In Hillebrandia there are five little scales like petals, also in Begoniella they appear as a tube. Stamens are free in Hillebrandia but found in many others.

♀ has no staminodia (in Hillebrandia there are small druses around ovary. Carpels winged. Placenta sometimes grows in irregular lobes to bear ovules. No nectar and almost odorless, yet color and form suggest insects.

Wallichians)

Hillebrandia after loss of petals

in both ♂ and ♀ (in latter styles turn to petals).

Teratology: Very many such forms - double flowers/ Sometimes the pistil becomes superior and turns into a petaloid body and may be open, and carry rudimental ovules on margins. Also the sexes get mixed in flowers and instead of carpels in right position they are found in the stamen circles. Warburg speaks of one tuberous begonia fl. with 5 abnormal pistils surrounding the stamens of a ♂ flower. Proliferation also takes place. Begoniaceae in all tropics. Hillebrandia, however, is in Hawaiian islands. Begonia has 400 species, center in Brazil. Husia and Empetalum (tuberous forms) in Andes, adapted to dryer habitats.
Relationship obscure tho much has been suggested. Related to Datiscaceae thru Hillebrandia in epigyny, unsex fls, leaf nervation, placentation, dehisc of fruit, shape and germination of seeds. Near also to Passiflorac and Loasc. The Cucurbits show affinities in unisex fls., epigyny, union of filaments, cystoliths, leaf nervature, and sometimes leaf form, also placentation, (exactly as in Hillebrandia), also seeds. But Cucurbits differ in bicollateral bundles, and odd branching.

Uses. A few in medicine as astringents, sudoufics, purgatives. One eaten in Asia as also certain in America as antiscorbutics, yet all trifling. Main value as ornamentals.

We have mentioned Hillebrandia several times. Here is description:

Flowers monoecious. Male calyx 4-5 free, alike, petals 5, alternating and very small; stamens many, free,; no rudiment of pistil. Female calyx 5, almost superior, persistent; petals 5 alternating, tiny; pistil inferior, free only above not winged, 5 loculed with each placenta projected into two hooked projections with seeds. Ovary is surrounded by tiny stalked druses. Styles 5, persistent, and 2 split. Tips surrounded by a spiral band of stigma - papillae. Fr rounded, wingless. Opening above with pores between the styles. Seeds tiny, no endosp.

H. sandwicensis, from Hawaii, one specie.

Cucurbitaceae.

Woody, herbaceous or even small trees and often climbing. Flowers u. unisexual, and pentamerous. Corolla often almost choripetalous but u. gamopetalous. Stamens 5 free, or usually with 4 united in 2 pairs and one left free; or all united. Pistil inferior 3 loculed with parietal placentae which usually project inward. Fruit seldom dry, uausly a special kind of berry (pepo) with leathery or woody rind. [illegible] bundles (fibrovascullar) bicollateral.

The tendrils of curcurbits are perplexing organs and have been interpreted as roots, ems, leaves, stipules, petioles, or organs sui generis. Thus in C. Peps alone, one s all transitions from slender threads to true leaves with tendrilar ends.

The corolla have all transitions from choripetaly to sympetaly. The lower part of corolla is usually fused with calyx tube. The androecum is very odd. Foundational comes Fevillea which has choripetaly and also 5 free stamensh but they have only 2 pollen sacs and in no Cucurbit are 4 ever found. In Thladiantha one sees the first move toward staminal zygomorphy since 4 stamens stand in 2 pairs and one remains free. In Sicydium the lower parts are fused; in Schizopepon the union reaches to the anthers while in Melothrieae even the anthers are involved.

Series is:

Luffa cylindrica gives the luffa-sponge from the fibrovascular system of the fruit.
Bryonia gets into middle Europe.
Ecballium just before falling becomes turgid with water and as it detaches from the stem the seeds are shot out with explosive force.
Citrullus vulgaris, - the watermelon is a native of tropical Africa and thru culture has been remarkably developed. The wild forms are described by Livingston the explorer who says "The most surprising plant of the South African desert is the kengive, or keme, the watermelon, in years when more than the usual quantity of rain falls, vast tracts of the country are literally covered with these melons. Some are sweet and others so bitter that they are named by the Boers the "bitter watermelon". The bitter ones are deleterious but the sweet ones are quite wholesome." Livingston's bitter melon may have been C. colycynthis, which is a dry bitter species.
Melons have been cultivated in Egypt and Orient since early times and even before Christ were carried thru S. Europe and Asia. Still form chief food and drink in Egypt for several months. Introduced to Britain in 1597. Mentioned in Mass. in 1629.

Cucumis melon is the canteloupe or muskmelon, another African plant. Seems to have come rather late into cultivation, now runs into many forms; some no larger than small plums; others get to 66 lbs. One variety is scarlet, another 1' in diameter, and 3' long, and coiled like a snake.

C. sativas is the cucumber. Probably from E. Indies, and long cultivated. Philological data says at least 3000 years in W. Asia. Known to Greeks and Romans. Very variable.

Lagenaria vulgaris. --the gourd is a native of tropics of old world -- used for dippers, buckets, etc. very variable, some edible.

Cucurbita maxima. -- the Turban squash , nativity unknown but perhaps Chili. Parent of Hubbards etc. In 1828 a variety called Commod. Porter's Valparaiso brought from Chili after war of 1812 was offered.

Cucurbita moschata -- the Crookneck. Nativity undetermined. Ray in 1686 received seeds from America.

Cucurbita pepo, The Squash or Pumpkin - an Indian name written by Roger Williams as askutasquash, size of a large apple. Words squash, pumpkins, gourd, etc. very much confused, as are the plants themselves.

Native wildcucurbits are Echinocystis lobata and Sicyos angulata. In Australia lives A. S. australis while S. bryoniaefolius comes from Chili and Peru.

Cyclanthera of 30 species stands highest among cucurbits. C. explodena at maturity rolls its 2 halves quickly back and expels seed forcibly.

Next the three stamens (4+1) begin to approach one another by their upper parts and fuse by the backs of the connectives. Finally they may completely unite into a central column traversed by three furrows, but even this disappears in Sicyos.
In lower forms the anthers are straight but as one advances they become twisted first half moons, then half circles, U, S, Z. forms, and finally much coiled. The most peculiar is in Cyclantheia, where the androecum is sheidl-shaped, and carries on its border two ringformed loculi lying one over the other. Connective is usually thick and may bear outgrowths.

Pollen grains usually rounded and with 3 furrows. Cucurbita has several caps. Inferior ovary of many forms, from spindle-shaped to flat; and cylindrical to angular or winged, smooth to hairy or spiny. Loculy vary 1-10, seeds 1-1000. Originally 5 loculi, commonest 3. Axillary placentation as in Hillebrandia, often whole loculus becomes filled with parenchyma.

Relationship of Cucurbits much in question. B and H put near Passifloraceae, A. Braun - followed by Engler put near Campanulaceae. Baellou sees affinity with Begoniaceae and Loascaceae.

Geography: Reach height in tropics and fail in cold lands. Sicyos angulata gets to Canada. There are others at Cape, Australia, N.Z., and Argentina. 85 genera. Classified in androecial features. Many of economic importance. Running thru the Englerian genera we may note:

Acanthosicyos horrida, the plant of southwest Africa. It is a thorny 1-1.5 m shrub, without leaves. The fruit is green and 10-15 cm. diam. pulp juicy orange red and aromatic. The plant grows on sand dunes and often gets buried but young parts push out. Fruit ripens December to March. Monkeys fond of fruit and also used by Hottentots which in the region where it grows live almost wholly upon it. Make into cakes with the seeds, also soup. Seeds are exported to Cape as butter-pits.

Umbellales.

Last order of the Archichlamydeae, which are to be characterized as: Woody or often herbaceous without stipules. Fls ☆ , seldom zygomorphic, P 4 and 4, or 5 and 5 A usually 1 circle and episipalous, calyx often reduced. Ovary usually inferior 5-1 but mostly 2 carpellate and 2 loculed; each locule with 1 hanging seed. Mostly 1 integ; endosperm present. Among Araliacea and Umbelliferae these are schizogenous r c., among Cornaceae they are sporadic.

The first two are closely allied, but last is more distant. No doubt but what the simplicity of Umbellales is due to reduction (reduced calyx) stamen row, red. in carpels, and in ovules). Wettstein finds affinity with the Terebinthales, Celastiales and Rhamnales where one gets same condition of seeds, tend to tetramery and reduction of stamens, strong discs, secretory spaces. Wenham says "Umbellates -- a side branch from the Calycifloral or rasalian plexus. They realize complete epigyny and umbellate inflorescences with ovule reduction. Affinities thus:

Araliaceae.

In these the calyx seldom fails but is much reduced, they are mostly woody with pinnate or palmate leaves. Flowers usually in compound inflorescences, usually pentamerous, ☆ with calyx and corolla, stamens sometimes increased. Ovary inferior, sometimes only half so, 1-5 cappels, with hanging ovule. Fruit a berry or drupe, often falling apart into parts.

The woody forms often run up as simple trunks and their large leaves give a palm-like aspect, certain Cassonias resemble Caricas. C. angolensis has an almost ball-shaped crown, and was called Sphaerodendron by Seeman. Hedera belongs here and climbs by roots.

Flowers very similar in all. Calyx usually reduced to points. As to stamens the Dizygotheca are 4 locular, viz they have 8 microsphorangea.

There are usually 5 stamens, but in a few they become more than ten. Carpels usually same as petals but varies on both sides. As to fruits, there is uaully an exocarp and endocarp; the outer may be fleshy, while the inner is woody, crustaceous, etc. Mostly a tropical family with centers in Indo-Malay and tropical America.

A few of note are Hedera, the English Ivy, a root climber sometimes with leaf demorphism. Tetrapanax papyrifer of China is cultivated for its pith which gives "rice paper". In a full grown specimen the pith is about 1' in diameter. It is divided into pieces 3(feet long and by aid of a sharp instrument is unrolled forming the thin narrow sheets known as rice paper used for drawing and for artificial flowers. Root of Ginseng famous among Chinese. Theirs is Panax Ginseng, ours P. Quinquefolium. Fatsia japonica. Baily gives as Fatsia papyrifera. F. japonica is an ornamental. Native are Panax trifoliu, P. quinquefolium, Aralia medicinte, A. hispida, A. racemosa.

Umbelliferae.

These are the dominant group of Umbellifers and there are 2100 species. They stand highest among the Archichlamydeae as can be seen from fact that calyx is much reduced, stamens only 1 circle of 5, carpels 2 and inferior with one maturing and one abortive ovule in each loculus. Thus the formula is that of the Compositae as far as numerical plan goes K 5 + 5 A 5G(2). Coulter raises question as to whether they do not really belong among the higher Sympetalae, apopetaly is perhaps trivial feature.

Flowers, very stereotyped and a most difficult family to classify. Vegetatively the stem is herbaceous with hollow internodes; leaves have broad amplexicaul base and often an inflated sheath. Blade usually pinnate or dissected, it is often compound and the outer flowers may be zygomorphic. Involucres and involucels usually present.
The fruit, however, is the most striking part and it is on fruit characters that the family is divided. The 2 styles unite at their base into a stylar foot or stylopodium which is really a nectarial disc. The fruit itself is a schizocarp which divides into two mericarps which split away at maturity but remain hanging at their tips to a carpophore, a slender single or bifid prolongation of the axis. Each mericarp usually bears 5 ridges on its surface (juga primaria); three on its back (dorsal ridges) and two on its edge near the plane of division (marginal ridges). Sometimes there are also secondary ridges, (juga secondaria) 4 in number which lie between the primaries. These may have long spines. The grooves between the ribs are called alleculae and in the pericarp beneath them run schizogenous oil tubes or vettae. Two of these often run on the ventral side of the mericarp also. The seed is usually united with the mericarp. The embryo is small and is embedded high up in the endosperm. The latter has no starch but has oil. The shape of the endosperm in cross section is used in systematics (a) one is flat on the ventral side and has the Orthospermeae, (Carum, Pastinaca,); (b) the endosperm has a ventral furrow or groove , -- Campylospermeae (Arthriscus); the cross section may be nearly a crescent. (c) the endosperm is concave on the ventral side, -- Coelospermeae (Coriandrum) Following are figures of the above:

Drude who has written a lengthy discussion for the Pflanzenfamilien divides as follows:

A. Hydrocotyloideae: Endocarp woody, no free carpophore, secretory canals lacking or in the main ribs, never in the valleculae.

B. Saniculoideae; Endocarp soft parenchymatous. Stylopodium surrounded by a ring formed outgrowth. Secretory canals various.

C. Apioideae: Endocarp soft but sometimes with sub-epidermal woody layer. Style setting on a shield-shaped outgrowth. Secretory canals in ovary in the valleculae.

The Umbelliferae have many genera of economic importance but many also are poisonous.

Taking up a few from each of the Prudian Tribes we find under Hydrocotyloideae: Hydrocotyle americana, - the water pennywort, a small marsh plant with reniform leaves, propagated by tuber bearing stolons. No importance. The genus has its greatest development in southern Hemisphere. There are 27 in Australia, 10 in N. Z., 20 in extratrop. S. America, 6 in extratrop. N. America, 10 Mexico, 14 trop. S. A., 10 trop. Asia, 20 in So. Africa, 2 in Europe, 5-6 in China and Japan.

Saniculoideae give us Sanicula marilandica or Black Snakeroot, supposed to be a specific against snake bite. The large genus is Eryngium, abundant in So. and W. Europe and western Asia, also central and South America. They are cultivated for their striking steel blue stems, foliage and teasel like heads; 220 species.

C. Apioideae: Daucus Carota, native of Europe and prehistoric. Vilmorin was able to breed in 3 years from wild carrots roots equal to those of garden varieties. Parsley, Petroselinum hortense, native of Meditt. Celery (Apium graveolens) indig. to Great Britain, is of two types, tap rooted, (celeriac) cooked and eaten, and celery, eaten for stalks. Dill(Anethum graveolens) gives dill oil; Caraway (Carum Carvi); Anisi seed from Pempinella Anisum; Asafoetida comes from Ferula Martlex or F. Asafoetida, a native of Tibet. It is obtained from the milky juice, is used in medicine, in Worcestershire sauce and by Persians as a condiment. Called food of the gods by Persians. Odor disappears when leaves are boiled for salad. Foeniculum vulgare is the fennel, Levisticum is the lovage; Arracacia xanthorrhiza is much used in Peru for edible roots under name of Peruvian carrot. Has flavor between a carrot and roasted chestnut. Yields some 15 tons per acre. Attempts made to grow in Europe and America have been unsuccessful, roots are worthless. In India etc. is considered superior to potato.

Many contain valuable ethereal oils (Sweet Cicely etc). Of great interest are the poisonous members which are always causing troubles, particularly among foreigners:

Conium maculatum, the herb"by which criminals and philisophers were put to death at Athens" is a tall branching herb with spotted stem. Contains the alkaloid Conniin C8H17 N, also Conicein C8H15N which is much more poisonous; also conydrin C8H17 No, pseudo-conydrin C8H17 NO, and methylaconiin C9H19N. Produces gradual weakness and finally paralysis of muscles, leading to cessation of lung motion; mind remains clear.

Cicuta maculata is more common with us, - called cowbane. Europe has a deadly poisonous C. virosa responsible for hundreds of poisonings. Both contain coniin and cicutoxin. People sometimes mistake the roots for parsnips. In fact in Iowa it is called wild parsnip. Children in several cases have been killed by it. Produces convulsions, "profuse sweat, and convulsive agitations, consisting of tremors, violent contractions and distortions, with alternate and imperfect relaxations of the whole muscular system, astonishing mobility of eyeballs and eyelids, widely dilated pupils, strider dentrum; trismus, frothing at the mouth and nose mixed with blood and occasionally violent and geniume epilepsy". Poisons cattle too.

C. bulbifera, common here, is very poisonous also, as are also Sium cicutaefolium; Aethusa Cynapium (fool's Parsley), Angelica atropurpurea, used by Canada Indians in suicide. "Dr. Schell claims that 15-20 grams of the dried root will cause a disgust for all spirituous liquors."

Heracleum lanatum, the cow parsnip, is said to poisonous, also said of wild Pastinaca sativa but experiments do not bear out. Dr. Kremers says "I have on different occasions eaten the wild parsnip without any ill effect". I will admit that I had some hesitancy at first and that Mr. Sexton, the foreman of the horticultural department of the Iowa State College did not expect to see me alive by evening. I must confess that the roots were somewhat woody and not very palatable.

Cornaceae.

Usually woody with flowers usually 4 parted and perfect or imperfect in cymose inflorescences which often become umbels or capitula. Carpels 1-4 and in each loculus a hanging ovule. Fruit a berry or drupe with 1-4 seeds. Often there is a showy involucre of 4 bracts around the flowers (cf. C. florida). We have two genera, Cornus with many species in cultivation and Nyssa the Tupelo tree or Pepperidge. Wood is very tough since fibers are crooked. Turns bright red in autumn, drupe blue. Called blue gum in South.

The Ericales--called Bicornes B H. Lowest among the Tetracyclidae stand the Ericales with the families Pyrolaceae, Clethraceae, Ericaceae which are obdiplostemonous. The Australian Epacudaceae have a single alternating stamen whorl and the degenerate Lennoaceae has the same. Drapensiaceae has an intermediate stage with an outer whorl of staminodia opposite the petals, Gynoec. usually multiloc and multiovel. U. isomerous. Clethraceae and Diapensiaceae has 3. Also reduction in ovules is at work. Clethraceae, Pyrolas, some Ericaceae and Epacrids have poly petaly. Conspicuousness is attained by aggregation; in Rhododendron there is weak zygomorphy. Best way to get it is to plot the possible phylogenetic tree and discuss each group.

The Sympetalae

Wholly cyclic and most often with formula P 5 5 A 5 G ($\overline{2}$). Calyx gamosepalous and persistent, corolla gamopetalous with stamens aduate; ovules have one thick integument and a small nucellus. Again the members are much more largely herbaeceous--as Weinham says the termini of the phylogenetic tree are herbaceous just like tips of any tree. They are not monophyletic but show stamen and gynoec characters that attach them to various points of Archis.

Can be divided into two groups. The Pentacyclidae including Ericales, Primulales and Ebenales; and the Tetracyclidae with Gentianiales, Tubiflorales, Plantagenales, Rubiales and Campanulates.

Pentacyclidae have 5 whorls equal in number P 5 5 A 5 5 G Somtimes the presence of an ancestral third whorl may be indicated by obdiplostemony (outer stamesn)opposite petals). Sometimes when there is A 5 5 the outer circle is staminodial or even entirely gone--then again the stamens stand opposite the petals. The flowers are usually regular. Carpels sepals but in some cases are polycarpellary or rarely bicarpellary. Petals sometimes free Tetracyclidae--have stamens alternate with petals and never exceed in number. Gynoec is usually bicarpellary and petals practically always united. Sympetaly is associated with staminal eprpetaly, zygomorphy, olegomery of androec; aggregation of florets is followed by calyx reduction while an invalucre takes on role of protection and calyx takes on a dispersive function. Ovary reducation proceeds, nearly 30% of Tetracyc, being uniovulate with one fertile loculus.

As we have learned the foundational geraniales were based on 5,5 formula and often has disc as do Ericales,again there is the same tendency to reduce stamens and carpels but in the Polygalas they reduce to 2 carpels and have much zygomorphy.

Starting with Clethraceae we find them usually put with Ericaceae but their choupetaly and 3 carpeled gynoecium causes Drude to follow Klotzsch (1851) and raise to family rank. Their stamen is of the Ericaceous type opening by terminal pores. Only 1 genus Clethra which gives us C. ahufolia--the sweet-pepper bush. Emerson says "It grows naturally and abundantly by slow streams or in islets in deep bogs where it can at most seasons bathe its feet in water". Takes readily to cultivation.

Pirolaceae

Under this family the Monotropas are included. All are herbs with evergreen leaves or are saprophytic and colorless. The seeds are very many. Most are still polypetalous. The embryo is tiny and few celled--cf. orchids.

Vegetatively most of them form a thick rhizomie which forms terminal buds for winter protection though the old plant remains green.

Pyrola aphylla is poor in chlorophyll and develops little green scales in place of leaves. All are humus plants, elaborately involved with mycorrhiza. Kerner has an interesting note on the pollination of Pyrola unifloia. Following figures show how by bending of pedicel and stamen filament autogany is brought about when out-crossing fails

Native species of Pyrolaceae with noting are chemaphila umbellata (Prince's Pine or Pipsissenia) also C. maculata, moneses unifloia, various Pyrolas. Monotropa uniflora and M. Hypopitys (Osterhout has been able to keep color by destryoing oxidases)

Lennoaceas

While we are on these saprophytes the Lennoaceae may be treated which are herbs without chlocophyll, brown or red root parasites witho scale-like leaves. Parasitize certain Clematis and Prosopis bushes in No. Mexico--Some grow a meter high and may be buried in sand up to the flowers. Ammobroma and Lennoa are best known and have dense cymose inflorescens. They are confined wholly to Southern California--Central Mexico.

Ericaceae

Woody plants or herbs with simple and usually evergreen leaves and with flowers either single or more often compacted. Usually but in Rhododendroideae weakly zygomorphic. Corolla nearly always sympetalous. Stamens free or on corolla base. Anthers opening by pores and commonly provided with horns (whence Bicornes of B & H) Pollen chugs in tetrads. Gynoecuim usually superior but inferior in Vaccinoideae which leads Weinham to split off this tribe and derive from Roses. Fruit a capsule berry or drupe.

The term "heath" suggests to us the prevalent habit of these plants which especially among the Ericoideae are xerophilous shrubs with needle-like leaves, posessed of backwardly rolled edges. My corrhiza abundant. Calcifriges.

Ericaceae may be divided into 3 subfamilies: A Rhododendroideae: Pistil superior--fruit a septicidal capsule, corolla caducous, sometimes . Here stands Rhododendron with some 200 sps. with many varietes and many garden forms. There is one in Australia but most are in E. Asia, S. China to E & W Himalayas or Japan. They give blazes of color to the high Himalayas. Another center is in temparate North America. Others in Europe where called Alpine roses.

R. maximum with us is a small tree or sprawling shrub of the Alleghenian deciduous woods to New Hampshire, Maine and Nova Scotia. In New England it is abundant in southern Rhode Island near South Kingston. R. lapponicum grows on alpine arctic granites, limestones and serpentines has masses of royal purple flowers. R. nudiflorum is our "swamp Pink" or Sawmp Azalea. R. Rhodora or canadense is famous thru Emerson's poem. Loiseleuria procumbens is a plant of arctic alpine regions and forms mats on granites and serpentines. Foliage like that of the Box. Ledum groenlandicum is another boreal, alpine plant of acid soils--peat, etc. Leaves brown and wooly below and incurved.

Kalmia--named from Peter Kalm--queer pollination device. Wholly American K. latifolia takes the name of Spoonwood with us. Usually a low shrub but farther south grows to be a tree. Emerson speaks of seeing it 20 degrees high in shady ravines of the Green Mountains. Indians called clamoun. Wood was once used by wood engravers; for small tools, handles and apparently for spoons.

K. angustifolia--called sheep's laurel--in all old pastures. Both these Kalmias have bad reputations as poisonous plants. They contain andromedotoxin $C_{31}H_{51}O_{10}$. Chesnut says: scores of cattle and sheep are poisoned annually by eating the shrub. Horses and even goats have been killed. In May 1895 a monkey was killed

at the National Zoological Park at Washington, D. C. by eating a few flowers and leaves offered to it by a visitor. Meat from chickens fed on the poisonous extract given to cats produced nearly fatal results. Flesh of partridge who eat Kalmia is claimed to be poisonous. The honey from the flowers also seems sometimes to be poisonous.

K. anguclifolia works same. We have one other species K. polifolia of cold bogs. Leaves glaucous beneath Arbutoideae: Gynoc. superior, fruit a loculicidal capsule or a berry. Corolla caducous.

Arbutus lives along Meditteranean and in North Africa. Arctostaphylos Ulva-Ursi is a boreal circumpolar trailer over rocks and sand. The fruit is yellow-ish red, mealy and bitter-sweet. Flowers are colored like those of Epigaea. A. Manzanita of Pacific Coast has edible berries used for jelley--much liked by Indians. Gaultheria is our wintergreen or checkerberry--really a trailing shrub. Farther north it lives only in sphagnum bogs. The Gaultherias comprise about 100 species, one set run from North America to Chile; another East and South Asia to Tasmania. G. Shallon, called "shallon" or salal by the Pacific Coast Indians produces a black glandular hairy edible fruit--very abundant in Oregon.

Andromeda, Lencothoe and Lyonia mayalso be mentioned. Ericoideae: These have superior ovary with fruit a capsule or nat-corolla persistent. The dominant genus is Erica and is the one gardeners mean by heath. The leaves are needle-like and beset with white, pink or yellow bells--very many hubrids. Difficult to grow since require peat soil About 1809 they took English floriculture by storm--most coming from Africa. Bailey says "The old English gardeners still lament the glorious days when the hard-wooded plants of Australia and the Cape formed the chief feature of European indoor horticulture. They complain that the present generation is not willing to give them the care they deserve".

Closely allied to Erica is the famous heather-Calluna, word comes from Greek to sweep since brooms were made from it. The leaves are needle or scale like and the flowers scarious and pink or white. Grows all over Europe, Iceland, Azores and very locally New Jersey to Newfoundland. Famous in story and legend. Vaccinoidea: Ovary inferior--fruit a berry. These are par excellence the economics forms. Several Systematists have been perplexed by the inferior ovary in a family which doesn't normally show it and have suggested another affinity. Thus Weinham would remove to a Rosalian group. His idea is this:

This doesn't look reasonable. Note Gantheria All other features are too purely Ericalian: stamens have appendages (bicoines) pollen grains in tetrads, seeds tiny and anatropous, embryo in albumen.

Ranales.

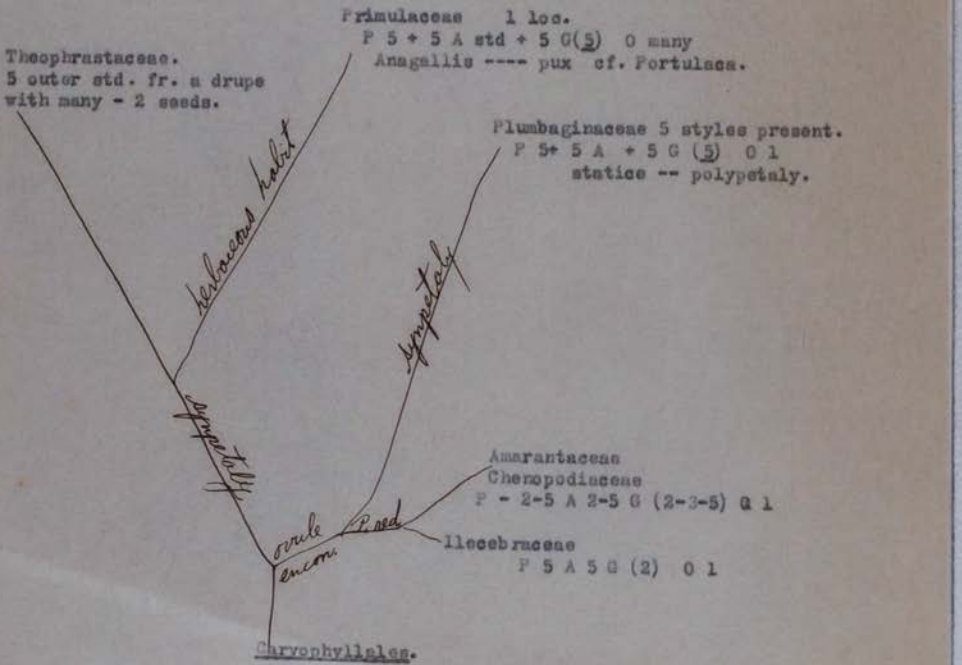
Chiogenes hispidula: the bear berry is a trailing matted shrub of Candadian and Hudsonina regions--has ivory white fruit. The leaves contain oil of wintergreen and the berries are delicious. Oil sells for $1 a gallon in Nova Scotia. fruit is used for preserves and tastes like lemon and wintergreen.and heliotrope. French call Capillaire. It was much confused with Adrantiun Capillaris-Veneris by early writers. I have found in swamp near Locke's Pond. Gaylussacia--the huckleberry is a plant of sterile soils and bogs. lo hard seed-like nutlets--so really a drupe. Looks much like Vaccinium but leaves are resinous. Our common specis is G. baccata, a very black to dull blue or even white.

Vaccinuim--breaks into several genera if desired. In Botodendron comes V. stamineum--the deerberry with glaucous green fruit which looks like goose-berries, plant of sands and quartzites.

Cyanococcus--the blueberries. a wholly American section of which we have the variable V. pennsylvanicum. V. conpmbosum, V. vaccillans. En. Vaccinium are the bilberries both American and European have axillary fruits.

Primulales.

Usually 5 parted, 0 Stamens of same number, epipetalous and opposite the segments. This usually means an outer ancestral whorl and in some cases an outer row of staminoida are present. The gynoecium is usually superior. Ovary with 1 locular and 1-many ~~ß~~ ovules with free central placentation and 2 integuments. In the Alfyrsinaceae all but 1 ovule aborts; in Plumbaginaceae there is only a single and basal. Just as in Ericaceae there are traces of polypetaly (Embelia-Myrsinaceae) and Statice of Plumbaginaceae. As to how many carpels are involved in the ovary, we find that in Plumbag. there are 5 styles and that the capsule often opens by 5 teeth 8(or 10). A certain Primula has been seen to have 5 leaves in place of ovary.
Evident that the ovary character is one we have before seen in Caryophyllales.



Homoi - or hetero chlamyd. St = petals and anteposed. G 1- many and united with 1 loc. seeds campylot. with curved embryo
To Vitis Idaea belongs the famous Vaccinum Vitis - Idaea (Grape of Mt. Ida) called by Germans the Preisselbeere. It is a trailing evergreen plant fruit clustered and shaped like a blueberry. Only 1 sp. all over the north which is superior to the cranberry. The Nfld. Govt. is making efforts to cultivate it and it is guarded by wardens till ripe. Ship 8-10,000 barrels to Minneapolis for the Scandinavian trade. Very probably the Vineland of

Lief Erickkson was named from this plant. Several lines of evidence. They describe high mountains along coast (hardly Bluehills of Boston); abundance of "grapes", and these are not abundant in N. E. to impress strangers, Norwegians were always keen about the mountain Grape and import many bushels even now; last of all they ate flesh of a whale and were poisoned; there is but one whale with poisonous flesh and it has never been found south of Maine.

Oxycoccus: Here stand the cranberries. Most important is V. macrocarpon. V. oxycoccus is more arctic and boreal tho it grows in our cold swamps.

Epacridaceae: Represent in Australia the heaths of other places. They have but 5 episepalous stamens. A few in India and S. America. Many cultivated, especially Epacris and Styphelia.

Diapensiaceae. These have a 3-loculed ovary and also have epipetalous staminoidia: Half shrubs and shrubs spread in the Arctic realm. Drapensia lapponica is a pincushion plant with imbricated small leaves and white flowers 1.5 - 2 cm. wide. Found with us only on Alpine summits.

Galax aphylla of Va. to Ga. has rounded heart-shaped leaves. Used mostly for wreaths. Pyxidanthera, the Pyxie is a moss-like plant of N. J. Pine Barrens.

We already saw how the Amaranths and Chenopods ran off the old Caryophylline branch and ended up with great ovule reduction and wind pollinated flowers. The Plumbaginaceae took up the ovule economy idea and also arrived at one seed but kept the entomophilous feature with evolved sympetaly. Wettstein says "Die Plumbaginales duften einen sympetalen Typus der Centrospermen darstellen". They are shrubs or herbs with spikes, heads, or panicles of fls. Calyx is dry and persistent. Ovule with the micropyle above a long funicle which encircles the ovule. Fruit a nut like achene or a pyx. Seed with mealy endosperm and lead-colored (hence plumbago).

Geographically very wide-spread and commonly on salty soils. Plumbago itself has several species in cultivation. Limonium carolinianum is the sea lavender or March rosemary is a seaside perennial with fleshy rosette of leaves and paniculate flowers. Sometimes called a subgenus under Statice of which there are 120 species. Have powerful astringent properties, useful in diarrhoea. Roots of European Plumbago contain a fatty substance which [redacted] gives lead color to fingers and paper, used once to cure ulcers, etc. Beggars used to cause sores and provoke pity.

Primulaceae.

These again are herbs with A5 but these seem to represent the older inner row of a 5+ 5 original state. This is supported by the fact that in Samolus there are little scales where they should be, while in Steironema they also occur and Van Treghem showed that altho absent in many cases yet vascular bundles run to their former position.

The pistil is usually wholly superior and there is no evidence of 5 carpels except when the fruit opens into 5 valves. In Primula japonica an irregular cap falls off first, then the capsule splits into valves. This leads to the typical pyx of Anagallis. There are about 350 species in the Primulaceae and mostly in Northern Hemisphere. Name Primula from Primula-veris, -- "first in Spring", The primrose, has about 150 species. Primula obconica,much cultivated in Greenhouses, is a Chinese species and both this with P. sinensis contain a substance embelic acid which sometimes produces skin poisoning. Meehan says: "A person after potting a lot of Primula obconica had his face so swollen that he remained completely blind for a day.".

Some Primulas are dimorphic with long and short styled flowers. Very many in cultivation and in England are very popular. The Auricula group of primroses are derived from a hybrid of P. Auricula x P. hirsuta. The hybrid is called P. pubescens. P. Auricula has a golden yellow color, at the throat there is a floury efflorescence due to an epidermal modification. P. Hirsuta is bi-colored, the limb is violet red and the throat is white; this gives the effect of a white 5-rayed star in the center of the flower. The hybrid seems to show blended inheritance for the limb becomes brownish and the throat is yellow. Other genera of interest are:

Soldanella of 4 species in the high mountains of central and southern Europe. They blossom in the snow Kerner says: "As the snow melts and the tricklings therefrom moisten the earth below, the Soldanella plants are aroused from their winter's rest. Their little arched flower stalks begin to elongate and come into contact with the hard under-surface of the snow tho the temperature here is zero". Utilizing food reserves thru respiration, heat is liberated and melts the ice covering in the region of the flower buds. Thus each bud becomes arched over by a dome of ice. Stem continues to grow and slowly the dome melts upward, thus a hole is bored upward and the bud appears above the snow and expands. Naturally where the ice is thinner they appear first, - so, often the edge of a snow field is riddled with holes. 10-20 flowers may appear within a stretch of a meter. Sometimes the flowers actually blossom in a cavity in the ice reminding one of flowers enclosed in amber. Flowering is always at the expense of stored food. The leaves become flaccid and are replaced later by fresh ones.

Lysimachia gives us three species and a hybrid. L. terrestris grows along streams and produces chains of little bulblets in axils of leaves. L. quadrifolia in dry woods x L. producta is widely distributed hybrid. L. Nummularia is the moneywort, a creeping herb with round leaves and yellow flowers, escaped from cultivation. Grows at foot of Toby.
Sterronema ciliatum has ciliate peticles, word means steril + thread referring to the possession of staminodia. Trientalis, the star flower of early spring woods. T. america in Eastern U. S. T. europea middle and N. Europe. Siberia and n.w. N. America.
Glaux maritima, a salt marsh plant with pink axillary bells.
Anagallis. the Pimpernel called Poor Man's Weather Glass, closes its flowers at approach of bad weather.

Cyclamen of 10 species. C. persicum is the florist's species. The cyclamen corm is the swollen hypocotyl. Very interesting too is the fact that in germination of seed there is a close parallel to the conditions in Peperonia, only 1 cotyledon develops, the other remains as a indiment.
Dodecatheon, the Shooting Star (12 gods?). Found from Maine to Texas, from Atlantic to Pacific and from California to Behring Straits. Varies remarkably. Gray thought all one species; yet Pax gives 30 species. Ours is D. Meadia running from pure white thru lilac and rose to purple. Shooting star a good name, looks like a comet hurling thru space.

Theophrastaceae: Woody plants with perfect or imperfect flowers. Just like some Primulaceae, have 5 fertile epipetalous stamens and 5 episepalous staminodia. Live in tropical America. Roots of some have fish poisons; others are Theophrasta, Clavija, Jacquinia (gives valuable woods), Myrsinaceae,. Another woody family without the staminodes. Have schizog. r.c. Fruit a drupe or berry. Ardisia is in cultivation (A. crenulata) as a shrub for Christmas decorations. Has red fruits in funicles. The leaves bear bacterial pustules in the neighborhood of the margin. Aegiceras is a mangrove like plant of the old world and its fruits behave just as in Rhizophora.

Ebenales (or Diospyrales).

Flowers usually 4 or 5 parted. ♁, stamens in 2 or more circles with tend to chorisis. Gynoecuim superior or inferior and chambered. Integuments 1 or 2. Not related at all to the Ericales or Pumulales. but as Weinham sees it, derived from primitive Parietales such as the Guthferae. For they have chorisis and tend to epigyny. Stamens of Gerriferae tend to cohere just as in many Ebenales. Carpel numbers are similar in both orders but in Parietales there is a uniloc. gynoec. This does not occur in Ebenales so must have come off early.
Families: Sapotaceae, Ebenaceae, Symplocaceae, Styracaceae.
Best discuss families first and then throw into a phylogeny.

Ebenaceae: Woody plants with leathery leaves. Flowers usually unisexual. Stamens in 1 or 2 whorls and often increased and then found into bundles (cf. Hypericaceae) Gynoec. superior 2-16 chambered with 1-2 hanging ovules. 2 integuments and free styles. Fruit a berry. (Relation to Hypericaceae is evident).

Diospyros. This is the Persimmon of woods and old fields from Conn. to s.e. Iowa and south. A tree 6-30 inches high with very hard blackish wood and plum-like fruit which is green and very astringent at first but yellow and edible when ripe and after freezing. Sturtevant gives 18 species with edible fruit. Thus D. Kaki is the Japanese date plum, - cultivated for a long time in Japan and some are seedless. The fruit is as large as an apple with translucent pulp and is considered delicious. Introduced into U. S. by the Perry expedition; in 1877, 5000 plants in 10 varieties were imported and are now grown in California.
Georgia etc.

We naturally think of the valuable Ebony woods. D. Ebenum, D. melanoxylon, D. Ebenaster, D. haplostylis and D. microrhombus all

Sapotaceae: Are also woody but have perfect flowers 4-8 (usually 5) parted. Stamens 2 - several circles with the outer staminodial. Gynoec. still superior 4-many loculed with 1 integ. around the 1 ovule. Style simple, Fruit a berry. Have gone beyond Ebenaceae in gynoec. characters, fused styles, 1 ovule and 1 integ; also in staminodia. Mostly tropic, rarely subtropic. Some give guttapercha.

Guttapercha comes particularly from the Palaquimus:others of same genus have edible fruits.
Achras Sapota from the Antilles is called Sapodilla or Sapota, now widespread in cultivation. Bears a berry rough and brown, size of apple, with 6-12 cells with several seeds. Pulp tastes like pear but sweeter. Must be very ripe like the medlar, otherwise is full of astringent milk. Oil is pressed from seeds of Butryospermum Parkii of trop. Africa; also from various Illipe spc. (I. butyracea gives fuluabutter). Many give valuable woods. Iron wood from Sideroxylon species.

Styracaceae: Again these are woody plants but the stamens are in 1 circle and 2 N standing 2 in front of each petal. The ovary begins to show a tendency to sink into tones; it is 3-5 chambered and often only partially divided. Styles united. Ovules 1-several per cell. Integ. 1 or 2. The partly inferior ovary with partial septa causes Wernham to derive these from the Parietales of higher types, such as Flacourteaceae.
All tropical.

Styrax officinalis of S. Europe and Orient give officinal gum storax.
S. Benzoin gives Siam or Sumatra Benzoe resin.

Halesia carolina is the silver-bell tree cultivated farther south. Named from Stephen Hales. Many Sympolocaceae have sweet juice. Symplocos tinctora is called Horse sugar and is greedily eaten by cattle. Wild from Delaware to Florida.

Symplocaceae: Differ from Styracaceae in the fact that the stamens are united into bundles which stand before the petals, and furthermore in the wholly inferior chambered gynoecium

Tropic and sub-tropic of America and s.e. Africa. One genus Symplocos. Leaves of several species are usued as a substitute for tea.
Resume: Rather obvious that Ebenales have two series: one of superior gynoecia, the other of inferior. Can be thrown into following schemes.

Sapotaceae.

This finishes the Pentacyclidae. It is a polyphyletic group originating by introduction of sympetaly in three archichlamydean stocks: geramial, caryophylline, and parietalian. Sympetaly appeared before economy was initiated. All have polypetalous members. They are expressive of the first steps taken by the differentiating archichlemydeous stocks in the directions of sympetaly before their primary tendencies to economy were fully realized.

The Tetracyclidae.

In these the stamens alternate with the petals and never exceed them in numbers; the gynoecium is a bicarpellary and petals are almost always united. So economy has reached the highest expression. The new theme is a progressive perfecting of entomophilous mechanisms. Sympetaly is associatied with staminal epipetaly; zygomorphy is followed by androecial oligomery; aggregation of of florets leads to reduction of calyx to a pappus; while the involucre becomes protective. Ovary reduction proceeds apace, - nearly 30% of the Tetracyclidae being uniovulate with one fertile loculus. A single ovule in each loculus of a bi-or multi-locular ovary characterized some Gentianales, a large section of Tubiflorsles and many Rubiales. All have 1 integument.

Gentianiales. (Contortae or Bicarpellatae of B and H).

Here the names above attest two features of the order (1) the corolla is usually twisted in aestuation and (2) with rare exceptions 2 superior carpels are present but the unilocular ovary is a decided exception among them. The families are Oleaceae, (Jasminaceae) and Asclepiadaceae.
To begin with Wettstein cuts off the Oleaceae, Jasminaceae, Salvadoraceae into an order Ligustrales characterized by tetramery, actinomorphy, imbricate or valvate aestivation. Stamens 4 or 2, - carpels 2. He admits that it shows close affinities with the Contortae but derives directly from Celastrales with the Salvadoraceae as transitional. In fact he has classified the Salvadoraceae among the Celastrales tho they have sympetaly. Wettstein's Celastrales we placed as do most botanists among the Sapindales. They include the families Aquifoliaceae, Celastraceae, Staphyleaceae, Ern petraceae, Salvadoraceae which W. characterizes as woody plants with simple l aves, with secretory organs in vegetative organs, or without such. Discs in flowers. Stamens usually to petals and alternating. Raphe usually dorsal and micropyle above, or ventral raphe and micropyle below.

Now the Salvadoraceae differ in their 1-2 loc. gynoec and weaker disc. Only 5-6 E. I. species. LeMaout characterizes as: fls. in panicles. Calyx tiny 4-toothed. Corolla usually gemopet. umbricated, St. 4 on corolla, and alternate, ovary superior, 2 loculed, 2 ovuled, ovules anatropous berry 1-2 loculed. S. persica have aromatic and edible fruit. Grows in dry W. Asia.

Oleaceae: Usually based on the plan of P 4+4, A 2 G(2). No disc. Seeds hanging on ascending. Fruit a berry, drupe or capsule. Fls usually panicled.

Divided into the Oleoideae with the Fraxineae, Syringeae, and Olsineae; and the Jasminoideae, sometimes given family rank.

The Oleoideae have hanging seeds and fruit is without a constriction, while the Jasminoideae have upright seeds. More natural seems to be Gray's classification into:

Tribd 1 Fraxineae, Fruit a samara, leaves pinnate.
Tribe 2 Syringeae Fruit a loculic. capsule, leaves simple.
Tribe 3 Oleineae Fruit a drupe or berry, leaves simple.

Fraxinus. The Ash. Sometimes apetalous. St. 2 or 3 or 4. G 2. F. Americana is the common white ash, a valuable tree; F. pennsylvania is a plant of low grounds, called red ash- branches pubescent. Belchertown and Toby. F. nigra also occurs here. F. Ornus, the manna-ash of S. Europe gives exudation from bark, the official manna from which mannite is prepared.

Forsythia gives us two ornamental shrubs. F. suspensa and F. verdissima.

Syringa. Natives of E. Asia, and Europe. S. vulgaris was the common specie which has escaped so widely , - a native of Balkans and Orient. S. persica grows in Persia and Afghanistan and was introduced into Europe in 1640. Hundreds of varieties in cultivation, [redacted] Osmanthus fragrans of E. Asia cultivated in greenhouses, flowers used for perfuming tea. There is also an O. smericanus.

Chionanthus, the Fringe tree gives us one native sp. C. virginica which is a native of New Jersey to Pa. and s. The Germans call "Schneeflockenbaum". The only other specie is C. chinensis.

Olea: Dominated as a genus of which there are 31 species by Olea europea, the olive. This is an evergreen tree of the Orient now spread over earth and has been cultivated since ancient times, runs wild abundantly from India to Morocco, very abundant in Syria and Algeria. The wild forms are different since their leaves are smaller, more rigid, and fruits have little flesh. Sometimes called the oleaster. Used for grafting stock. Culture introduced by Phoenicians, Greeks and Romans, succeeds in America, in parts of Florida, Arizona, New Mexico, and Cal. Introduced to last by Franciscans. California has about 1,530,000 trees on 30,000 acres, Florida 8000. California had in 1910 800,000 gals. of oil and 1,000,000 gals. of pickled olives. Bailey gives methods usedin preparing.

Ligustrum is the Privet.
Jasminium: 140-160 sp., are shrubs or woody vines often cultivated for sweet scented flowers. Flowers used to perfume tea.

Loganiaceae: Vines, trees and herbs, with stipulate leaves and no milk, 4-5 parted flowers, stamens of same number as petals. Fruits follicles or drupes and usually many seeds. The Loganioideae have inner phloem but Buddleioideae do not. Rather a heterogeneous family which Baillon splits up and unites with Apocynaceae, Gentianaceae, Solanaceae, Scroph. and Rubiaceae. Stipules alone delimit. There are 360 sps. all tropical except a few.

Many are poisonous. Thus Strychnos Nux-vomica: a native of India is a small tree. with fruit resembling an orange but with hard rind and many flat seeds covered with hair. Contains in seeds strychnin C21H22 N2O2 and buicin C23H26N2O4 and 4H2). Tonic in small amounts speeds up heart; extremely bitter and detected in solution of 1 part to 700000. Fruit also has loganin in pulp. S. toxifera of the Orinoco has curare, used as an arrow poison, Curare comes from bark when steeped in water. Strychnin in more than tiny doses causes convulsions and subsequent paralysis from asphyxia due to spasms of respiratory muscles.

Gelsemium sempervirens is a native plant of the southernU. S. A climber with showy yellow flowers, called yellow jasmine. Contains an alkaloid gelseminum. Blyth records that 10 mgrs. killed a frog in four hours, 8 mgr. killed a cat in 15 minutes, and 1/6 grain killed a woman in 7 1/2 hours.
The Buddleras differ from rest of family thru failure of inner phloem. Buddleras are cultivated for flowers.

Family Gentianaceae: Usually herbs of a peculiar stiff, glabrous growth, opposite sessile leaves. Ovary 2 carpeled but sometimes only 1 loculus. Usually parietal, 2 placentations. These may grow out into the loculus till they nearly or quite meet and grow together. Of trifling importance. Many have a bitter principle used in tonics, particularly in stock foods. The bitter principle is a glucoside gentiopicrin C28 H30 O12.

Native are Gentiana crinita, fringed gentian flowering in fall, also G. clausa (Andrewsii of Manual). There are about 300 species of the genus.

Sabbatia is a genus of beautiful coastal plants with salmon pink daisy-like flowers.

Menyanthes, the Buckbean, is a circumpolar plant, 3 leaflets, racemes of flesh-colored bearded flowers. A swamp plant. Used in Lapland and Finland for nussen-brot. Rhizomes are powdered and washed to get rid of bitter staff. "In the outer Hebrides when there is a deficiency of tobacco, the islanders console themselves by chewing the root of the marsh trefoil which has a bitter and acrid taste".
Another interesting plant allied to Menyanthes is Nymphoides lacunosum, a submersed aquatic with leaves like those of a water lily and small white flowers.

Apocynaceae. Dogbane Family. Shrubs or herbs with cymose inflorescences; Fl ☿, 4-5 parted, 2 carpels with 1-2 loculi superior or a bit inferior with carpels often becoming apocarpous. Stigma often capitate. Fruit a berry or capsule or divided into mericarps. Seeds flat or with hair tufts. All have milk and intraxylary phloem. There are many climbing forms, trees and shrubs less common and there are no Annuals.
Flowers of great interest since lead us to Asclepiads. Borne in inflorescences usually. Usually based on plan of 5. On base of calyx between lobes occur often nectaries. The corolla is usually funnel form and sometimes has hairs or hair tufts or even projections and scales, seem to be homologues of something similar in Asclepiads, the Corona. Stamens always borne on tube. Filaments short except

except in Beaumontia where they are remarkably long, usually free, only in Themardia are they united.
Anthers dithetic, each theca with 2 loculi. The outer loculi sometimes have tails. Often the anthers are closely connivent around the pistil by their inner edge while their sides may be enclosed in pockets of the corolla.

In more detail the situation is as follows:
The four loculi dehisce by an inner cleft. All four loculi may be alike or The two inner are very decidedly shorter than the outer and the latter elongate into tails. The pollen-mother cells have developed before the tails develop hence the latter contain no pollen.

This tail hardens and grows into a pouch in the corolla. Homologous with similar structures in Asclepiads.
Among asclepiads the two kinds of anthers are again met with. One set with normal anthers filled with pollen (The Plumieroideae among Apocynaceae and the Peuplocoideae among Asclepiads have stamens like this

while the Echitoideae among Apocynaceae have their equivalents among the Cynanchoideae. In one genus Condylocarpus the pollen grains are in tetrads, a common feature among Asclepiads.

The carpels are very commonly separate but all believe that this is an advanced character, because all the other and more primitive Contortae are fully syncarpous, particularly the Loganiceae which are related closely. That the Apocynums are derivatives is shown by milk canals, specialized androecium.
The style is simple but swells above into a head. When stamens enter into association then cavities appear in the stylar head. Sometimes there are ring-like formations on the stigma while Vinca has 5 long hair tufts. In some species the stylar column secretes a sticky fluid and as an insect thrusts the proboscis between the stamens this becomes smeared. In withdrawing the sticky fluid catches pollen grains.
Fruit and seed: Commonly 2 follicles. In the Plumieroideae however, follicles are rare and seeds usually not comose. The Tabernaemontaninae have fleshy fruits and do not always open. Couma and Hancornia are edible. Fruit of Laudolphia are used like citron. Orbera Haughas has a fruit with a remarkable outer system of strong vascular threads which give it great strength; it is spread by waves. When it falls in water the soft tissues decay. It has been spread by waves from Madagascar to New Guinea.

Dry fruited forms very variable. Here are a few:

Divided as we have said into:
Plumieroideae: With free stamens not tailed. Here are a set of important rubber plants: Laudolphia of Africa, several species. In E. Indies Urceola, Willoughbya has a good caouchouc. Many have poisonous principles in the milk. Cerbera Taughin is the ordeal tree of Madagascar; formerly criminals were put to death by being pricked with a lance dipped in the juice of the kernel. A single seed contains enough poison to kill 20 people.
Vinca, the periwinkle also here, widely escaped is V. minor.

Echitoideae have stamen anthers bound to stylar top. Some used in medicine. Here too comes the Oleander much cultivated for decoration. Native of Mediterranean and poisonous.
Native with us are also Apocynum androsaemifolium the spreading dogbane with pink-striped flowers and interesting long pods with tufted seeds. A. cannabinum, the Indian hemp, is another with greenish flowers.
Stems were rotted in water and the soft brownish fiber was woven by Indians into clothing, or more often into fish or carrying nets, string or rope.
Peter Kalm says Swedes in Delaware River colonies preferred such ropes to those of hemp and bought from Indians at the rate of "14 yards for a piece of bread".
Of interest to note that Asclepias incarnata has similar fiber.

Asclepiadaceae.

A most remarkable group of plants which lead over from Apocynaceae, in fact, there is no sharp distinction. Better not to give diagnosis; but to show how they lead over.
Vegetatively they are mostly winding half-shrubs, a few are shrubs however, centering particularly in the steppes region of Central and South Africa where leaf reduction goes on and produces succulent forms simulating cacti. Periploca ephedroides simulates Ephedra. Some have great tuberous roots. Stapelia so resemble cacti as to have leaf cushions with leaves reduced to almost spine like bodies.

In Deschidia the leaves are modified into ascidia. Beccari says they function like Nepenthes leaves, but this vein is now abondoned and it is belie-

that these leaves gather humus. D. digitiformis of Celebes has nest leaves.
Anatomically they have milk and bicollateral bundles.
Flowers: Of great similarity and all have the following diagram:
Pleromery of gynoecium is wholly unknown. Fls. in umbel. like cymes, Calyx usually of free sepals, petals cut deeply but still united and tube is usually short, bend back in anthesis.

It is in sporophylls that the strangest things happen. In anthogeny all these start as free primordia, later the anthers combine closely with the style whose top turns into a 5-angled head exactly as in the Apocynacea, end is stigmatic beneath. To the margin of this stigmatic head the anthers glue themselves except in the group of the Periploceae where they remainfree. Furthermore, the anthers approximate by their sides and form a 5-sided cylinder. The whole apparatus is called a gynostegrum.
Remember that among Apocynums are 2 groups, the Plumieroideae without sterile tails and the Echitoideae with tails. Some among Asclepiads for the Peuplocoideae don't have appendages and the Cynanchoideae do have. And the genus Asclepiad goes yet another step for the content of the 2 loculi form into 2 wax-like bodies (Pollinia) while the Peuplocoideae have free pollen grains. The grains too adhere in tetrads, sometimes linear or in cruciform arrangement. In the Periplocoideae too the stamens are free.

The Cynanchoideae on the other hand are the extreme forms and seem to come from the Echitoideae directly. The only character which separates the Apocynaceae from Asclepiads is the possession of an apparatus which serves for carrying the pollen and is called the <u>translator</u>. These never appear among Apocynaceae. In the Periploc. these are simple; in the Echitoid. very complex. The translator consists of a sticky disc and arm (or arms) Many books call the disc the corpuscle and the arms the candicles. The Periploca type is like this:

On to the spoon-shaped or beaker-like top of the translator the pollen is shed and since the translator stands between two anthers it receives part of its pollen from both.
The second type of translator is found in all the Cynanchoideae and consists of an egg-shaped disc slit upward and bearing 2 arms of various shapes.

The term corona is applied to structures which are attached either to stamens or to corrola or to both. The corolla type is of ordinary form of such oragns; but the staminal type is manifold and runs all the way from small scales which jut out behind the ŝŝŝ anther sacs to odd hollow bodies with an incurved horn rising from them; contain nectar.

Pollination: In Periplocoideae the mechanism behaves much as in the Habenarias. The disc becomes attached to an insect's head and is pulled out with its stack and spoon filled with pollen.
Among Cynanchoideae (Asclepias) honey is secreted in the coronal cups. The insect finds best support on the stigmatic head and its foot slides easily into the chink where the corpuscle lies and in withdrawal is held in the cleft of the corpuscle. Finally the whole pollinium is torn out. In another flower the foot pushes into another chink and against the stigma, in retreating another pollinium is pulled out. The fruit is very stereotyped, all have 2 separating follicles, seeds with comose tuft.
Geographically most are tropical, only a few run into temperate climates. There are about 1800 species in 200 genera. Of small value. The hairs are too brittle for spinning, the bast fibers offer more promise if they could be freed of caouchouc. Calotropis procera is of interest as being the Sodom apple, its fruit being brightly colored but dry and inedible. A few are used as greens (A. Syriaca e.g.)
Hoya carnosa is the ŝŝŝŝŝŝŝŝŝ Wax plant.
We have several native Asclepias species.
A. tuberosa, Butterfly-weed or Pleurisy root. beautiful orange fl. sps. of sand plains
A. incarnata, Suany milkweed.
A. syriaca, conamon milkweed. A. amplericaulis;
A. phytolaccoides; A. quadrifolia; Asclepiadacea take 116 pages in Engler (K. Schumann). Many queer looking things.

Diagram:

The Tetracyclidae

Tubiflorales

A natural group with prominent zygomorphy coupled with andrœcial oligomery. Ovules 2 in over 40%. Most are herbs. There are 2 constant characters: (1) superior ovary with 2 carpels and (2) epipetalous stamens. B & H break into three orders:

I. Polemoniales. Transitional forms from the Gentianales fls. reg. or sub regular, androec isomerous.
II. The Personales or Multiovulatae: Have attained zygomorphy but still → ∞ ovules.
III The Lamiales. U. zygomorphic with 0.2 or rarely 1 per carpel.

Polemoniales

Convolvulaceae (1000 sps.). Hydrophyllaceae (170 sps.). Polemoniaceae (200 sps.) Borraginaceae (1200 sps.). Nolanaceae (50 sps.). Solanaceae (1500 sps.).

Family Convolvulaceae.

Perhaps first give the tree then follow its branchings.

Family Convalvulaceae:

Fls. typically and tubular; stamens mostly borne on base of corolla tube. Cp. 3 seldom 3-5 with u.2 basal ovules and 1 integ. cotyledons crumpled. Anatomically bicollateral bundles appear, also milk or resin canals. They are mostly climbing herbs. About 1100 sps.- mostly tropical.

Wernham says: "The bond between the Apocynaceae and Convolvulaceae is very close. Many Convolv. recall climbing suffrutescent apocynums in habit and general appearance while flower structures are similar. Their corolla is twisted in bud (Contortae). The advance which they have made is in reduction of ovules to two per carpel and a strong herbaceous habit. Wettstein sets off the Convolvulaceae and Auscutaceae as an order Convolvulales.

Another character which points onward is fact that fruit may be capsular or may fall apart into 1 seeded mericarps - (acheues).

At the base of the family stand these fruit splitting forms which relate to the schizocarpous Apocynums and are put into the Dichondreae with 2 genera. Dichondra is a creeping plant with axillary fls. of 5 tropic sps. It 2 carpels which are sometimes closely grown together. The styles spring from between the carpels rather low down. (Cf. borages.)

In the more typical Convolvulus members there are several economic members. I pomoea batatas Poir probably stands first. Originally S. and Cent. Am. and when discovered by Columbus was already of varietes as is attested by the fact that fruits and seeds are seldom seen. The edible part is the thick roots which are also propagative bodies by adventitious buds. Origin may be the wild I. fastigata of trop. Am. Bailey lists 33 Ipomoea sps. of hortic. value. I. leptophylla of dry Neb. and Wyo. plains is the man-of-the-earth; the root comes to weigh 100 lbs. and runs 40 into subsoil. The Cheyennes, Arapahoes and Kionas roast it for food when pressed by hunger - but not very palatable. Great size and depth makes it hard to get out.

I. pandurata is another "man-of-the-earth" of the e. U.S. in dry soil Can. to Fla. Roots weigh 80 lbs. and was also used by Indians to some extent. In some places is a bad weed. Sold as "hardy or perennial moonflower - will stand - 26° F.

I. purpurea is the common morning-glory from Trop. Am. I. pes-caprae is a sea strand plant on tropic coasts of both hemispheres. Certain sps. are strongly purgative - used in medicine (I. purga (jalap); I. congesta. Native is Convolvulus sepum with white or rose purple flowers.

To the Cuscutoideae belongs the dodders or Cuscutas - destructive parasites. Life history of interest given in Freshman Bot. Text. Our common native is C. Gronovii; C. arvensis, C. Epilinum also occur C. Epithymum on clover. C. europea has been found once at Gilead, Maine. It ranges from England to Japan and as far south as Algiers.

Referring to tree of phylogeny shows that line of evolution ends with the parasitic Cuscutas. We now take up a line of Schizocarpy already seen in the Dichondreae and advance to the Nolanaceae.

Nolanaceae:

A very interesting family taking its place between Convolvulaceae and Borraginaceae.

In structure of flower it is very like the Convolvulaceae and B & H unites it with them. But the fruit splits up into nutlets.

In Dolia the fruit falls apart into its 5 constituent carpels. All confined to the west coast of So. America.

Family Borraginaceae.

Mostly herbs and is hairy with alternate leaves. Flowers usually in double cymes which are also scorpioid. Fls. 5 parted as to corolla and seldom zygomorphic. Corolla not rarely with scales etc. Ovary superior of 2 median carpels each with 2 hanging ovules. The parts of the ovary around each ovule bulge out and hence the fruit becomes 4 parted and the style remains low down between these parts (gynobasic) Fr. a drupe or 4.1-seeded nutlets. Endosperm absent or trifling. Most primitive are the Cordioideae which have the two styles each forked. The fruit is 4 chambered but only 1 seed develops and whole becomes a drupe. Trees and shrubs.

There are 330 species of Cordia mostly in American Tropics. Woods are valuable C. Gerascanthus Dominica rosewood.

Ehretioideae. These have a terminal 2 split style and a drupe with 3, 2-seeded or 4 1 seeded kernels. Again they are mostly trees.

Heliotropoideae. Here the fruit is a drupe with 2 - 2 seeded or 4 - 1 seeded kernels or falling into 4 nutlets. Mostly perennial herbs. Most important is Heliotropium of some 220 sps. H. peruvianum is the garden heliotrope.

Boraginoideae. Style at base (gynobasic). Fr. four 1 seeded nutlets. Temperate climate herbs mostly. Many formerly used in medicine. Aekanna tinctoria Radix Alkannae which contains a purple-red dye - alkanna red - a microchemical test for fats.

We have several native members of the family Myosotis - M. scorpioides is widely escaped. Mertensia virginica found N. Y. w. and so. also at Grand Junction, Col. Another striking sp. - Echium vulgare - Vepers Bugloss also called blue weed and blue-devil - a plant of hot dry sands - harsh and bustly with blue flowers. Montague Station.

The Polemoniaceae.

This family is exceptional in a Bicarpellary group in having a tri-locular ovary. It is a very natural family of 200 sps. contrasted with 16,500 bicarpellary forms. The strongest claim for its retention among apocynal descendants is its isomerous and epipetalous alternating androecium, but the gynoecium stops at the level of the Epacrids and Diapensias. Wernham suggests that for its origin we may have to go back even to geranial stock. Our tree places in a non committal position.

Wettstein defines as herbs, seldom low woody plants with simple or parted, often hairy leaves. Fls. cymose u Calyx and corolla 5 parted St. 5, Cp. 3 and superior. In each locule 1 - seeds. Particularly abundant in w. N. A. with many valuable decorative plants.

Cobaea - named from Father Cobo, Span' Jesuit of 17th century and a naturali in America years. A genus of climbing plants. C. scandens is amo the dozen most popular annual vines. T plant is a leaf climber like the pea. Terminal leaflet a tendril.

Phlox of some 30 sps. Several in cultivation such as P. Drummondii, subulata and paniculata. Collomia may be mentioned because of the fact that its testa bears a layer of slime cells with spiral threads which swell and unwind remarkably when moistened. Used by mechanists to teach "growth." Polemonium of 14 sps. a few showy flowered sps.

Hydrophyllaceae

Differ from last family in the 3 carpeled gynoecium which is either 1 or 2 loculed. The inflorescence is scorpioid like that of the Boraginaceae.

W. America is center of home though [illegible] genera occur in India, Madagascar, Hawaii, Africa, Japan. Points to previous wide distribution. With us is Hydrophylium virginicum; while in west is the Genus Phacelia of 70-80 sps.

Noting the Borage line again we shall soon have occasion to derive the Lamiales from the same line of Schizocarpy which leads to Kolanaceae etc.

Solanaceae

Now we enter upon the multiovulate line which leads through Solanaceae to Scrophylanaceae. The Solanaceae lie close to the Apocynal stock and the transition to Scrophs. is made through the Subpiglossidae. These by B & H were put with Scrophylanaceae but Engler puts in Solanaceae. The distinct. feature between the two families is the weak zygomorphy of Solanaceae along with inner phloem - while Scrophs strong zygomorphy greater oligomery of androec and no inner phloem. The Solanaceae are not included among multiovulatae or Personales. They are not Personate though going that way.

Solanaceae.

Herbs or woody - Lvs. u. simple; inflo. cymose. Perianth and androec 5-fid. U or weak 1; ovary superior and u 2 loculed with axillary plac. and u ovules. Fr. a berry or capsule. Endosp 1. Inner phloem always present. 70 gen. 1600 sps.

One loculus comes into existence thru abortion of walls while in Nicandra, Solandra, Datura and Grabowskia false walls split the 2 in four loculi. This false septa character remember is characteristic of the Convolvulalian line.

There is rather abundant floral abnormality among Solanaceae as regards number of parts. Hexamerous fls. with numerous gynoecia occur in Solaneae. In the strict sense the flower is never actinomorphic since gynoecium is 2 carpeled. Zygomorphy may also express in androec and corolla. Following are a few types.

Nicandria Petunia Schizanthus Datura

The Nicandreae are placed lowest a convolvulus like flower with ovary divided by cross walls into 3-5 loculi which a dryish berry. N. Physaloides is an old garden flower cultivated as Apple of Peru.

In general the Solanaceae divide into two groups.

I. Those with sharply curved embryo - the curvature more than a semicircle. All 5 stamens fertile and of same length.

II. Embryo straight or weakly curved - the curvature less than a semicircle.