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

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

SYSTEMATIC BOTANY

I. As introduction to the course in Elementary Systematic Botany, we will begin as far back in time as possible. Namely, we will take up the origin of the earth and its oceans. Then we will very briefly review last semester's work before studying in detail the Higher Plants.

II. Origin of the earth and of the oceans,

A. According to the Nebular Hypothesis (of Kant and Laplace).

1. The Nebular Hypothesis was first proposed in 1755 by Emmanual Kant in his "Naturgeschichte des Himmels", and promptly forgotten until resurrected by von Humbolt 90 years later. But Laplace in 1796 had independently developed this same hypothesis and later even improved upon it. The gist of it is as follows:

2. Stages in the Nebular Hypothesis:

a. Astral Eon: Originally all the matter later comprising the sun, the earth, and the other planets of our solar system was diffused throughout an area having a radius of over 2,800,000,000 miles. This matter was extremely attenuate and constituted a nebula or luminous cloud such as one can see in Andromeda and Orion with the naked eye. As it contracted because of the force of gravity around its central nucleus or sun the condensing gases grew hotter and hotter. Thus the whole mass shone like a star. The gases were thought to contain the future H_2O of the globe or the dissociated elements thereof and other heavy gases. During this contraction toward the center, the extremely hot vapor also finally formed itself into an equatorial ring such as is visible around Saturn today. These

rings finally broke up by the aggregation of the gases, thus forming the planets. The smaller rings around the planets similarly condensed to form the satellites. This ended the Astral Eon of the earth's development.

b. Azoic Eon: The Azoic(or age without life) Eon of the earth's development followed the astral. It might be divided into two subdivisions:

1. The lithic era was characterized by the gradual cooling of the molten mass on the outside to form a hot rocky crust of original rocks which were naturally wholly crystalline and heated to above 2500° F. All the water was still in the atmosphere as well as all the CO_2 and O. As the earth shrank due to further cooling, lateral pressure developed wrinkles.

2. The oceanic era then came with the cooling of the globe to such an extent that the steaming atmosphere could drop its water. This then either formed a universal ocean or collected in the depressions. Then tidal action resulted and this friction engendered a retardation of rotation of the earth. The waves, currents and rivers began their work while the gases of the air combined with the rocks to produce limestones, and iron carbonates by purely chemical methods. Thus sediments gradually accumulated and formed the earth's supercrust.

c. The Eozoic Eon: Now with an ocean in which mineral salts were found in extreme dilution, life must have appeared in its most primitive forms. This was therefore named the Eozoic Eon, eo meaning dawn and zoon,animal. The plants must have

appeared first and as these increased in numbers, some of them discovered that it is far easier to steal the manufactured food of their relatives than to make their own out of the raw salts of the ocean. Thus the animal kingdom gradually evolved

3. Arguments against the Nebular Hypothesis: At first sight the Nebular Hypothesis seems quite plausible, yet many objections to it have arisen, especially of late years due to the advance in knowledge of celestial mechanics and of the molecular activities of gases. Furthermore, there is no evidence of an original crust of rocks. If the atmosphere according to this hypothesis was first very dense and acted as a blanket of thick gases to retain the heat how can we account for glaciation during the Permian and even Proterozoic times and for the fact that the animals of the early past were fitted to conditions much like those of today? And if the primitive water in the atmosphere was precipitated upon a dry earth, the oceans must have been larger than now as much of the water must have soaked into the rocks. But now we are beginning to realize that the oceans are getting deeper rather than shallower. Much of the additional water is being given out by volcanoes and thermal springs. The old geologists believed this water was merely that which had seeped into the rocks, and therefore named it vadose water; the present geologists hold that it is new, juvenile, or teluric water but recently freed from the deep lavas. Because of such objections to the Nebular Hypothesis we shall advert to the Planetesimal Hypothesis and see what that has to offer.

B. According to the Planetesimal Hypothesis (of Chamberlin and Moulton.)

1. If two stars, or suns, without any previous motion were allowed to attract each other by the force of gravity, they would move in a straight line toward each other's centers with ever increasing velocity until an inevitable collision results. But if the other heavenly bodies are allowed to exert their gravitational pull upon these two approaching masses, these instead of colliding would sail past each other and out into space. When these stars thus approached each other, they must have exerted mutual tidal forces. Such a force is of course exemplified by the moon's attempt to pull the ocean away from the earth, thus causing the high tide. The earth's force of gravity, however, is fortuneately too great to permit this attempted robbery. But in the case of the two hypothecated stars we are studying, the tidal forces were so great that they actually pulled parts of each other into space. Some of this material then promptly began to revolve around the one star, our sun, as a spiral nebula.

2. The Nuclear Stage of the earth's development then began as a nebulous knot acting as a nucleus in a spiral nebula. Gradually this nucleus increased in size by the capture of smaller planetesimals around it until it reached a diameter of 2000 to 3000 miles.

3. The Initial Volcanic Stage: The self-compression of the earth due to its own gravity now probably produced sufficient internal heat to melt the primitive rocks. Then tongues of lava began to creep toward the surface through the weaker zones of the earth's crust. This lava and the escaping gases of the interior may well have produced vast explosions which tore out great craters. At this time the earth may have been too small to keep its gases

from diffusing into space just as the moon is now. But with the added growth from attracted satellites, the next stage developed.

4. The Initial Atmospheric Stage arose when the heaviest gas was retained, namelybCO_2. Then came O_2 and later N_2. When the earth reached about the size of Mars, or a diameter of 4200 miles, it retained its H_2O. Even yet the earth is too small to hold the H_2 and many of the rarest gases. When at length the atmosphere became saturated with water vapor from volcanic action, the next stage began.

5. The Initial Hydrospheric Stage was characterized by the beginnin ning of marked erosion by the agency of water. The heavier materials were leached out of the rocks and deposited in the natural depressions or seas. Thus the dry land became lighter than the sediments at the bottom of the sea. The sea bed then became depressed relative to the land and this was the origin of the ocean basins and of the continental platforms which constitute the grand topographic features of the globe. Now that we have an ocean at hand, we can imagine that life on earth became possibl sible.

6. The Initial Life Stage: The period when life began on earth may be termed the Initial Life Stage of eozoic time. As to how life originated and finally evolved into its present diverse forms, we will postpone until later.

7. The Last Stage of Planetesimal Accretion: The growth of the earth by accretion probably became slower and slower as the neigh: borhood was drained of planetesimals. The earth from this time on probably has caught only such heavenly bodies as stray meteors, most of them of such a small size that they never reach the ground

but are vaporized by the extreme heat which is generated by their friction with the upper limits of our atmosphere. Thus they flare up as so-called "shooting stars" and are then snuffed out of existance, the gases being a welcome addition to our globe. Yet many of the larger meteors reach the earth's surface weighing many tons. These commonly contain such gases as H, CO_2 , CO , CH_4 , and N. At the beginning of the last stage of planetesimal accretion the earth probably had a greater diameter than its present 7918 miles. This is due to its shrinkage.

8. The last stage is that of Gradation as the surface of the earth is no longer subject to continual burial from planetesimals. From that time on to the present, the usual geological processes have taken place.

9. A summary of the planetesimal hypothesis might be given in W. M. Davis' words: "But today the confident acceptance of the earlier view [the Nebular or Laplacian Hypothesis] is shaken by the introduction of a very different concept, according to which the earth has been built up slowly of scraps of cold matter - planetesimals - loosely at first, when its mass was small and its gravity was therefore weak, more compactly as it grew to greater and greater size and the cold exterior weighed down more heavily on the cold interior; more compactly still when the increasing outer parts crushed the inert inner parts and thereby generated a growing store of interior heat, thus providing for a beginning of the various processes of vulcanism. Eventually, as the present size of the earth was approached and reached, volcanic eruptions became powerful and frequent enough - as they still are - to expel great volumes of gases from the interior and to pour out vast floods of lava; and in so far as

these gases include water vapor, a large part of it cooled and condensed in clouds and fell as rain; then - as was also supposed in the earlier hypothesis - the rain water gathered into streams and, even with greater fluidity than the molten lava, ran down the slopes of the lands and spread out with a level surface in the primitive depressions. Thus explained, the oceans began to form from a supply of interior or teluric water, not of exterior or atmospheric water; and thus they have continued to grow to greater and greater volumes through the geologic ages; thus they may, according to the later hypothesis, be growing still. It is impossible to say which one, if either, of these explanations is true; but in this sort of long-range archery, it is well to have two strings to one's bow."

III. Origin of life.

A. Chief theories:

1. Spontaneous generation as described in Milton's "Paradise Lost" and formerly almost universally accepted. This theory now is rejected by almost everyone because of the work of such men as Redi and Tyndal.

2. Cosmic pangenesis as described by Richter in 1865 and amplified by Arrhenius in 1908 that the spores of life were pushed to earth from some other planet by means of molecular bombardment of light rays.

3. Primal spontaneous generation on earth while the sea was yet nyoung. Certain chemicals may have come together in colloidal state and gradually developed into an almost living thing as exemplified by the "chemical seed". Such structures may then have evolved into living organisms similar to some known today. Up to this point we have been indulging in rank speculation. We don't know

how the oceans originated, but we have an idea as to how they may have originated. We don't know how life on this earth arose but we have at least tried to explain its inception. The fact remains that we have an ocean and life in it. Let us now proceed to a study of the two.

IV. The ocean.

~~A. Physical features.~~

A1. Size.

a. The sea covers about 71% of the earth (or 140,000,000 sq. miles out of 197,000,000 square miles).

b. The average depth is about 2.5 miles, while about 60 great abyssal deeps with a depth of over 3000 fathoms occur (one fathom is 6 feet.)

1. In the northwest Pacific lies the Challenger Deep of 5269 fathoms, while north of Hawaii is the Murray Deep.

2. North of the Philippines lies the Swire Deep of 5348 fathoms (or over 6 miles). Of this Murray says: "If the highest known mountain (Mt. Everest, 29,002 ft.) could be placed in this area of the Pacific, its summit would be covered by the waters of the ocean to a depth of 3,087 ft."

c. The bottom of the ocean does not necessarily slope gradually from the land to the great deeps. Certain more or less definite areas may be noted:

1. Continental Shelf: This comprises the area bounded by the shore and a depth of 100 fathoms. It has been divided into two regions:

a. Littoral Region or Strand, which lies between high and low water mark, is the most important area because

here marine organisms evolved into terrestrial forms.

1. The area comprises only 62,500 square miles and is very narrow, and thus competition is correspondingly keen. For that reason the animals surviving ther there today are heavily armored as exemplified by clam and other molluscs, crabs, sea-urchins, star-fishes, horse-shoe crabs, etc.

2. The area is alternately exposed to air and to water with each tide so that organisms were obliged to adapt themselves to radical changes which in many cases prepared them for later terrestrial life. This gradual change to land organisms can still be observed:

   a. Algae of the strand region are usually hard and leathery or have mucilagenous covering for protection from dessication. In some regions, the common Fucus or Bladderwrack of the Atlantic Coast has even crept onto the saltmarshes which are covered only at spring tide to grow with vascular plants.

   b. Sea-urchins, star-fishes, and many molluscs like the opii are exposed at low tide without inconvenience while many crabs like the sand crab and rock crab live most of their lives above high tide level

b. Shallow Water Area, which lies between low tide region and the end of the continental shelf which usually occurs at 100 fathoms. This area for the world amounts to about 10,000,000 square miles and is the great feeding

ground of fishes and whales.

2. Intermediate Slope constitutes the part of the ocean bed from 100 fathoms to 1000 fathoms.

3. Profound Abyss comprises the ocean bottom below 1000 fathoms. Here the deeps occur.

B. Temperature.

1. Heat from the air and sun penetrates to about 250 fathoms; thus the bulk of the sea water is relatively cold.

2. The surface temperature is automatically regulated for if the temperature rises, then greater evaporation checks the rapidity of the rise. If the temperature goes down, fog forms and checks further radiation.

3. Murray writes: "At the depth of 50 fathoms it is probable that the temperature does not change by so much as 2° F. at any one place through the year; and below the depth of 100 fathoms, there is no evidence of any annual change of temperature whatever. The temperature below 500 fathoms is below 40° F. This includes about 87% of the entire ocean." In the great deeps it is a little above 32° F. or even 30° F. (-1° C.). The ooze dredged from the ocean floor is so cold that it cannot be handled without discomfort. This cold is largely due to the fact that cold water is the heavier. Thus the water that is chilled in the frigid oceans near the poles sinks and creeps very slowly to the torrid zone, where it must slowly rise.

4. The only basins that have not at the lower depths these cold waters are the enclosed mediterraneans like the classic Mediterranean between Europe and Africa, the American mediterraneans like the Caribbean Sea and the Gulf of Mexico, and several others

in the Australasian region. The deep water of these basins, instead of being frigid, is only as cold as the open ocean at the level of their deepest entrance.

C. Pressure.

1. At 2500 fathoms the pressure is 2.5 tons to the square inch. A log of wood becomes thoroughly waterlogged when put down. A corked bottle shivers to fragments through implosion. Deep sea fishes, if they become fool-hardy and swim up to an unaccustomed level, may "tumble upward" and finally explode.

2. According to W.M.Davis "Water is, moreover, so little compressible that the ocean is of almost uniform density from surface to bottom; in this respect it contrasts strongly with the gaseous atmosphere, which is so easily compressible that, while its lower layers are dense enough to permit seeds and sailing vessels to be propelled by the winds and to support birds and airplanes if they move rapidly enough through it, its upper layers are like a vacuum in their extreme tenuity. On the other hand, in spite of the pressures of two, three, or four tons to the square inch that are exerted at the greater ocean depths, the bottom water is only about as much denser than the surface salt water of the ocean is denser than the fresh water of lakes. Hence any object that is heavy enough to sink at the ocean surface will pretty surely reach the bottom; the old idea that even an anchor would cease sinking when it had descended to a depth where the water is compressed to the density of iron is a fable."

D. Composition.

1. The amount of salts dissolved in seawater varies to a slight degree. The average amount of salt, however, is about 35 grams

per 1000 cc. of sea water. This is of course the same as 3.5 lbs., of salt per 100 lbs., of sea water. If concentrated, the sea salt would amount to about 4,800,000 cubic miles. This would be sufficient to cover the whole United States 1.6 miles deep. It is computed that the amount of sodium now in the sea would require 80,000,000 to 90,000,000 years to accumulate.

2. The composition of sea salt is about as follows:

$NaCl$	(sodium chloride)	77.8
$MgCl_2$	(magnesium chloride)	10.9
$MgSO_4$	(magnesium sulphate)	4.7
$CaSO_4$	(calcium sulphate)	3.6
K_2SO_4	(potassium sulphate)	2.5
$CaCO_3$	(calcium carbonate)	0.3
all others		0.2

3. Naturally the seaxwater contains more salt in land-locked areas with much evaporation. In the Mediterranean there are 38 grams per 1000 cc., and in the Atlantic 36. On coasts with many rivers this amount is decreased, andvthe fresh water being lighter floats on top of the salt water. One or two interesting cases are known in which mariners have been able to scoup up a supply of drinking water from the surface of the ocean after a heavy tropical rainstorm. But the salinity is usually greatest at the surface due to evaporation.

4. The salts of the sea have of course been derived by the age-long leaching of the earth. The CO_2 of the sea has been in part absorbed from the air, and in part from submarine volcanoes. O comes partly from the atmosphere and partly from photosynthesis.

5. In addition to salts sea water contains dissolved gases, chiefly air and CO_2, whose amounts vary according to temperature and depth, and accordingly in the past as the ocean has been under glacial or warm climates. Roughly, as an average, we may say

that each liter of sea water contains about 20 cc. air, which is much richer in oxygen than the atmosphere, and about .045 grams of CO_2. The importance of these gases is very great, for upon the supply of oxygen depends the life of the organisms in the sea, while the CO_2, whose total quantity is at present about 20 times that in the atmosphere, acts as a regulator of the amount in the air and the amount in the air determines the temperature to a certain extent.

6. There is an interesting correspondence between the salts in the sea and the salts in mammalian blood:

	SEA	BLOOD
Na	30.6	39.0
Mg	3.8	0.4
Ca	1.2	1.0
K	1.1	2.7
Cl	55.3	45.0

Bayliss explains this in the following words: "When vertebrates with a closed circulatory system took to the land, they took with them a blood of the same composition as regards salt as the sea water which they left behind."

E. Penetration of light.

1. Much light is reflected by the ocean as all know by the glare from the surface. The heat rays are absorbed in the uppermost layers. Then follow the red rays through the spectrum till finally blue and ultra-violet remain. With a delicate apparatus, Murray found that at 1700 meters in the Atlantic there was no effect on a photographic plate. But considerable light penetrates to 1000 meters. This then constitutes the diaphanous region. Below this comes the aphotic region.

2. Heiman Fol, a Swiss naturalist, experimented in a diving dress

off Nice. At 10 meters, the sun disappeared; at 30 m. the light was so bad that it was difficult to gather animals on the bottom; he could see stones at 7 - 8 m.; shining objects at 25 m. Dark red animals looked black to him, green and blue-green algae appeared lighter. This is explained by the absence of the red rays.

3. A common method of studying transparency is to lower white discsn noting the depth of disappearance. Detritus and plankton often hinders visibility.

F. Bionomic divisions.

1. Nekton is the collective name for the actively swimming organisms of the sea such as fishes and whales, while plants are wanting in this group. To offer as little resistance to the water as possible, such organisms possess the torpedo shape.

2. Benthos pertains to the organisms at the bottom of the sea such as barnacles, sea-urchins, and the seaweeds attached to the bottom.

3. Plankton may be defined as those organisms, either plant or animal, which float freely in the water but are unable to regulate effectively their own location. Many of them exert movements of their own which permit them to change their level in the water or to approach or move away from objects. Yet these movements are actually so insignificant that the plankton is dependent upon wind, waves and currents for dispersal.

4. a. Historical: The first to use the microscope on these sea organisms was the famous Danish zoologist O.F.Mueller who in 1777 described Ceratium tripos, a phosphorescent plant belonging to the Peridineae or Dinoflagellates. Ehrenberg followed and did much work on species, their significance as sea food,

and their structure. A regular gold mine of rare forms was four found by various investigators in the intestinal canals of Salpae - some so minute that they can be captured only with difficulty. In 1883 von Stein published the first monograph on the Peridineae, based chiefly on specimens taken out of Salpae. The plankton constitutes a wealth of life more abundant than is contained in the richest and most luxuriant forest. The Challenger Expedition (1872 - 1876) with a staff of scientists did an enormous amount of work. They went around the world and made physical and biological observations. The results were published in fifty quarto volumes by the British Government. Other scientific expeditions have been launched since from America, France, and Germany. After 1885 the Prince of Monaco worked constantly until his death a few years ago. Other workers were Nansen, Agassiz, Anton Dohm, etc. About 1880 Hensen introduced the term plankton. He tried to calculate the amount of pelagic organisms by drawing nets vertically through the plankton zone of about 200 meters, determining the species, rates of increase, etc. But Hensen's nets did not capture the smallest of the plankton, called nannoplankton, which will be mentioned more fully later.

b. General biology and classification according to form: The pelagic algae exist in countless myriads of minute individuals Though invisible to the naked eye, they are often highly organ ized and remarkably fitted to their mode of life. Surrounded by food materials on all sides and exposed to light throughout the photic or diaphonous zone and being protected by their tininess and often transparency, they are admirably fitted

for their environment. As their density is greater than that of sea water, they are kept from descending either by their own exertions or by suspension organs or even oil drops. The phytoplankton includes chiefly the diatoms, peridineae and brown flagellates as well as a few green and blue-green algae. These will be discussed later in their appropriate places. S Schuett, a member of Hensen's Plankton Expedition of 1889, classified these forms under,

1. The Bladder Type, or Sphaeroplankton of Ostenfeld: These have comparatively large cells while the wall and protoplasm are merely thin membranes around a central vacuole filled with sap of about the same specific gravity as sea water. Coscinodiscus, shaped like a drum, is a representative diatom, while C. rex is over a millimeter in diameter and is quite common in the warmer Atlantic. Halosphaera viridis is a green globe which in masses forms the piente verdi of Naples fishermen. Pyrocystis noctiluca is a phosphorescent form.
2. The Ribbon Type: Here the surface is enlarged owing to the cell being flattened into a plane which is often bent or twisted. Here belong such diatoms as Melosira and Fragilaria.
3. The Hair Type: The cells are much prolonged in one direction or united in narrow elongated colonies. Thus there is great friction produced with the water. This type is very common.
4. The Branching Type: These possess hair-shaped or lamelliform outgrowths.

c. Geographical distribution and kinds of marine plankton.

1. The organisms constituting the plankton vary in the same locality at different seasons. Cleve, a Swedish student, believed that the differences were due to changes in the currents which swept new forms in from special provinces. Thus in the Skagerrack from February to April there appeared species which we connect with the Polar Sea. From May to June the plankton resembled that of the Western Baltic. During the summer and autumn first came the North Sea species and afterwards Atlantic forms. Cleve's view was wrong: These changes depend on light and heat. Certain forms rest as spores through unfavorable conditions although some of course may be swept in.

2. Neritic plankton is a term first used by Haeckel for plankton of coastal waters. A whole series of species belong here and these occur in myriads. The reasons for the occurrence of neritic species are lesser salinity near the shore and more food as this is washed in from the land. Then also, some have resting spores that remain at the bottom of the shallow seas. A species which begins spore formation disappears shortly afterwards from the surface layers. Neritic species are often met with far from land where they still continue to increase slowly. North of the Shetland and Faroe Islands is an area well known for its neritic diatoms. These last are borne in by snow water currents. In the Polar seas during the summer close to the melting ice, a rich flora of neritic diatoms occurs which forms a brown layer over the floes. Often as they get away from the land, the neritic forms become weak and simpler in

form. Away from the land they never seem to form auxospores and thus finally perish. Strong neritic forms, however, may sporulate even in the open sea. One might think these spores would be lost, but it would require months for them to sink. They are so small that they are rarelt caught in nets. They may be detected by means of the centrifuge. In a liter of water from lat. 46° 48' N., long 27° 46' W. (north of the Azores) from a depth of 100 meters Murray secured 1160 resting spores of three species of Chaetoceras though the species were not present in any part of the area. Neritic phytoplankton is largely diatomaceous while oceanic plankton is mainly composed of peridines and coccoliths. In a broad way, the neritic algal species can be divided into arctic, temperate and tropical species (with exceptions). The arctic species are mostly diatoms of which Thalassiosira is characteristic. These are characterized by long strings of short cylindrical cells united by a slime thread. In the densely populated areas of the north Atlantic, there are 3000 to 12000 individuals of different species in a quart of water. The temperate species are even more numerous. Chaetoceras didymus is most characteristic. There are many tropical species. Many of these have their northern limit the coasts of the Mediterranean. The antarctic species have been little studied although hardly a single species is common to both arctic and antarctic waters.

3. Oceanic plankton algae are of far wider distribution than are the neritic. Thus Ceratium species are hardly ever absent. These may roughly be divided into arctic, temperate

Atlantic and tropical Atlantic forms. Speaking of tropical forms Hjort says: "On this cruise (of the Michael Sars) we made acquaintance with the tropical Atlantic plankton in all its abundance. For a northerner it was most fascinating to study the many strange forms especially of peridinae. Every fresh batch disclosed species that were new or rare or else remarkable stages of development. The multitude of species was surprising though none of them was very numerously represented. Every day one might sit and examine some unique microscopical form which might be lost only too easily and consequently had to be drawn there and then." Using a centrifuge to collect all material in 300 cc. of water in one drop, Murray and Hjort found much of interest. Myriads of tiny forms appeared which normally pass through the finest silk nets. These are most abundant in the open sea while large diatoms and peridines are scanty - about 10 per liter. Plant life below 100 m. is extremely scanty. The maximum lay at about 50 m.; at some 1100 feet it ceases entirely. In general then:

1. Plankton is less abundant in the open sea than in coastal waters.
2. Plankton is less abundant in tropical than in temperate seas.

d. Limnobiotic or fresh water realm and its plankton.

1. The limnobiotic realm involves the study of rheology and limnology. Rheology is the science of flowing bodies of water; limnology is the science of static bodies of water This refers to fresh water only. In flowing water the life

varies inversely with the rate of flow. This has not been studied very much, the whole science being barely fifty years old. Rheology includes all gradations from a rill to a river. In static waters the grades vary from a puddle to a lake - a microcosm of the ocean. This is the most complicated inland environment. A lake is only a temporary body of water because the stream that flows through it tends either to fill it up with detritus or to cause its drainage by lowering its outlet. Temporary bodies of water are naturally inhabited by forms which reproduce rapidly, and during unfavorable seasons can pass into a resting state (Spirogyra, blue-greens, diatoms). Bodies of water on poor soil are usually barren. Wide stretches subject to river overflow produce the richest flora and fauna. Lakes produce a great variety of ecological conditions depending upon the kind of bottom, shore, islands, depths, etc., chemicals in water, exposure to wind and sun, inflow and outflow, sediment, vegetation, etc.

2. Big lakes produce an immense amount of plankton. This is artificially divided into the net-plankton (taken in the plankton-net of bolting cloth) and the nanno-plankton to which Lohmann sets an upper limit of 25 mu. These pass th through the finest silk gauze and must be filtered out of the water or centrifuged. Filters are not so good as they become clogged. A machine making 2500 revolutions per minute will produce a sediment in 5 - 8 minutes. 15 cc. of water is usually enough. The organisms are then transferred to a counting cell. This nanno-plankton (Lohmann 1911) consists

of flagellates, algae and bacteria. The number and variety is astonishing. Even in clear alpine lakes Ruttner says they stand in a ratio of 160 to 3 to the net plankton and at least two-thirds of them are still undescribed and difficult to include in known genera. The maximum number yet found is from Lake Mendota, Wisconsin, where Cyclotella was found to number over 30,000,000 per liter. Ruttner calculates the volume in the Lunzer lakes as three times the net plankton. Birge and Juday say that the weight in dry organic matter from three Wisconsin lakes is from 15 to 20 times the weight of the net plankton to 5 to 6 times of the nanno-plankton.

3. The net plankton is collected in nets of fine bolting cloth. (For more details see Ward & Whipple.)

4. Plankton organisms are transparent, delicately colored, and buoyant due to their form or by containing gas or oil. Heavy walls and shells are wanting. They bear floatation organs such as wings, bristles, spines, parachutes, spiral threads, or gelatinous covers.

5. No climate is too rigorous for plankton organisms. They are are found in fresh water lakes at 77° N.L., which are hardly if ever free from ice, with a maximum temperature of less than 2° at the bottom. The shackelton expedition describes an extensive microfauna and flora at 77° 30' S.L. from lakes frozen solid for many months, often for several years. At the other extreme comes Cypris, a crustacean, which is recorded from hot springs at 50° C., while ciliates and rotifers occur at 65° C., and oscillatoria and nostocs

at 70 - 90° C.

6. Plankton cannot exist in young streams as these are too turbulent. Some deep lakes produce a bottom "fauna relicta" composed of types related to marine forms. These are often regarded as a survival from times of oceanic connection. The limnetic life is far less varied than the marine. This is due to the severity of the fresh water conditions, currents, newness of such bodies, and today sewage, factory and mine wastes, etc. "Streams below great cities and in mining and manufacturing districts are aquatic deserts."

7. Fresh water life is quite uniform over the earth. Europe, North America, and even islands show a close affinity. This is most evident among the Protophyta and Protozoa. This is probably due to their dissemination with dust.

e. Cryoplankton or the organisms of ice and snow. These are of course allied to the true plankton. Sometimes they occur in such numbers as to color the snow. All these plants seem to be devoid of any special protective device against the cold or to drying out, and lie exposed for months. During most of the year they are frozen in ice and snow and exposed to the dark arctic night. As the snow melts, they vegetate in water with a temperature scarcely above 0° C.

1. Red snow is the commonest. It varies in color from blood red to rose red, and brick red to purple brown. It is most often caused by Chlamydomonas nivalis which may color the snow to a depth of a few centimeters. Other plants that color the snow red are Gloeocapsa sanguinea, Uerasterias nivalis, Pteromonas nivalis, etc.

2. Brown snow: This is frequently caused by the desmid Ancylonema Nordenskioeldii which contains violet cell sap and, with other algae and mineral matter, absorbs sunlight and so melts cavities. In company with it live Pleurococcus vulgaris, Scytonema gracile, Diatoms and other algae.

3. Green snow: This is usually due to desmids, also Raphidium nivale, blue-greens, moss protonema, and green Chlamydomonads. Yellowish green or bright yellow snow is tinted by another alga, possibly Chlamydomonas flavivirens, which occurs frequently in the Carpathians.

e. Economic importance:

1. vOf course the great economic importance of all this is that pelagic phytoplankton is the sole food supply of pelagic animals. Salpae have stomachs filled with coccoliths, peridines and diatoms. Their number is so great that Stein could write his original monograph on peridines contained in the stomachs of Salpae. Copopods are, however, the chief consumers of these minute organisms. We know most about their food from a study of their excrement which is brought up abundantly in nets. This is composed chiefly of coccoliths, peridines, and diatoms. Animals sometimes seem to far outweigh the plants of the plankton. Foraminifera and Radiolaria occur in numerous species and in enormous quantities. Haeckel described 4318 species of Radiolaria taken by the Challenger. In one of his hauls from 4475 fathoms in the Pacific, 338 species were found. Brooks speaks of coursing two weeks along the edge of the gulf stream surrounded by an army of brown medusae (Linerges mercutia) to a depth of

50 to 60 feet. They drifted by for more than 500 miles. S Similar crowding occurs among the nekton, or actively swimming organisms. Mackeral schools have been seen in a windrow of fish one half mile wide and twenty miles long. Herring banks are almost solid walls. In 1879 three hundred thousand river herring were landed in one haul at Albermarle Sound. Copepods occur in red swarms. The Challenger steamed for two days through a cloud of a single species. Such masses may be a mile thick.

2. Not many years have elapsed since science began to realize the importance of this drifting life of the sea. "The occurrence of plankton in natural waters has a definite and direct bearing upon the occurrence of fish life. Algae and protozoa and organisms play an important part in the cycle of changes which extend from the decomposition of organic matter by bacteria to theffood supply of man..... The protein products of metabolism are consumed by bacteria; bacteria are eaten by protozoa and the nitrate formed by bacterial action in the presence of oxygen is utilized as food by algae; algae and protozoa are consumed by rotifers and crustacea and these latter form the basis of the food of many fish. Some fish are provided with special mechanisms for straining the plankton from the water, a notable instan stance of this being the menhaden, a salt-water fish which swims with its mouth wide open. The water enters through the mouth and passes through the gills, while the organisms that are thus removed are carried to the stomach." "Experiments at Woods Hole, Mass., have shown that the abundance

and size of the menhaden are closely related to the abundance of plankton." (Ward & Whipple.)

3. Many planktonic organisms get into the water supply and often make it quite objectionable for drinking because of their odors. These are due to ethereal oils. After these organisms die and disintegrate, this oil is diffused. The quality of the odor frequently changes with the intensity. If in small amounts it produces an aromatic odor; if in large amou ts it become fishy. The amount of oil required is small. Synura oil is recognisable with one part in 25,000,000 of water while oil of pepermint is recognisable in 50,000,000. The following table of odors is interesting:

Aromatic Odor:

DIATOMACEAE

1. Asterionella	Aromatic - geranium - fishy
2. Cyclotella	Faintly aromatic
3. Diatoma	Faintly aromatic
4. Meridion	Aromatic
5. Tabellaria	Aromatic

PROTOZOA

1. Cryptomonas	Candied violets
2. Mallomonas	Aromatic - violets - fishy

Grassy odor:

CYANOPHYCEAE

1. Anabaena	Grassy & moldy - green corn
2. Rivularia	Grassy & moldy
3. Clathrocystis	Sweet - grassy
4. Coleosphaerium	Sweet - grassy
5. Aphanizomenon	Grassy

Fishy odor:

CHLOROPHYCEAE

1. Volvox	Fishy
2. Eudorina	Faintly fishy
3. Pandorina	Faintly fishy
4. Dictyosphaerium	Faintly fishy

PROTOZOA

1. Uroglena	Fishy and oily
2. Synura	Ripe cucumbers - Bitter and spicy taste
3. Dinobryon	Fishy like Fucus
4. Peridinium	Fishy, like clam shells.

G. The character of the ocean floor.

1. Origin of sediments.

a. Land sediments which have drifted 150 to 200 miles away from the continent but rarely more.

b. Volcanic dust and pieces of pumice from eruptions which may either float in the air or in the water for thousands of miles before sinking to ocean floor.

c. Cosmic dust derived from shooting stars or meteors which the earth picks up in its journey around the sun.

d. Organic material such as the microscopic shells and skeletons of Diatoms, Foraminifera (chiefly of the genus Globigerina), Radiolaria, etc.

2. Kinds of sediments.

a. Blue and green muds found comparatively near the coast, as the continental slope, and derived from the finest land sediments. The green color is due to grains of glauconite composed of a silicate of alumina, iron, and potassium which forms in the sea.

b. Red muds found comparatively near the coast, as the continental slope of eastern South America, and derived from the land.

c. Calcareous ooze found away from land and derived from the skeletons of Foraminifera like Globigerina which settle down like rain from the diaphanous region of the ocean. This is especially common in the Atlantic.

d. Siliceous or Radiolarian ooze found away from land and derived chiefly from Radiolarians and Diatoms. This is found chiefly in the arctic where diatoms are very common, or in

very deep water because there the calcareous matter is more readily dissolved away by the larger percentage of CO_2.at those depths.

e. Red clay found in the deepest abysses and composed of volcanic ash and fragments of meteorites.

V. Review of the Thallophyta.

A. Myxomycetes or Slime-molds.

1. General characteristics: Nakedvindividual protoplasts, or cells, of the flagellate type all but during the spore state, which might be considered a cyst, dependent upon an almost aquatic environment. They are neither strictly plants nor animals but possess some of the characteristics of both.

2. Evolutionary significance: This seems to be an extremely archaic type of organism thatvapparently gave rise to nothing better - a cul de sac. Since they lack chlorophyll, weeneed not bother with them in our search for the evolution of the higher plants.

B. Myxophyceae or Blue-green Algae.

1. General characteristics.

a. Cell wall is very elastic and usually becomes gelatinous and swells. Its function is undoubtedly to enable the plant to withstand periods of dryness as the water is but slowly evaporated from such investments, and is very readily absorbed. Thus it forms a protective layer as well as a water reservoir.

b. Cell structure, although extensively studied by over 50 investigators, is little understood.

1. The outer central body is bluish green due to granules of phycocyanin and probably chlorophyll, while the inner is colorless. The blue-green color, in some cases, may be masked by other pigments. No distinct chloroplast exists as is found in other plants. Sugar is present due to photosynthesis but never starch.

2. The inner central colorless body is a true nucleus according to some scientists, no nucleus at all according to

others, while according to the most plausible theory it is an incipient or diffuse nucleus composed of irregularlyl placed granules of chromatin-like material.

c. Movement is observed in most filamentous blue-greens and especially is noticeable in Oscillatoria. The most important theories as to cause are the following:

1. Due to a fine pellicle or layer of protoplasm on the outside of plant which flows. The reason was advanced because the filament moves only if it touches the substratum.
2. Due to uneven growth of cells.
3. Due to minute cilia as in bacteria. This theory was advanced by Phillips who states he could distinguish them. But other investigators believe Phillips mistook parasitic bacteria for cilia.
4. Due to formation and explosion of a series of microscopic bubbles of gas similar to mechanism of automobile. This reason was given because movement occurs only when exposed to light.

d. No sexual method of reproduction is known for any blue-green.

e. Spherical or cylindrical resting spores, found in some of the higher types, are formed by the growth in size of a vegetative cell and the thickening of its wall. These can usually live several years under adverse conditions. In fact some one in 1846 sealed up a quantity of dry soil and put it aside. In 1912, or 66 years later, this soil was moistened. In a short while appeared a blue-green, Nodularia turicensis, which must have arisen from resting spores that had lain dormant for over half a century.

f. Heterocysts are found usually in the higher types. These are formed from young vegetative cells by the disintegration of the incipient nucleus and the gradual assumption of a homogeneous character by the whole of the cell contents. Neither their structure nor function is well understood. It is probable that the heterocyst has a historic significance as a reproductive cell. The blue-greens possibly have degenerated as far as a special method of reproduction is concerned and the heterocyst is probably the remains of that asexual reproductive organ.

g. Hormogonia, which are merely multicellular segments of a filament, form in many filamentous species to aid in disseminating the plant.

2. Evolutionary Significance.

a. Although they are commonly called Blue-green Algae they are not related to the Algae at all. Their only relatives seem to be the bacteria as the following evidence tends to show:

1. Neither bacteria nor Blue-greens have a definite nucleus, while both possess other features in common such as slime sheath, gliding motion, remarkable resistance to high temperatures, and internal anatomy.

2. There are several organisms which seem to bridge the gap between bacteria and blue-greens:

a. Beggiatoa mirabilis, a sulphur bacterium, could be considered a saprophytic Oscillatoria. The latter, in fact, has a tendency to be saprophytic and for that reason occurs so frequently in foul water where it can make use of decaying material such as drainage from manure, sewers, etc.

b. Clathrocystis rosea-persicina, a bacterium, seems very much like Microcystis.

b. Primitive cell organization.

c. The earliest fossils known.

1. Eozoon of the limestone of Archaeozoic Era may be a calcareous blue-green rather than a protozoan as was originally held.

2. Cryptozooan canadense, an undoubted blue-green fossil of calcareous rocks of Proterozoic time is composed of concentric layers of two different kinds of rock. We know that these were blue-greens because even today we find that certain blue-greens deposite calcium carbonate in their gelatinous sheath and this deposition occurs at varying rates, thus gradually building up a cabbage-like structure.

d. A study of evolution among the blue-greens gives us a clue as to how the many-celled plant and animal arose:

1. Chroococcus is obviously the simplest, each daughter cell being round and after a division minding strictly its own business.

2. Aphanocapsa is more highly evolved than Chroococcus becaus the daughter cells more or less remain together due to a common jelly, thus forming a very primitive colony having no definite shape.

3. Gloeocapsa is more highly evolved than Aphanocapsa because here we find that the daughter cells are firmly held together by jelly to form a colony of more definite shape.

4. Oscillatoria is more highly evolved than Gloeocapsa because its cells divide in but one plane and all the daughter

cells remain together to form a filament. Here apparently we find how a colony has evolved into a many-celled plant. We can say that the filament is probably a many-celled plant because it moves in definite directions showing that the cells work in unison. Here also we find the breaking up of the filaments to form hormogonia.

5. Nostoc is more highly evolved than Oscillatoria because many filaments build up a large filamentous colony embedded in jelly. It is also more highly evolved in so far that heterocysts as well as vegetative cells occur.

6. Gloeotrichia is more highly evolved than Nostoc because we get regularcellular differentiation into heterocyst, gonidium or resting spore, and vegetative cells that gradually taper toward the tip of the filament. Here also we find the most primitive type of branching called false branching.

7. Stigonema is more highly evolved than Gloeotrichia because its cells occasionally divide into two planes and thus give rise to true branching.

SUMMARY: The blue-greens apparently evolved as far as Gloeotrichia and Stigonema and could then go no further because they did not divide into three planes to build up a solid colony which would have given rise to different kinds of tissues. They also failed to evolve sex. So this is the end of the line - they gave rise to nothing better. Now we will have to turn to the true algae and see how they gave rise to the higher plants.

C. Flagellatae or Flagellates.

1. General characteristics: These are a very variable group of unicellular or at most colonial organisms, some of which are definite animals, some definite plants, while some possess the characteristics of both animals and plants. Here then we must search for the ancestors of the higher plants and animals.

2. Evolutionary significance:

a. Proterospongia Haeckeli is a colonial flagellate having for each cell a choana or collar-like contractile protoplasmic cup or rim surrounding the flagellum. The identical structure is found in the endodermal cells called choanocytes in the ampulla of sponges. Thus the sponges were derived from certain flagellates. The sponges or ancient relatives of the sponges in turn gave rise to the higher animals and to man.

b. Euglena, a unicellular flagellate, easily leads over to the green algae or Chlorophyceae, as we will see later.

c. Hydrurus, a colonial flagellate possessing a brown chromatophore PROBABLY gave rise to the brown algae or Phaeophyceae.

d. Rhodomonas, a unicellular flagellate possessing a red chromatophore, POSSIBLY gave rise to the red algae or Rhodophyceae.

D. Chlorophyceae or Green Algae.

1. These have undoubtedly been derived from the Flagellates through an organism like Euglena. In fact, so many organisms show intermediate characters that some authorities class them with the Flagellates while others class them with the Chlorophyceae.

2. General characteristics:

a. They are typical thallophytes or plants composed of a thallus This means that there is little or no differentiation of vegetative organs.

b. They contain chlorophyll and usually no other pigment to mask it.

c. The protoplast always has a distinct nucleus and one or more chloroplasts, this type of structure being retained by all the higher plants.

3. Evolutionary significance as indicated by certain species.

a. Euglena, though usually considered a Flagellate, is practically a green alga.

1. It is a unicellular motile organism possessing a red eye-spot, chloroplasts, pyrenoid, and a single flagellum.

2. It lacks sexual reproduction.

3. It can encyst, if the conditions become unfavorable, to become a spherical non-motile green cell.

b. Chlamydomonas, a true green alga.

1. It consists of a single cell bearing two cilia, a thin membrane investing the protoplast, a cup-like chloroplast, a pyrenoid, a central nucleus, two contractile vacuoles, and a red eye spot which apparently induces the plant to swim to the light. It is thus essentially a biciliated Euglena.

2. Here we get a clue as to how sex may have arisen. In asexual reproduction a few large zoospores arise identical to old Chlamydomonas cells. But occasionally a larger number of much smaller zoospore-like cells arise, called gametes. Each offthese is possibly too small and weak to develop into a Chlamydomonas so two of them unite and pool their resources and then develop into a typical Chlamydomonas cell. Thus hunger may be the origin of sex. Additional evidence that se sex arose from hunger is afforded by Kelbs' cultural studies

on Hydrodictyon. Whenever the plant was kept in a solution relatively free of available food it produced small gametes, while if kept in a solution rich in available food it produced zoospores.

3. Under certain conditions the cell may lose its cilia, secrete a quantity of jelly around itself and become quiescent. This zoogloea-like stage is called the Palmella stage. This temporary loss of motility in the vegetative cells of Chlamydomonas becomes the permanent condition in higher forms.

c. Pleurococcus.

1. This is a common alga found on tree trunks, etc. It is unicellular and round and resembles Chlamydomonas in the non-motile palmella condition.

2. Asexual reproduction is merely by the division of the old cell into two daughter cells, similar to method in Chroococcus, the Blue-Green.

3. Sexual reproduction is unknown.

d. Schizochlamys.

1. Here we find the beginning of the colonial habit induced by the formation of common jelly in which the individual cells are imbedded. The plant is reminiscent of the ancestral Chlamydomonas form by possessing a number of worthless and motionless cilia called pseudocilia. When the old cell divides into two daughter cells, the mother cell wall does not stretch but appears as two or more crescents in the common jelly.

2. Sexual reproduction is unknown.

e. Scenedesmus.

1. This represents a definite colony consisting of 2 to 8 cells lying side by side. The two end cells are somewhat different from those that lie between them, thus we have here the beginning of cellular differentiation in the Greens

2. Asexual reproduction is by the breaking up of the contents of each cell into smaller cells which arrange themselves and then emerge as a young colony.

3. Sexual reproduction is unknown.

f. Many multicellular algae have sexual reproduction similar to that of Chlamydomonas. Namely, numerous and smaller zoospore-like cells called gametes are produced which swim around for a time like a Euglena or Chlamydomonas and then unite in pairs. Since these gametes are all alike, the plant is said to be isogamous. The union of these isogametes is conjugation and the result is a thick-walled zygospore or zygote.

g. In many multicellular algae we find that the one gamete has become smaller and smaller and correspondingly more active. The other gamete, on the other hand, has become larger, heavily stored with food and consequently sluggish. A plant with a small microgamete and a larger megagamete is said to be heterogamous. If the megagamete has evolved still farther so that it has lost motility entirely, we call this kind of heterogamy oogamy. The union of heterogametes, namely a microgamete, male gamete, or sperm with a non-motile megagamete, female gamete or oosphere is fertilization and the result is an oospore. Thus we find that the origin of sex arose by the slow differentiation of the two gametes for a division of labor

the one being very active and without stored up food while the other is inactive and rich in stored food.

h. It is not difficult to imagine that some form of green alga with oogamy gradually built up a more massive multicellular body. With the formation of a multicellular mass, the internal cells would naturally be exposed to conditions that differed markedly from the superficial cells. This environmental difference would then induce cellular differentiation as well as cellular division of labor.

E. Characeae or Stoneworts: This group is composed of queer thallophytes found in fresh and brackish water. They frequently become encrusted with lime, a condition which no doubt is responsible for the common name of Stonewort. Their exact position in the plant kingdom is unknown. Some authorities classify them as Green Algae or Chlorophyceae, others believe they are related to the mosses, while still others believe they should constitute a group distinct from both Algae and Mosses but possibly distantly related to both of them. The common genera are Chara and Nitella.

1. Chara.

a. This is composed of a cylindrical stem or main axis which at regular intervals branches regularly to produce a whorl of usually 6 to 8 shorter branches. These in turn produce still shorter ones usually with an adaxial oogonium and an abaxial antheridium. Both the main and lateral axes grow in length by means of an apical cell. The main axis is regularly reinforced by the formation of a series of cells below and sometimes above the secondary axes which grow closely pressed against the main axis. The latter is thus enveloped by a

false cortex. The plant is attached to the mud by colorless rhizoids similar to the vegetative part of the plant in structure.

b. Asexual reproduction: No special asexual spores are produced.

c. Sexual reproduction.

1. Oogonia are formed adaxially or in the upper axil of the smallest series of branch-like filaments. Each oogonium is more or less egg-shaped and composed ofvan apical cell surrounded by 5 spirally would elongated cells. These converge at the tip and form 5 more cells that project beyond the oogonium. These are the crown-cells. The oogonium contains a single large oosphere rich in oil drops and starch grains. This develops into an oospore after fertilization by a sperm that enters through the center of the row of crown cells. Nothing like this entire organ is found in the plants previously studied. It does resemble, however, the female organ, called archegonium, found in the Mosses and Higher Plants.

2. Antheridia are formed abaxially or in the lower axil of the smallest series of branch-like filaments. These are spherical, their surface being composed of 8 triangular plate-like cells called shields. From the inner center of each extends a club-shaped or clavate cell called the manubrium. At its tip are a series of head cells and from each one of these extend two spermatogenous filaments composed of about 200 cells. Each cell contains a single sperm which is long, coiled, and biciliated. Each antheridium thus produces 20,000 to 50,000 sperm. Nothing like this

antheridium is found in the plants previously studied. Even the sperm are peculiar. They do, however, resemble more closely the sperm of the higher plants.

3. From the study of the reproductive organs of the Characeae we are entirely confused as to where these plants belong.

2. Nitella.

a. This plant lacks the cortical cells found in Chara.

b. This plant has ten crown cells instead of 5 as in Chara.

VII. The Psilophyton Flora, composed of the earliest land plants known.

A. Known only from the Silurian and Devonian. Because of their extreme age the fossils are usually very vague and indistinct. They have, nevertheless, been recognized in rocks in Scotland and Sweden. In spite of their age, a few were well-enough preserved to recognize the following characteristics:

1. Roots known to be missing in some kinds.
2. Stem with subterranean rhizome which bears rhizoids.
3. Unbranched or at most dichotomously branched.
4. In cross-section, stem has central cylinder of wood surrounded by phloem.
5. Sporangia cylindric, elatively large, terminal, isosporous. This terminal position of sporangia certainly differentiates them from everything else.

B. Families.

1. Rhyniaceae: neither leaves nor roots; subterranean rhizomes with rhizoids; special sporangium-opening mechanism wanting. Here belongs Rhynia Gwynne-Vaughani and Hornea Lignieri which latter differs by having tuber-shaped rhizomes and a sterile columella in the sporangium.
2. Asteroxylaceae: innumerable leaf-like emergences for assimilation on stem; it is thought that roots may be present on rhizomes; stomata at tip of sporangium seem to help as an opening mechanism. Common genera are Asteroxylon and Psilophyton.

C. This ancient Psilophyton Flora then is displaced by two distinct groups of plants or it may have given rise to one or both of them: Lycopsida and Pteropsida. The representatives of these two groups will be studied in greater detail later.

1. Lycopsida.

   a. These are characterized by innumerable minute leaves. They probably arose as emergences or "outpushings" of the outer 1 layer of stem tissue to aid in assimilation and photosynthesis.

   b. Representatives of this group are the Lycopods.

2. Pteropsida.

   a. These are characterized by a few large leaves. They probably arose as modifications of an entire branch system.

   b. Representatives of this group are the Ferns.

Lycopodiales

1. Lycopodiales
   a. Lycopodium, ops. ----
2. Selaginellales
   a. Selaginella ops. ----
3. Lepidodendrales
   a. Characteristics: 1. Only known as fossils in Devonian, Carboniferous and Permian.
   2. Usually 100 ft. trees bearing linear leaves toward tips which gradually fall off as branch becomes older, thus the entire trunk and older branches are beset with characteristic scars:

   3. Ligule present for each leaf.
   4. Stem with central strand of tracheids, sometimes with pith in center.
   5. Secondary growth in thickness
   6. Strobili at tips of branches.
   7. Heterosporous.
   8. Prothallia as far as known remain enclosed in spore.
   9. They had huge rhizomes or subterranean stems similar to the present lycopods. Since fossils are usually found in a fragmentary condition, these rhizomes were called Stigmaria as Stigmarian trunks in the belief that they belonged to a distinct group of plants. Now we know that the stigmaria are merely the rhizomes of lepidodendrales bearing special scars however an advantageous root had arisen.
4. Kinds.
   1. Lepidodendraceae – leaves in spiral arrangement and anatomical differences.
   2. Sigillariaceae – leaves in alternate rows, and anatomical differences

Bennettitales

A. Only known as fossils

B. Two great groups.

1. Bennettites usually sparingly branched, the leaves fern-like. Flowers or strobili bisexual, having ~~a single~~ megasporangia or sporophylls surrounded by innumerable fern-like microsporophylls. (see fig.)

2. Williamsoniella usually much branched, the leaves fern-like or more often simple. Flowers or strobili bisexual, frequently long-stalked, having ~~a single~~ megasporangia surrounded by relatively few microsporophylls, which are not fern-like and which bear only a few microsporangia or pollen sacs.

Ginkgoales

A. Known as fossils except for one species, Ginkgo biloba of China.

B. Ginkgo has definite staminate and pistillate flowers. One significant feature as ~~that~~ the pollen grain or microspore sends out a feeding tube into the megasporangium. This is the beginning of the pollen tube formed in all subsequent plants. After a while two motile sperms are liberated into the pollen chamber of the seed in which a drop of moisture has been secreted to simulate the ocean. Now the sperm can swim to the egg to fertilize it. This is the last time in the plant kingdom in which the individual in its autogeny returns to its planktonic ancestor. From now on we will find ~~that~~ the pollen tube goes direct to the egg and that the sperm does not develop but remains merely as a nucleus. This sperm nucleus then fertilizes the egg

Hillebrand

a. Campylotheca

1. Section Adenolepis
5 sps.

2. Section Campylotheca
7 species

Hoffmann

a. Bidens

1. Section A
2. Sect. B
3. Sect. C
4. Sect. Adenolepis
5 sps

A. Coreopsis

1. Sect A
2. Sect B
3. Sect. Campylotheca
7 species

Sherff

a Bidens

All Hawaiian spp

Brown

a Campylotheca

All H. spp

Hilkbrand using Campylotheca places 12 endemic species into it.

For his key to the genera he says:

1. Pappus of 1–5 retrorsely barbed or bristled awns or bristles:
   a. Achene beaked. Cosmos
   b. Achene not beaked, straight, with 2–4 barbed persistent awns. Bidens
   c. Achene not beaked, complanate, winged and straight, or wingless and curved or twisted, with 2 or 1 deciduous bristles which bear upright retrorse cilia, or naked; the style surrounded at base by an involate disk. Campylotheca

Under his generic description he breaks the group into 2 sections, namely Adenolepis and Campylotheca and says as follows: p. 211

lie near the micropyle a little root-like thread which enters the host as a haustorium and intimately associates its own tracheids with those of the host. The part of the thread still outside the host swells to a tubercle from whose under part arise adventive roots - but from ab[illegible] arises the flower stalk. The primary haustorium sends more outgrowths into the host which can new fl. stalks which from the roots arise new haustoria.

Lathraea Squamaria the toothwort. The seeds germinate in the earth and the young root fastens to a host to form a disc from which parasitic sinkers enter. Then the seedling grows into a great subterranean plant covered with curious scale leaves thickly set and a resemblance to a mass of branching open fur cones - pure white in color. Individual plants extending over a square meter and weighing 5 kg. are not rare. Finally the purplish inflorescences push through the soil.

The squamiform leaves of Lathrea are queer structures and were formerly supposed to trap insects but are now believed to be special water secreting devices. The blade is bent sharply back on itself so th[illegible] both upper and apparent under surfaces are really abaxial. The abaxial surfaces approximate and contain about 10 chambers. Thus there is a transverse groove at (a) into which open th[illegible] mouth of some 10 chambers - one shown in 2. These chambers do not communicate laterally. Each bears stalked glands and also odd shield like structures. Seem to be hydathodes. When water is forced into the rhizomes under pressure it gushes out the basal orifices of the leaves. Lathrea often lives where soil is soaked with water and this leaf device is a special structure where transpiration is impossible.

If Weinham is right then this family lies on another line that arose among primitive Scrophulariaceae and is characterized by the <u>primitive unilocular</u>, ovary due to fact that carpellary leaves are united only by their edges. By placental protrusion they finally attain to bilocular conditions. Conopholis is parasitic on oak. Epifagus on the beech - 2 kinds of fls. roots look like an old pine cone. Petaliferous above seldom give seeds, cleistog. below do. One more line of evolution can be traced from the advanced Scrophulariaceae. This is the line of the Selagineae - Globulariaceae.

The former are a group of Scrophylarians often woody with small leathery leaves and small zygomorphic aggregated flowers. St. 2 or 4. Anthers with loculi united to one. Ovary 2 loculed or through abortion 1 loculed. Fruit with 1 seed in each chamber and falling into 2 nutlets. [illegible]. Af. and Madag. The family has often been put with the Lamiales because of single ovule but it is pendulous not erect and basal as in [illegible]nta.

The Globulariaceae are closely allied but differ in having a [illegible]cular ovary with 1 pendulous ovule from the apex of cell. As we [illegible] locules of the Selagineae commonly aborts. B & H put Selagineae [illegible]ulanaceae in 1 family.

[illegible]riaceae

[illegible]ng off somewhere near the Orobanchaceae is this family to be [illegible]ized thus. U. herbs; fls. single or u. in cyme[illegible] Fls. [illegible]

[illegible]

placentae Fr. a capsule or berry. Seeds
5 sps. Monophyleae and Locophyllium they fuse.
y with marginal placentae is orobanchean, while the infer
ew feature. The flowers are usually very brilliantly
hairy habit is distinctive.

egetative organs of gives interesting morphol. features.
Sinningia speciosa ("Gloxinia" of Gardeners) Most genera too
scaly rhizomes which are of value in species determinations.

In the Cytandicideae there is a remarkable foliage reduction and a single great leaf which is really the cotyledon. The establishment goes on thus. The embryo fills the seed completely - there is no endosperm and the embryo gives hypoc. and 2 cotyledons. There is no bud and no root develops. The hypocot. penetrates the soil and swells to a corm fastened by rhizoids. Then adventive roots develop above and the hypocotyl dies. Meanwhile one of the cotyledons grows into a great leaf and the other dies. In flowering the stalk arises from the cotyledon stem just as do adventive shoots. The fruit is a long twisted pod.

The Gesneriaceae are tropic and subtropic. The Cyrtandroideae reach much devel. in Indo-Malay The family can scarcely be separated from the Scroph. Orobanchac and Bignon. In fact the Orobanches are only parasitic and leafless. Gesneriaceae - Only value as decorative plants Sinningia - the Gloxinia gives about 30 sps. wholly Brasilian. S. speciosa is much crossed with others. Achimenes, Isoloma, etc, are cultated. In 15th century and 16th century they were very popular.

Columelliaceae

Two species of shrubs that carry the Gesneri floral type a step further. Live in Andes Ecuador and Peru. P5+5 A5 G(5). The an have contorted shape like those or Cucuibi and the ovary is wholly inferior.

some The Columelliaceae with their shrubby habit would seem to be the of the old Gesnerian stock. They cannot have led to higher latter are not oligomerous in androecium.

Acanthaceae

This is a very advanced family - u. shrubby with fls. in cymes or racemes and u. conspicuous. Calyx or corolla 5, seldom 4 parted and latter u. bilabiate. St. 4 or 2, seldom 5. in first case didynamous. Staminodes u. bilabiate. Ovary superior 2 loculed and in each locule 2, seldom more or 1 ovule. Fr. a loculicidal capsule u. with retinaculae. No endosperm.

In more detail. The corolla is remarkably developed with long tube u. - when 2 lipped the upper lip may be upright, hollow and 3 toothed, or may fall and then a slit may run down the dorsal side of the flower. Lower lip either inrolled or more often spread out and 3 lobed - often hairy. In justicieae there is a groove in the upper lip which contains the style. Stamens vary. Peristemon acanthus gives 5, others 4 or 2. Often variations in different flowers of same sp. Thus in Barberia one finds 4 stamens, and 1 std; or 3 stamens and 3 reduced stamens and 1 std; or 2 stamens and 3 std. etc. The anthers are queer for there is a tendency to abort one side and further the sacs are oblique.

The pistil is often long. Fruit is u. capsular and loculicidal clean down to base. It usually bursts with violence and casts out seeds. Seeds large and flat. The Acanthaceae show affinities with the Thunbergieae among the convolvulaceae for these too give primitive retinaculae in capsules. Gray puts Thunbergia with Acanthaceae. One other point. In no family is there such a manifoldness in pollen shapes - holds for genera. Lindau classifies thus:-

1. Smooth round pollen with 2 or 3 pores.
2. Furrowed pollen - u. elliptic with three long grooves and pitted exine.
3. "Barrel stave"? pollen with broad stave like furrows with pores.
4. Ribbed pollen - Ribs run between poles with three pores at equator.
5. Studded pollen - and 6 more forms.

Almost all are tropic yet a few get into temperate regions. Dianthera americana I found in Pa. on river gravels. Various brilliant ones in cultivation. Otherwise of no value. Acanthus spinosus and mollis served for models for the Corinthian capitol - leaves pinnatifid.

Bignoniaceae - 500 sps.

So far all the Personalian families have been from the Scrophularian stock. With the next - Bignoniaceae there is an assemblage of primitive features recalling the more ancient apocynal condition. They are u. trees or shrubs or lianes, rarely herbs (Incarvillea) Chiefly of S. America. Many give compound leaves. Fls. u. brilliant in racemes or cymes. Corolla is almost regular. Stamens are four with a staminode (Catalpa gives 2 staminodes) while isomerous androecia occurs in 7 sps. Ovary [illegible] Fr. a capsule or septic or fleshy. Seeds without endosperm

Note then the primitive features.

Woody habit - almost reg. fls. 5 stamens in 7 sps. ovary 3 loculed and fr. even fleshy. Yet their affinities with Scrophs. is very close and must have come from same group. The lianes of the family are particularly notable. They climb by leaf tendrils which sometimes have discs like the Bnederas. Their wood is as a rule anomalous - being divided into wedges - often 4 at right angles to one another or a greater number may occur when cambium ceases to form wood at certain points (Prob. connected with leaf arrangement. Some seem to resemble young grooved oak twigs and due to same thing.) Tecoma and Catalpa.

Family Pedaliaceae

These are cut off because of herbac. stem and simple leaves and also because the capsule is cut up with false walls. Chiefly Africa. Mostly Xerophyles and strand plants. The fruits are often very odd and spiny.

Sesamum indicum of this family has been used for food for ages. In Sicily the seeds are eaten scattered on bread a custom mentioned by Theophrastus. Seeds very oily and not only seeds but expressed oil used for food, particularly for frying foods but gives one of most "horrific smells". Large quantities are imp. into Europe for adulteration of olive oil and for soap. Called benne or teel oil. Negroes of S. C. use seeds parched, boiled etc. Lns. contain mucilage.

Martyniaceae. Closely allied to Pedaliaceae and has the same horned fruit character. Ovary 1 loculed at first with 2 T shaped placentae which later grow together and gives a 4 chambered fruit. Exocarp of fruit is soft and soon decays.

LAMIALES OR DIOVULATES.

A small number of families- 3 only and of these 75% fall into the Labiatae. Keynote of the whole group is schizocarpy with one seed associated with a simple mericarp. This takes us back obviously to the Borage line. There are only 2 ovules in each carpel. The families are Verbenaceae, Labiatae, and Myporaceae. The Verbenaceae are most primitive, and many are trees and shrubs.- some with compound leaves. In some 14% the corolla is nearly regular and with isomerous androecium. About 80% have 4 stamens, while 8% have only 2. Even in the Labiatae diandry occurs in less than 85%. Hence in androecial features the Lamiales do not go as far as the Personales. The fruit is a drupe or dry fruit which may remain closed or open. In this fruit appear false walls which give rise to schizocarpy. There are 750 sps. A striking tendency is to aggregate the flowers into heads or spikes often associated with colored bracts.

Here stand Verbena of 80 sps. To make up the garden Verbena hybrids 4 sps. seem to have blended. We have several wild sps.- V. hastata is the blue Vervain, V. urticaefolia the white Vervain.

Lantana of 50 sps. also gives floral varieties: Callicarpa has shrubs with purple fruits- ornamental.

Tectona is the famous Teak tree of India. T grandis may be 28' in circum. and 80-90' high. Used in ship building and does not float until dry. Usually the trees are girdled down to heart wood, left standing for 2 years and then felled. Teak wood contains an/ oil which prevents iron from corroding. It is shipped in vast quantities to Europe and N.A. It is scarcely harmed by sea animals except Teredo navalis.

Avicanndas are mangrove plants which send breathing roots into the air, and are viviparious.

-Plantaginaceae. A very problematical and isolated family. B. and H. called it an "anomalous order". Engler puts it at end of Tubiflorales Warming puts among Personales. They are herbs and shrubswith insignificant flowers in spikes or heads. Flowers are ☆ and tetramerous. P4+4 A4 G2-4. In each locule 1-∞ ovules. Fruit a nut or a pix. Usually anemophilous. They look like a group specialized for insects,- they have long filaments, versatile anthers and powdery pollen. Verhan would derive from the Apocynal plexis.on a brunch cognate with the Polemoniales Perhaps the reduction to entomophily is due to geophilous habit. P major P. Rugelli are commmon. P. ariotata near Pratt Field. P. lanceolata on lawns.

Summary to Tubiflorae of Engler.
Tetracyclidae and Tubiflorales
Divided by B. and H. into Polemoniales, Personales, and Lamiales.
1. POLEMONIALES. Families. Convolvulaceae, Nolanaceae, Borraginaceae, Polemoniaceae, Hydrophyllaceae, and Solanaceae.
As an order characterized by actinomorphy and androecial isomery.
a. Convolvulaceae. habit, anatomy, flower structure, and relation to Apocynaceae: Dichondria- Ipomea batatas, I. leptophylla, I. panaurata, I. purpurea. Convolvulus sepium, C.arvense, Cuscoideae and seed germination.
b. Nolanaceae. As Dichondia derivatives. leading to the Borages.

d. Polemoniaceae.; As direct derivatives of Apocynal or Geranial stock. Cobaea, Phlox, Collomia, and mechanistic "growth". Polemonium.
e. Hydrophyllaceae: wide distribution- affinity.
f. Solanaceae- as transitional thru Salpiglossidae to Scrophulariaceae. Inner phloem and weak zygomorphy- Multiovulate line. Description of flower. False septal tendenvy and wall abortion. Androecial modifications. 2 groups of species based on embryo and stamens. Nicandra, Atropa Belladonna, Hyoscyamus niger, Physalis pubescens, P. Alkekengi, Capsicum annuum, Solanum floral features, S. melongena, S tuberosum and history. S. uporo, S. Lycopersicium, Mandragora, Datura Stramonium Petunia, Nicotiana, and Nicotine.
g. Salpiglossidae: As transitions to Scrophulariaceae. Schizanthus.

2. Personales or Multiovulatae: ./' and oligomery. ∞ ovules.
a. Scrophulariaceae: Flower and fruit. absence of inner phloem. Conventional separation from other families. Habit- parasitism. Pseudosolanae (Verbascum) as an interesting transition. Antirrhinum; Penstemon and Paulounia.
Rhinanthoideae and aestuation- semi-parasitism. Gerardia, Melampyrum, Digitalis, Veronica.
b. Orobanchaceae. Questionable afinity to Rhinanthus. Placental evolution within the family. Seed evolution of Orabanche, in germination. Lathraea Squamaria- ecology and odd leaves. Conopholis, Epifagus.
c. Lentibulariaceae: Derivatives from Scrophulariaceae. Utricularia. Habit. land and water forms. bladders. Flower structure. The unilocular ovary. Pinguicula insect traps and effect on milk.
d. Selaginaceae. Globulariaceae. Schizocarpy and ovule reduction. Globularias as end of line.
e. Gesneriaceae: Inferior ovary and 1 loculus. Orobanches as parasitic members brilliancy Rhizomes Cyrtandroideae and single leaf and its origin Gloxinia Achimenes Isoloma.
f. Collumelliaceae: As terminal epygynous members. anther character.
g. Acanthaceae: Convolvulaceaen affinity thru Thumbergioideae. Fruit and retinacula. Extreme floral features. Oblique anther and abortive sac. manifold pollen. Acanthus spinosus as model for Corinthian capital. Dianthera. Justicea.
h. Pedaliaceae: Departure from last family. Odd fruits. Sesamum indicum as a food plant.
i. Martyniaceae: Hooked fruit.

3. Lamiales or Diovulatae- schizocarpy and phylogeny.
a. Labiatae. Vegetative features. Zygomorphy and androecial reduction. fate of fifth stamen. Butterfly and bee types.
b. Verbenaceae. Habit and sub actinomorphy. usual stamen condition. Fruit aggregation. Verbena hybrids.
c. Plantaginaceae: Problematical position habit anemophily formula, fruit-

INFERAE.
RUBIALES.

The Inferae are in the van of evolution and have some 20,000 spe.; more than 1/2 the total number of the Sympetalae. They divide up into very natural groups. Their connection with groups already considered can be traced only thru an archichlamydean ancestry.
Under Rubiales Engler includes Rubiaceae (4500), Caprifoliaceae (350), Valerianaceae(215), Dipsacaceae(150).

In general the Inferae have: (1) Inferior ovary; (2) androecium isomerous with the corolla; (3) tendency to zygomorphy rare and when occurring is due to crowding, affects outer flowers of any inflorescence and is not accompanied by oligomery; (4) Ovary frequently composed of more than 2 carpels although tending toward 2. In this group the bicarpellary feature is progressive, not ancient and fixed as in the Tubiflorales.

Wettstein says: Flowers tetracyclic, corolla ♣ of ⅕, 4or 5 merous. Stamens of same number as petals or less. Ovary inferior, one or more loculed. 1 integument, leaves opposite. All these features point in one direction- to the Umbelliferae. The constant epigyny shows that already the ancestral polypetalous ancestor must have had it. Note too in the Umbelligerae the 1 integument, tetracyclic flower, analagous ovary, calyx, actinomorphy. " The ~~Umbelliferales~~ Umbellales represent a side branch from the calyciflora plexus. They realized complete epigyny and umbellate inflorescence with ovule reduction. Before the latter tendency was fully realized a side branch with sympetaly emerged to give rubialian stock."Phylogeny can be shown thus:

[illegible]IACEAE: 300 gen. 50000 spe.

Shrubs or herbs with decussate leaves with stipules. Flowers usually 4-5 parted. Stamens usually = to petals. Ovary u. 2 loculed, sometimes [illegible]. Ovules in each locule 1-∞, anatropous. Fruit a capsule or falling [illegible] 1 seeded nutlets or berry or drupe.

As can be seen this is rather a hetergeneous assemblage and may not natural. Warnham says it is a famil with extensive primitive evolutionary activity at work.

Noteworthy are the stipules which is really the only character that separates them from the Caprifoliaceae. These organ have 2 positions- either interpetiolar, where they stand on the sides of the stem between the leaves, or intrapetiolar, where they stand between leaf stalk and axis. [illegible] become leaf like and give the effect of verticillate leaves.

Some Rubiaceae are myrmecophilous. Thus Myrmecodia has its hypocotyl swollen into a great tubercle traversed by chambers. In their inflorescences some have entomophilous variations. In mussaenda, Calycophyllum, etc. a sepal becomes overgrown and attractive. Mannetia is probably ornithophilous. Tthis can be divided into 2 subfamilies.
1. Cinchonoideae. Ovary with many ovules.
2. Coffeoideae. Ovary with 1 ovule per loculus..

Wernham would split Rubiaceae into 2 families and set apart the Galiums Their weak herbaceous habit, insignificant flowers with reduced calyx and regular bicarpellary ovary, frequent reduction in their inflorescences, and specialized fruit makes a natural reduced group. Again their stipules are wholly different.

To go back to the sub families.
Cinchonoideae:
1. Fruit a capsule: Cinchona, all the sps natives of Cordelleras of S. Amer. but cultivated in Java, India, Jamaica, and Quinine is derived from several sps. C. officinales, C. Lancifolia, etc. Contains ∞ alkaloids; cinchonin, quinamin, quinin, hydroquinin aricin, disinchonin,
2. Fruit fleshy: Sarcocephalus sambucinus of tropical W. Africa is edible Gardenias are cultivated fro flowers.

Coffeoideae:
Most important is Coffea of which three sps. give coffee beans. C. arabica with home in Abyssinis; C. liberica, and C. stenophylla of Sierra Leone. Other sps. are locally cultivated. The first has been longest in culture and was introduced from Persia in the 15th century. Came to Constantinople in 1554. Natives of Africa chew the grains raw as a stimulant. For trade the seeds are freed of the fleshy pericarp and silvery skin. Green seeds contain about 1.2% of thein or caffein. Caffein causes the heart to beat more rapidly , is also a cerebal stimulant.

Cephaelis Ipecacuanha (Brazil) gives Ipecac, used as an emetic. Contains emetin.

Rubia tinctorum is a red dye.

Galium a genus of 250 sps. are mostly small creeping herbs. Fls. almost destitute of calyx and the fruitlets are nut like and sometimes provided with hooked hairs for dispersal.

Houstonia should also be mentioned. Genus increases southwest.

Cephalalanthus is the button bush one of the Coffeoideae. Lives on pond margins, clay and peats. S.N.B. to the tropics and up Miss. to Lakes. In Florida it becomes trees 40° high. On Block Is. also gives single trunks to 12°.

Caprifoliaceae

Position in relation to Rubiaceae can be shown by what Wernham says. 300 sps. almost all trees and shrubs and largely temperate. They merge into the Rubiaceae. Lack of stipules is the sole constant difference but this fails in Sambucus. Sambucus is sometimes called a transitional genus between the two families, but there is no gulf to be bridged. Sambucus has been suggested too, as a plant connecting up with the epigynous polypetalae.

The Caprifoliaceae have a strong trend toward zygomorphy. (Note Lonicera In most sps. the inflorescence is umbellate or capitate much as in the Rubiales and offers a continuous surface to insects. This is the the ancient umbellifloral inflorescence and the resemblance to Umbelliferae is height-ened bythe outer large sterile flowers (Viburnum Opulus). The whole inflorescence is tending to become the Biological equivalent of a single flower.

The ovary usually has 3 carpels but all save one often abort (Viburnum) Linnaea gives and interesting transitionfor there are 2 abortive carpels ovules in each of 2 loculi and only one in a third which matures. Similar in Symphoricarpus. While the Caprifoliaceae are trending to the unilovulate

Economically certain Valerians are used for salads. V. olotoria is the corn salad or Lamb's lettuce. V. edulis the tobacco root is the principle edible root of Indians who live on w. Rockies. It has a strong and offensive odor and peculiar taste - large, bright yellow. Baking converts to a soft pulpy sweet mass. V. officinales is the Garden Heliotrope Cat's valerian, or St. Georges Herb used in medecine.
Nardostachys Satamansi of India gives the perfume known as nard.

In conclusion though the family seems to simulate the Compositae yet it must be merely the independant working out of basic principles common to both- for zygomorphy and trilocularity of Valerians militates against their close relationship..

Dipsacaceae. (Scabiosaceae)

Now we have the climax of aggregation of the line and the individual flowers give 2 types of '/'.
(1) The ray flowers get their '/' as a resultof aggregation while (2) the disc flowers bring over the old entomophilous condition.

They are haerbs u. with opposite leaves without stipules. Flowers with an epicalyx and also involucre of bracts and stand in heads. Calyx 5-4 toothed. Teeth often bristly or absent. Corolla '/' 5-4 lobed (in last case the union of 2 parts.) Stamens 4 or less. Ovary 1 loculed and 1 seeded. Ovule hanging. Fruit and achene.
Flowers blossom from center out- congested cymes.

This represents the terminus of the line the 2 sterile carpels of Valerians have gone completely. Payer says a second carpel appears as a primordium. Just as in Valerian, the calyx assumes new role. Wernham says: "In a close inflorescence the mere crowding of the florets provides a source of mutual protection among them; and the calyx being no longer required for purpose of protection is pressed into the service of fruit dispersal." Wettstein says as to position: Trotz der grossen Ahnlichkeit mehrerer Gattungen (Dipsacus, Cephalaria) mit Compositen welche auf einem ahnlichen Baue der Inflorescenz, auf ahnlicher Ausbildung des Kelches und der Frucht beruht, ist an eine nahere Vernandschaft mit diesen nicht zu denken; die vernandschaftlichen Beziehungen zu den Ubrigen Rubiales sind klar."

The epicalyx of the Dipsicalian flower is an odd thing which envelopes the inferior ovaru. It may have arisen from concrescence of 2 bracteoles.

Warming divides into 2 groups.
A. With a scarious bract to each flower. Scabiosa has epicalyx a collar while its calyx is of 5 bristles. Dipsacus, the teasel, large spiny herb with capitula resembling composites. Epicalyx almost entire. Leaves unite in pairs and rain water collects.
B. Bristles, but no true bract to each flower.

Dipsacus heads used in fulling cloth. D. fullorum.
Scabiosa cultivated as " mourning bride"

ɒvided into 3 Tribes.
Lonicereae: Diervilla the bush honey suckle has its calyx tube pro... into bristle like lobes. Asian Diervillas are cultivated under the name of Wiegela, one pink and white form D. florida is common.
Lonicera- the honeysuckle has both bush and climbing forms. The latter often has connate upper leaves. Run S. Me. to tropics.
Symphoricarpos is the snowberry. S. albus is the common one. The ovary is 4 loculed the 2 median have ∞ ovules in 2 rows all of which abort, the 2 lateral ones have only 1 ovule each , and this develops.
Linnaea , named after the " immortal Linnaeus" is a trailing vine of Hudsoni -an and Canadian country.

Sambuceae: Corolla wheel shaped or urn shaped,regular 5 lobed- Stigma nearly sessile, Inf. terminal and cymose.
Viburnum Lentago the sheep berry of rich soils. Others V. dentatum, V. acerifolium. V. Opulus the high bush cranberry. marginal show fls. big red fruit an Crosses n. Europe , Asia, and reappears on the Pacific Coast. Var. americanum lives in e Asia and in Canadian zone. Used in drug business as"Crampbark", and berries are used for fruit. "Snowball" a sterile form. V. alnifolium the hobblebush has habit of natural layering same show flowers in cyme and red fruit.
Sambucus gives elder berries. S. canadensis and S. racemosa.
Triosteum (horse gentian) root gives a cathartic. Bark of Viburnum prunifolium (Black Haw) is used as a uterine sedative.

DIPSACALES.

Sometimes the Dipsacaceae and Valerianaceae are merged into Dipsacales. Their flowers are irregular and the loculi are reduced to 1 with a single ovule. They are herbaceous.

Valerianaceae: Leaves opposite and often pinnate without stipules. Fls. ⅂/; calyx and corolla u. pentamerous , but former in anthesis scarcely visible , later it increases. Stamen 1-4, ovary 3 carpeled and with 3 loculi but only one matures with a single hanging ovule and becomes a nut. (Observe composite features|) There can be little question but that these are the progency of the Caprifoliaceae. Centranthus has but 1 stamen and has a long spur.

The dotted line in both these diagrams represents a wa... tube, which divides it into two compartments, one of which the corolla ...vides-it-into 3 encloses the style.

...arises from concrescence

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INFERAE CAMPANALES.

The last and most advanced order of the Plant Kingdom. Most herbaceous. The fundamental tendency is approximation and syngenesis of anthers to give a pollen presentation mechanism. The anthers dehisce introsely and shed pollen into the tube formed by their union. The young style is clavate and as it grows it sweeps the pollen before it out of the tube. Later the stygmas expand and present a fresh surface for foreign pollen. Ultimately in many Compositae they may curl over, touch the anthers and so effect self pollination if cross pollination fails. Such is a tendency in Campanulatae.

A second tendency is aggregation of florets. The head are really congested racemes, in Dipsacaceae they are congested cymes. (This is a fundamental distinction between the two stocks) Again there is no tendency to an oligomerous androecium; even when zygomorphy enters as in Lobeliaceae there is no oligomery. Only exception is Candolleaceae with only 2 stamens fused with style to give and irritable gynostemum, comparable to Asclepiads and Orchids. From Wettstein may be added the following: The relationship of the Families is clear. Not only in morphological but in ecological features and in anatomical physiology. (Inulin, milk canals), The Campanulaceae represent the original types from which one line of development leads to the zygomorphic Lobeliaceae; another to the peculiar Composite inflorescence. With the other Sympetalae there is no phylogenetic relationship. Seeming relation to Dipsacaceae is due to convergence. Curbits had better be put with Parietales.

CAMPANULACEAE.

Herbs or woody. Perianth ⊕, rarely '/', and U. pentamerous. Stamens isomerous, free, but anthers show every degree of syngenesis from complete freedom to close union (Lobelias) Infloresscence typically a raceme with large flowers but tend to aggregation is seen in Jasione and Phyteuma. Ovary inferior 2-5, but u. 3 carpeled and 3 locular. Style beset with collecting hairs. Sometimes the ovary is half inferior, so the epigynous tendency is not fully realized- suggestive of a direct Rosalian derivation. Fruit u. a capsule with ∞ seeds. A considerable number are in cultivation for flowers , but otherwise their economic importance is small. The large genus is Campanula of 230 sps: C. rotundifolia and C. aparinoides, C. americana, - [illegible]ecularia.
Insert pollen presentation of Campanula.

LOBELIACEAE.

This family stands near the Campanulaceae, but is distinguished by zygomorphy and the anthers bound into a tube, thro which the hairy stigma moves and sweeps out the pollen. Futhermore the ovary is 2 carpelled. Engler reduces to a Sub-Family under the Campanulaceae. Gray defines as herbs with acrid milky juice, alternate leaves and scattered flowers, and irregular gamopetalous 5 lobed corolla, the stamens free from the corolla and united into a tube commonly by [illegible] Style 1; stigma often fringed.

2. General features: There are 8 genera and 170 species that throughout the warmer parts of the world. 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 tubers get to be half a yard long and are 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 XI,327) has its tubers covered with long thorn-roots; this is seen also in the palm, IREARTEA ferox. The tubers often show a remarkable phelloderm formation. Some of the species are monoecious while others are dioecious.

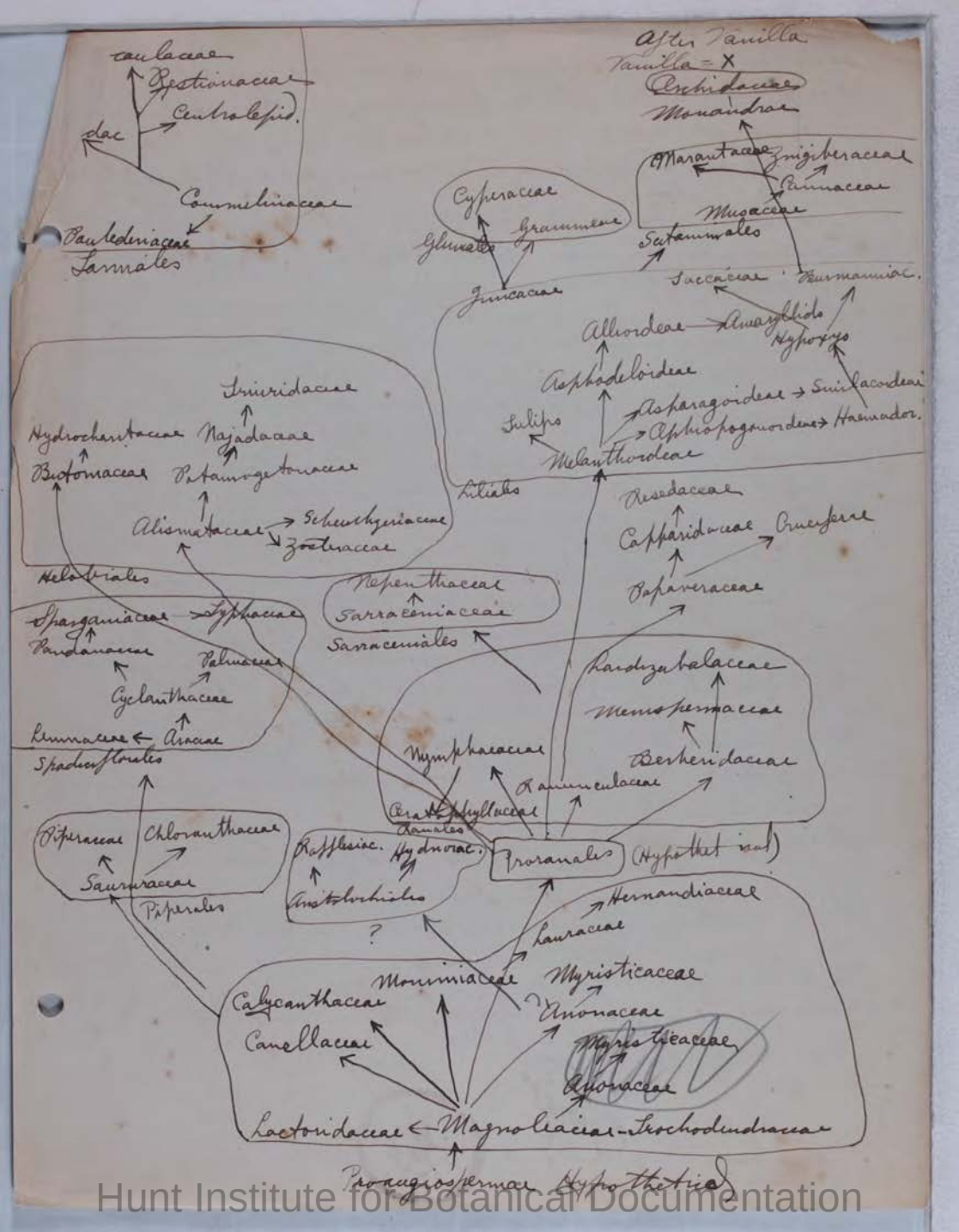
3. Genera.

a. DIOSCOREA is the largest genus. This gets into the United States and into China and Japan. There is also one in the Pyrenees with a close ally in Chili. Several species are grown in the tropics for the very starchy tubers. In the Fiji Islands some 50 varieties are cultivated and many weigh 50 - 80 lbs. D. alata is cultivated widely in the Indian Archipelago, in eastern Africa and in America. The Negro word yam means "to eat". Sturtevant mentions 25 species in cultivation. D. villosa, which really should be D. paniculata, is the only one found within the scope of Gray's Manual. It gets north to Long Island Sound although formerly it grew up to Boston.

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 around and 3 feet high.

ORDER SCITAMINALES.

(We begin to get now into the extreme members of the Monocots which show wild extravagances in floral structure. The small family TACCACEAE of 2 genera and 10 species have been especially puzzling to systematists. Jussieu puts them near Narcissus. R. Brown places them between the ARACEAE and the ARISTOLOCHIACEAE - the aracean idea based on leaves of TACCA leontopetaloides which resemble those of AMORPHOPHALLUS. Reichenbach puts them with the Aroids, while Masters sees a relationship to ARISTOLOCHIACEAE, SANTALACEAE and Aoids. Thus everyone seems to see both Mono- and Dicot affinities. But Baskerville puts them between the Aroids and the PANDANACEAE. Hooker puts TACCA with the BURMANNIACEAE, Clark and Baillon with the Orchids. They do seem to be related to the Burmannias. Both are epigynous and have parietal placentation, many small anatropous bitegumented seeds, and endosperm. But the TACCACEAE have only one loculus in the ovary. Pax says they form a bridge from the AMARYLLIDACEAE over the DIOSCORIACEAE to the BURMANNIACEAE. Lotsy would derive them from ASPIDISTRA among the ASPARAGACEAE and run over to THISMIA among the BURMANNIACEAE. TACCA pinnatifida is wide spread in the tropics, the tubers yielding arrowroot. The flowers have long bracteoles like threads. Thus it seems the plan of the inflorescence places them near the AMARYLLIDS but they differ in having a one-celled ovary. They seem also related to DIOSCORIA and run into the BURMANNIACEAE on seed features.)



Of the Polycarpicae (Protogenen of Hallier) we have left the Aristolochiales, Nepenthales, Rhoeadales, and Hamamelidales (and according to Bessey might be added: Malvales, Geraniales (with Amentiferae) Caryophyllales, and Rosales. All except the last two are blind alleys.

So we turn back to the Dicots and begin again with the Aristolochiales: Families: Aristolochiaceae, Rafflesiaceae Hydnoraceae and Balanophoraceae

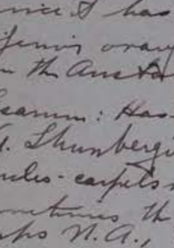
Hallier would derive from extinct Lardizabalaceae since he sees resemblances in stem structure of Aristolochia, Lardizabala, Menispermum, Clematis (that vine habit commonly → similar appearances). Wettstein derives from Polycarpeae without specifying where: the evident 3 partite flowers perhaps hint at Anonaceae which has the epigynous genus Eupomatia: The Aristolochiales have departed widely and have also undergone reduction. Lotsy says it gives him the impression that the group should be allied to the Araceae.

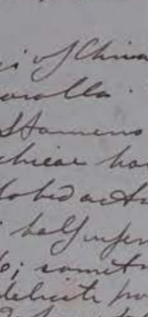
Aristolochiaceae: Herbs or shrubs or vines. Flo. perfect & sometimes ⊕ but usually zygomorphic. Perianth of 2 or 1 circles - and usually 3 parted. Stamens sometimes 36, mostly 6 and often bound with Gynoecium to → a gynostemium. Ovary of 6 rarely 5 carpels, inferior with ∞ marginal or parietal ovules. Seed endospermous. Fruit a capsule. Can see how suggests Nymphaeas to some in ∞ stamens and parietal ovules. Among actinomorphic sps comes Asarum; zygomorphic Aristolochia

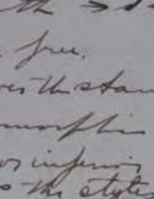
Saruma Henryi of China is a bit more primitive than Asarum since it has a corolla. Both → 12 stamens and a half-inferior ovary. Stamens are free.

In the Aristolochieae however the stamens free to → gynostemium.

Asarum: Has 3 lobed actinomorphic corolla with superior (A. Thunbergii); half inferior or inferior ovary. Stamens 12 in 2 circles - carpels w. 6; sometimes the styles are separate, w. fused. Sometimes the 3 delicate points of a corolla remain.
4 sps N.A., 7 Japan & Himalayas, 1 Europe.







Aristolochia: XXI

Has Gynostemium but resembles Asarum except in zygomorphy. Perianth tube is inflated around sex apparat. 80 sps.
Asarum canadense - wild ginger → asarin and a volatile oil used in perfumery.
Aristoloch. Serpentaria comes from Plato Ct. used in medicine - common name Virginia snakeroot shows that was used as antidote for snakebite. A. macrophylla of rich woods Pa - Ga is hardy as far north as Minn. and Wisc. Called "Dutchman's pipe". A. grandiflora var. Sturtevantii has giant flowers with a tail sometimes 3" long - putrid odor as Bailey says "the odor when in bloom beggars description". This is often exploited in the presses - the Pelican, Swan, Goose, or Duck flower and causes a run on greenhouses by public.
(Resumé: Origin somewhere among Ranales or Annonales. 3 partite flowers, resemble Anonaceae.
Aristolochiac: 2 sections (1) Actinomorphic with free stamens → Asarum = $P(3)+0\ A\ 6+6\ G\ \overline{(6)}$
(2) Zygomorphic and st. united to pistil

Rafflesiaceae

Close to Aristolochiaceae in simple perianth and central gynostemium. At least apparent relation. Wholly without chlorophyll, parasitic on woody plants, veget. tissue thallus-like and living wholly concealed in tissues of host - even reduced to mycelial-like threads, only seldom contain vasc. tissue. Flowers alone break out. On flower stalk occur scales like leaves. Flow. unisexual - Vary much among genera.
Rafflesia Arnoldi: The following description of the discovery was found after Arnold's death: "But here (at Pulu Lebbar on the Manna River, 2 days journey inland from Manna) I rejoice to tell you, I happened to meet with what I consider as the greatest prodigy of the vegetable world. I had ventured some way from the party, when one of the Malay servants came running to me with wonder in his eyes and said: 'Come with me Sir, Come! a flower, very large, beautiful, wonderful.' I immediately went with the man about a 100 yards into the jungle and he pointed to a flower growing close to the ground under the bushes, which was truly astonishing. My first impulse was to cut it up and carry it to the hut. I therefore seized the Malay's parang and finding it sprang from a small root which ran horizontally (?) and removed it to our hut. To tell you the truth had I been alone, and had there been no witnesses, I should, I think have been fearful of mentioning the dimensions of this flower, (a hand as large as 2 fingers, or a little more) I was detached

 ... had

ever seen or heard of; but I had dr Hamford and Lady Raffles with me and a Mr. Palsgrave, a respectable man, resident of Manna, who, though equally astonished with myself, yet are able to testify as to the truth."

And before opening deep red-inside of cup is intense purple and densely villous with soft flexible spines. toward the mouth it is mounted with ~~depressed~~ depressed white spots. The petals are brick red with many pustular spots of a lighter color. Has an unpleasant putrescent smell, Many things!

More technically: the 5 perianth leaves unite to form a tube: & boundary of this and limit is a flat disc. In middle lies the column with numerous stylar points. The united carpels. The inside of the flower tube is covered with nectariferous. On the underside of the diaphragm are many waxlike depressions and the sepals are also so covered. The column and perigon are 2 strongly developed annuli. The outer border of the disc is recurved to conceal the 5 stamens. The anthers pendulous - apical pore. In the ♀ fl. the underside of the disc margin is the stigma. hence disc is cup-shaped. On its inner border it carries the stamen rudiments. Ovary is very peculiar - a fleshy mass burrowed by irregular chambers covered with ovules. In section it looks like a tuberales fungus. The ovary seems to have originated by carpel fusion and the columns seem to represent the carpel points.

found in haunts of elephants - on ground covered with their dung. A can readily hamper upon elephant's foot.

Other genera of Rafflesiaceae are known such as Richthofenia a rare - called flower from Siam with a column like that of Cytinus hypocistis; Sepia from Himalayas 3000 - 5000'

Pelostyles Ingae grows on young twigs of a legume of the genus Inga in New Granada and Brazil. Others in Africa and Persia. Seeds eaten by birds - bird evaded. Cytinus hypocistis gets into Europe and lives on roots of Cistus sps.

Balanophoraceae

Heller writes these with Aristolochiales but perhaps on slight grounds. It is a remarkable family of parasitic plants. Only 40 sps are known but included 14 genera. Found in wet belt encircling the equator. In dark beds of primaeval forests where are parasitic on roots of woody trees.

Langsdorffia is a tropical American genus. Also L. Montezuma occurs in Venezuela and New Granada parasitic on roots of palms and figs. Found at 2000 - 3000 mr. Plant consists of a cylindrical stock sprouting from its parasitic root, felted externally like gauze. Thus stems which produce flowers are some 30 cm. long. All pale yellow. At extremity a bud develops and grows through cortex; inflorescence is surrounded by a whorl of imbricated scales - stiff, shiny and ranging from waxen yellow to red - whole inflorescence resembles a Helychrisum. The seeds when mature have mouths.

Embryo is an undifferentiated mass of cells. The seeds germinate and send down "search roots" which meet a host & embed themselves. They develop tubercles. The cortex of the host is destroyed and its woody tissue laid open, lacerated and unraveled. The roots and other cells of the parasite penetrate between those of the host so intimately in the relation that the parasite looks like a branch of the host. The stem of Langsdorffia is much wax called balano phorin, so much that the stems burn like wax tapers if lighted. They are actually collected and used for candles at Natal.

The Balanophoras occur in eastern hemisphere. B. elongata is abundant in Java on mountains of 2000 - 3000 mr. and is collected for wax. Almost all sps are vivid in color: yellow, purple, red-brown or flesh color - thus resembling the russet browns around them - no trace of showy. All early observers thought them coral-like marvellously beautiful flowers. Thus a famous member of the "nature philosophy" school says: "They are in the vegetation as a hieroglyphic key between two worlds, which interest and evade one another in an infinite variety of ways, like dreaming

Hygeny Balan. consists of an irreg. tuberous stem resting on clump of host root - May be size of man's head, uneven, or convoluted like a brain or covered with knobs or lobes like coral - resemblance to latter heightened by little star-like papillae. Inflorescence spadix-like on a thick shaft with scale leaves - One reaches Lathrophytum Peckoltii of Brazil has lost all trace of leaves. Sarcophyte sanguinea has stinking and horrible descriptive name. Ichthyosoma (fish-carcass) has odor of rotten fish. Cynomorium is the only indigenous European species. It thrives on roots of Pistachio, Myrtles and on certain maritime plants - Salicornia, Salsola.
C. coccineum is blood-red in color and has a red juice once supposed to be blood. It was used as a styptic in Middle Ages. Sold in apothecaries shops as Maltese fungus (fungus melitensis). Had miraculous virtues.

~~Nepenthales~~

Nepenthales

Cephalotaceae, Nepenthaceae, Sarraceniaceae, Droseraceae
Another order that is much debated as to affinities. Following Wettstein it comes somewhere among the Polycarpeae. Simplest flowers belong to the Cephalotaceae from W. Australia. The plant looks something like a Sarracenia but its upper leaves are simple foliage leaves while the lower alone are made into ascidia. Originate just as in Nepenthes. Flowers alone concern us. Has a terminal inflorescence and small white fls. without bracts. Fls. 6 parted. First 6 perianth leaves then 2 whorls of 6 stamens, then 6 free carpels which become one-seeded follicles. So in apocarpy and hypogyny the flower is low. Looks like a Magnoliaceae derivative. Since only one perianth whorl remains the question arises whether the plant is diplostemonous or obdiplostemonous. If the whorl is the 6 petals it is diplostemonous; if sepals, obdiplostemonous. Probably former. The latter view has led some to put it with Crassulaceae.

Sarraceniaceae.

Simplest member is Heliamphora with inflorescence instead of single flower. In general the flower is as follows: sepals 4-5 Petals 5 free. Stamens ∞ hypogynous free. Ovary of 3-5 locules - n. axillary placent. with ∞ small anatropous ovules. In Sarracenia the style is dilated into a parasol. The Nepenthaceae have an inflorescence and flowers on the plan of 4. All in all the order shows affinities with the Ranales.

Most interesting part of whole plant is their ability to trap insects by their pitcher-like leaves. Darlingtonia californica grows in Sierra Nevadas at height of 300-2000 m. leaf may be a meter long - a long funnel tube with a hood and a ladder which hangs from the lip like a fish tail. The funnel is really developed as an invagination - the blade, or better say by gradual growth around a depression. The bottom of the utricle is filled with secreted liquid - impossible to reach it without destroying the organ. The organ is reduced to a slit covered by the helmet. The lower part of the leaf is green but upper part is gay with red veins and purple marks. Between the veins the leaf is thin and translucent - like small windows. Insects are attracted by color and find honey secreted around the opening; they crawl into the opening and get upon inner tooth decurved points of epidermal cells - as in Sarracenia purpurea. Then unable to stop they slip to bottom and perish. Wings and legs try to fly out but they never succeed in finding the opening but mislead beat themselves nearly to death against the "windows" in the hood, finally fall into the cistern below. They often live 2 or 3 days but meanwhile the plant has time to stimulate (secrete proteolytic enzymes?) which digests the dead bodies. Bacterial decomposition also set in. A brown liquid of fetid odor is produced. As it is a residue of skeletal pieces such as elytra of beetles, thoraces, claws, etc. Amount of prey is surprising. Pitchers of Sarracenia variolaris get to be 30 cm long and 6 cm. contain 8-10 cm of remains - even 15 cms has been seen. This sp. has a honey gland leading up the outside to the inside and stamps gets many complaints for Darlingtonia on the other hand catches flying insect and the purple-red "fish tail" is a signboard like a petal. Very strangely a few flies and a small moth make their homes in same pitchers. The maggots of a blow-fly Sarcophaga Sarraceniae are abundant in the decaying remains. When mature they bore their way through pitcher wall and pupate in the earth. The mature fly can pass in and out of the pitchers. On the last joint of each foot it has a long claw with a sole-like lobe and with such grappling irons it climbs among the hairs.

Why are not the larvae digested? Hooker says that in Sarracenia there is no enzyme - only decay but in Nepenthes there is enzyme and yet worms live in it. The "Nepenthes worms" are like those - Tunnicliffe: white, with thick cuticle; some are naked, slimy. Has been thought they may secrete antiferment. Ed. Indies.

Nepenthes: 36 sps, all tropical - particularly in E. Indies.

Flowers in marshy ground. The young plants →

rosettes which resemble Sarracenia very closely. Later however a new type of leaf arises; its lower part is a winged lamina. then comes a terete coiling portion which grasps every twig etc. it can find; the pitcher stands at the extremity and is thus slung at the extremity of the clasping portion. By means of these climbing leaves the plant rises higher and becomes entangled over its support. Mature pitchers are 10-15 cm. long. Pitchers of N. Rajah are 50 cm long while their orifice is 10 cm in diameter - hence would accommodate a pigeon. Often hairy outside when young, may glitter or be snow white. As the lid rises they lose hairs and display a yellowish green ground color flecked and veined with purple; some bluish or rose tinted or dark blood-red. Lid also gay and often with a pale blue zone; the interior beneath the rim - look like flowers. Secrete nectar vigorously around rim. On inside is a coating of smooth wax and a chevaux de frise of sharp teeth "like the set teeth of a beast of prey." Insects fall in and are digested by a ferment. Seed very small with 2 long air-filled processes from seed coat. Weight of seed of N. phyllamphora is .000035 g.

Sarracenia our native genus (S. ~~P~~ purpurea) - named for Dr. Sarracen, a French Canadian physician runs north to Nfd. s. to Fla. S. flava (Trumpets) is found in bogs of Virginia and southward. Fernald says it's an ancient Tertiary ~~Conclus~~ (Summary Nepenthes Sarraceniales - perhaps plant related to old Ranalian group. Sarracenia → P_{5+5} A∞ G (5) Seed anatropous with small embryo at base of much albumen. Cephalotaceae → 6 separate carpels and part of leaves normal. Sarraceniaceae: Darlingtonia - habitat, leaves and structure; "windows" - amount of prey; Sarcophaga sarraceniae - history Nepenthes - life history and pitchers - "Nepenthes worms")

(This might be a fit place ~~to~~ consider the means of dispersal of organisms. Animals can move although there are exceptions to this common method among them. Thus insect and birds may be blown by the wind; insect larvae and cocoons may be transported by drifting trees. In fact snakes and crocodiles have drifted to the shores of the Cocos Islands in the Indian Ocean, 700 miles from Java, the nearest land. Plants are passive and depend on the wind, streams, ocean currents and animals. De Candolle regarded the wind as "the most general and ordinary cause of the distribution of species over the entire surface of a country" but he would not allow

for their crossing the sea (based on negative evidence). But seeds of Nepenthes ampullaria are known to have been transported from Ceylon to the Seychelles, 1500 miles away. Engler calculated that of 675 species in Hawaii, 140 ferns etc. and 14 angiosperms came by wind. This is common of island floras.
Warming notes that there is no oceanic island destitute of plant life though many are surrounded by hundreds or thousands of miles of water. In 1901 there fell in Switzerland much dust from Africa - why then not light seeds? Previous to 1899 Fimbristylis spathacea was not known on the Great Bahama Island of the West Indies. But after the Hurricane of Aug. 13, 1899 this sedge appeared and soon spread as a bad weed. It is now called "Hurricane Grass" there.
In August 1883 Krakatoa west of Java blew up. 3 years after this Treub found 6 algae 26 vascular plants of which 11 were ferns and 15 seed plants. 10 years later Penzig found 62 vascular plants of which 60% came by ocean currents, 32% by wind and 8% by fruit eating birds. Within 25 years the island was green with forest and in 1906 a party of botanists confined their collecting to a shore zone "because of the difficulty of cutting a way through the dense growth of tall grasses".
Winds in the U.S. carry every year 850,000,000 tons of dust as far as 1,440 miles. Nepenthes phyllamorpha seeds weigh .000035 gram; seeds of Rhododendron verticillatum .000028 gram; of Dendrobium attenuatum .00000565 gram.
James Small (New Phytol. 17:226, 1918) using artificial air currents found that dandelion fruits (with humidity above 77%) would remain in the air with a wind of 1.9 miles per hour. In moist air the pappus closes and the fruit falls. "Hypothetical land bridges are not needed to explain the present distribution of the Compositae and we don't need to raise and sink continents in a quite reckless manner as Darwin put it." The Compositae are too recent to depend on land bridges. Small contends that "a rational study of the history of the Compositae, their migrations and colonizations, their paths of travel and regions of concentration" is not possible without understanding conditions of wind dispersal. Thus Senecio species occur in the Falkland Islands 300 miles from the nearest land; another is on St Helena and on Princes Island nearly 1500 mi. from land. This is due to the trade winds. Small has worked this out in detail. Senecio produced 2300 species of wide distribution concentrated chiefly on mountains. Since it responds readily to the environment there are many species. No species covers the same ... [illegible]

extensive with an altitude of 3000' or more and the fact point to the Andes of Bolivia as the center of the genus whence it spread rapidly "along the snow-wooded mountain ranges of the world". This has been rapid. The genus is young and marked by variable with many local species with centers of distribution along the paths of migration of the genus as a whole".

Seeds must be able to stand prolonged soaking even in salt water. The strand flora of Krakatoa certainly was brought by the ocean. Guppy cites that the fruits of Rhizophora and the mistletoe of the Mangrove are dispersed on floating logs in small holes and crevices. 85% of the Hawaiian flora is endemic but 75% of the flora of the coastal zone is introduced. The natives at the time of the discovery had canoes made of Douglas spruce (which only grows on continent), and very fine branches and - - - -

To finish

W.P.

Papaverales

This is the last order of the "Protomegamen" of Hallier and comprises the Papaveraceae, Fumariaceae, Capparidaceae, Resedaceae and Cruciferae. From the order Hallier also derives the Caesalpiniideae.

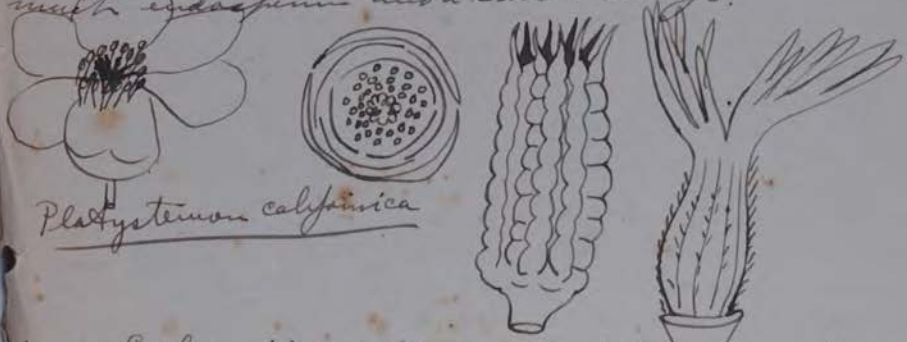
The Papaverales are mostly herbs with leaves inclining to be ultimately pinnate or usually with 3 palmate veins. Flowers are either actinomorphic or zygomorphic and usually hermaphrodite with calyx and corolla. Perianth 2+2-4 (rarely 5) parted. Stamens the same number as the petals or more. Ovary is syncarpous, 2-∞ carpels, are called or second only ∞ called and almost constantly superior. The seeds are united and usually with endosperm. The plant usually has much milky juice. There seems little doubt that the order came from the Ranales. Remember that Glaucidium of the Podophylloideae was very close to Glaucium, a true poppy.

The Papaveraceae are divided into 3 subfamilies (the last however is usually ranked as a family).

1. Papaverideae: All the petals same pattern - SA 6-∞.
2. Hypecorideae: " " - SA 4.
3. Fumarioideae: Both outer petals are of them spurred, here the flower being Zygomorphic. SA 2 and 3 parted.

Papaverideae

Platystemon: Only 1 sp., P. californicus, is a milky juiced herb with simple leaves and terminal long-stemmed flowers. It resembles a Ranunculus very closely and in fact makes the transition. It has 3 sepals, 6 petals (in 2 circles), ∞ stamens and a many celled pistil. The styles only are free above but as the fruit ripens the carpels split apart showing that syncarpy is not very profound. Each carpel produces a number of seeds; between them may be false partitions. The fruits may break into 1-seeded fruits. The seed has much endosperm and a small embryo.

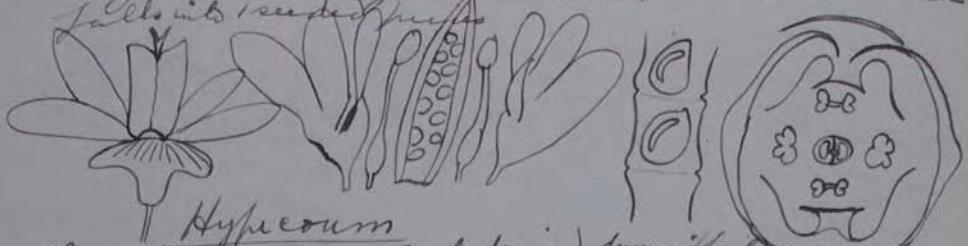


Platystemon californica

Flower: Easily derived → full syncarpy but sometimes has numerous flowers as departures from normal (P. crenatelobatum, bracteatum). Usually 2 sepals, and a 2+2 corolla, ∞ stamens and 2 carpelled ovary with a shield

shaped stigma and fruit opens by pores at top.

Hypecoideae: These reduce stamens to 4 and have dimerous fls. Two sepals with 3 alternating petals and then 2 episepalous mostly 3 lobed petals. Androecium of 4 stamens 2 opposite outer; 2 opposite inner petals. Carpels 2, fruit elongated and has false walls between seeds hence falls into 1 seeded parts.



Hypecoum

Fumarioideae: Easily derived from the last. E.g. in Dicentra. The 2 outer petals are sack like; the 2 inner become spoon shaped at their tips and enclose the stigma and anthers. The stamens are peculiar. Opposite each outer petal stands a broad filament, then parted & apex and carry 3 anthers. Seems at first sight to be made of 3 fused stamens. But only the middle lobe produces a pollen sac - the side lobes bear each a half one. De Candolle's interpretation is: The 2 inner stamens of Hypecoum become split and their halves grow to fill the spaces of the outer circle. In Fumaria only one petal is spurred, omniferum.

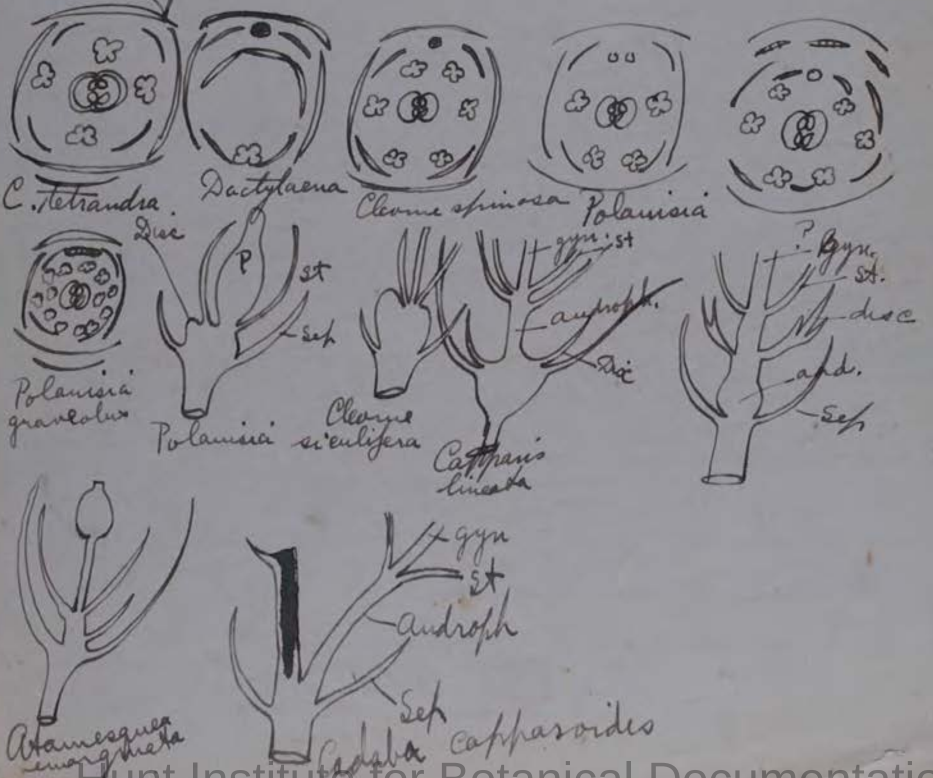
Economic features: The poppy is the most important species. The unripe capsules are cut across the veins and the milky juice oozes out and hardens, in about 24 hours the opium gatherer scrapes off the hardly dry juice and rolls it into a flat cake. This is moulded into smaller cakes of 100-200 grams which contain 12-15% opium alkaloids. There are some 20 alkaloids in the juice. The Egyptians knew the drug. It was particularly cultivated in Thebes. We still use opium tincture under the name of "Tinctura thebaica". Besides opium, the poppy also produces oil which is expressed from the seeds and used as a substitute for olive oil. The alkaloids in opium are: Hydrocotarnine, morphin, pseudomorphin, codein, thebain, protopin, laudanin, codamin, papaverin, thebaidin, meconoxyptopin, laudanosin, narcotin, cauthopin, narcein, oscopin. Morphin, a colorless or white and shining, bitter substance is $C_{17}H_{19}NO_3 + H_2O$. In summary one might say that opium is the important and valuable medicine of the whole

Medica and the source, by its judicious employment of more happiness, and by its abuse of more misery than any other employed by man kind."
Other possessions of little importance except as ornamentals.
P. nudicaule, the Arctic Poppy grows to the limit of northern vegetation. P. orientale is a beautiful garden flower. P. Rhoeas is the european field poppy. This also escapes in Canada in limestone soil. There are many new varieties as the Shirley poppy. Natives are: Chelidonium majus with yellow juice. In the Middle Ages it was said the celandine opened the eyes of those young boys applying it. It was a "cure for jaundice. The juice is said to be poisonous sometimes to the Dani. Sanguinaria c. has red juice. This was used in folk-medecine. The pumaria are of no special significance. F. officinalis emits a strong odor of nitric acid when rubbed up. This probably gave it its name pumitory, fumus - smoke. Dicentra is Adlumia fungosa, a delicate vine climbing by its leaf stalks. There is also Dicentra and Corydalis.

Capnoideae: Papaveraceae - thin ordinal features. C. Platystemon with Ranunculus P_{3+3+3} $a \infty$ $g(\infty)$. Anomalous difference is in the parietal syncarpy and the fruit. Fall apart. Tend to produce false septa. Recall Glaucidium. Papaver: P_{2+2+2} $a \infty$ $g(\infty)$. Abnormal flowers 3 parted (G. Macranthum) Hypecoum: same formula as Papaver but inner petals produce 3 lobes and middle lobe stands erect. Inner stamens seem ready to divide - anthers different. Fumariaceae: Dicentra: petals spoon-shaped and embrace stamens and stigma. Inner anthers stamen due to splitting of inner 2 of Hypecoum and fusion with outer.)

Capparidaceae
These immediately of Hypecoum. Cleome tetrandra really differs only in having 4 sepals instead of 2. The departure from this plan lies particularly in the androecium. In Dactylaena the 3 posterior stamens become transformed to staminodia. More commonly the 2 median stamens suffer abortion and then the true cruciferous type arises (not 2+2+2 of Cleome). In most species of Polanisia the cruciferous type is modified by the fact that the two posterior members change to staminodia. From the cruciferous type 2 other lines lead:
1. The transverse stamens remain simple, the median split in various ways. Thus in Atamisquea the median posterior stamen splits to 3 parts, the anterior in 2 and the middle one of the 3 posterior becomes a staminode.
2. The anterior median also undergoes abortion like the

posterior. Then also the laterals begin to split so that in
~~Pol.~~ Polanisia graveolens e.g. we get the following: (see
In Capparis itself there is great chorisis and ∞ stamens.
thing that often lends to the Capparids a queer appearance
the odd lengthening of the axis and the formation of discs. Po-
isia alone lacks androphore and gynophore. The gynophore
of Cladostemon becomes 10-15 cm long in Capparis
even 30 cm. (See diagrams of longi sections)
The Capparidaceae are essentially a tropical family.
Capparis spinosa yields the capers of commerce whose green
flower buds are pickled for use in sauces, etc. They are [illegible]
pungent (cf. Cruciferae)
Conclusion: This whole order Rhoeadales deserves a rather
thorough study from the standpoint of variation in a flower then
Origin in Hypecoum. → floral diagrams and curious evolution
of the disc by diagram. Capers of commerce. The line ends
blindly.)



Cruciferae 1500 sps.

These took up the capparid theme at the level of Polanisia. They produce hermaphrodite actinomorphic hypogynous fls. $P_{4+4}\ A_{2+4}\ G_{(2)}$. The 4 longer stamens have arisen by chorisis of the two median inner ones. Eichler says the origin as 2 primordia can still be seen in some. Stamens and petals may be reduced or rarely the former increased through chorisis.

All contain pungent juices. Seed is campylotropous and embryo curved. Systematics is difficult since flower is so similar in all. Lack of traits; pods and seeds furnish the chief features. We have many natives and introduced. The natives also tend to seek limestone soil. Most important economically are members of the genus Brassica, a [illegible] protean forms and has been cultivated since ancient times. B. oleracea L. is probably the parent of all the cabbages, Kale, Kohl-Rabi, ~~[illegible]~~ Brussels Sprouts, Cauliflower, Charlock, Chinese Cabbage. As to the parent of the turnip, Rape, Rutabaga group some say B. napus and B. rapa; others tend to put in one species. Sturtevant gives a full historical discussion.

Other economic forms are: radish (Raphanus) watercress (Radicula nasturtium-aquaticum) Horse radish (R. Armoracia) which rarely sets seeds. Many are cultivated for flowers: candytuft (Iberis) sweet stock (Matthiola) sweet alyssum (A. maritimum). The characteristic odor is due to an enzyme myrosin which is also found in Capparidaceae, Resedaceae, Tropaeolaceae, Limnanthaceae, Papaveraceae. It occurs in special myrosin cells - becomes red with Millon's. It splits the glucoside (sinalbin in white mustard, sinigrin in black) into oxybenzyl thiocyanate (in white mustard).

Crantz once gave the name Antiscorbuticae to the family since Cochlearia officinalis is a plant of sea-shores of Northern Europe. It has been of greatest value to sailors in curing and preventing scurvy. Others occur on other coasts. Thus we have C. [illegible] - Probably vitamines.

Another of interest is Isatis tinctoria "woad" an herb which yields a blue dye and which was used by Picts and Celts for body paint. Blue has remained the national color for royal robes in England. Anastatica hierochuntica is a small annual of sandy places in Arabia, Egypt, and Syria. Its stem branches from the base and bears small rounded fruits. As it ripens the leaves fall and the plant curls up to a rounded cushion becoming a tumble weed. If wetted it begins to uncurl and the pods open. Called Rose of Jericho. Popular superstition that it opens once a year at day and hour of Christ's birth.

Resedaceae:

Attach best to Capparidaceae: Habit, smell, taste, zygomorphy, disc, parietal placentation, campylotropous seed all recall. But are different from other Papaverales in peculiarity of flower construction: never 4-parted; androecium not of dimerous whorls, carpels partly open. Eichler ~~[illegible]~~ suggest referring it to the Cistiflorae.

There are 2 series: Astrocarpeae with free carpels, and Resedeae with the carpels united below.

Herbaceous or shrubby plants with zygomorphic flowers in racemes or heads. Sepals 4-8 and petals 2-8 which are cut into divisions; 3-∞ stamens and a 2-6 carpeled gynaecium. Receptacle grows out to androgynophore or gynophore and discs form. Resembles Capparids but not dimerous plan. Following are a few diagrams.

Randonia

Reseda

Flowers often open while ovules are young

Astrocarpus
(no drawing: see text)

Oligomeris has a curious distribution: 4 sp. at Cape; 1 through the whole Mediterranean region & East Indies and also in California.

Concl: Apocarpy & syncarpy. Allied to Capparids in disc and gynophore and seeds - differs in numerical plan, slitted petals, open carpels.

ORDER MALVALES - This order must also be looked upon as derived from the RANALES. Its families are very uneven in advancement. Thus the Sterculias are little removed from the RANALES in gynoecial characters but their stamens are monadelphous; while the TILIACEAE on the contrary have free stamens and complete syncarpy. In general we may say that it is an order derived from the old type P 5 # 5 A 5 # 5 G many. Bessy defines them as follows: Pistil usually of 3 to many weakly united carpels with as many cells (sometimes reduced); ovules mostly few; stamens indefinite, monadelphous or free; endosperm usually present. The following families belong to this order: MALVACEAE, STERCULIACEAE, ELEOCARPACEAE (and Bessey adds BALANOPSIDACEAE, ULMACEAE, MORACEAE and URTICACEAE).

A. MALVACEAE.

1. General features: Trees, shrubs, or herbs with mucilage cells in the pith and bark. The perfect and actinomorphic flowers often produce a double calyx. The stamens are usually many in 2 circles; the outer circle sometimes producing staminodia or being suppressed and the inner being monadelphous. Furthermore chorisis splits the inner circle into indefinite numbers, and the anthers are one-celled. The pollen grains are prickly. The gynoecium is composed of 5 - 8 carpels with the styles usually united. There are one to many endospermous seeds in each locule. The fruit is capsular or composed of parts which fall free at maturity as achenes. There is a tendency to cut up the ovary by false septa to produce free pieces. This has led in its extreme to the MALOPEAE which have a blackberry-like head with nutlets arranged in tiers. There are two main groups::
   a. MALVEAE, having a ring of carpels which fall apart at maturity.
   b. HIBISCEAE, having loculicidal capsules.
2. Genera.
   a. ABUTILON, the Flowering Maple, is supposed to contain about 80 species. They are much hybridized.
   b. ALTHAEA officinalis is a tall plant with velvety downy ovate or trilobed leaves growing in salt marshes and sometimes inland. The generic name comes from "to cure". The root yields marshmallow, a mucilage though marshmallows as a confection are mostly made of gum arabic, white of egg and sugar.
   c. ALTHAEA rosea is the hollyhock of gardens.
   d. MALVA rotundifolia is a weed of rich garden soil commonly called cheeses.
   e. HIBISCUS Moscheutos is the beautiful Rose Mallow common in brackish marshes near the coast. Its fruit is a large, many-seeded capsule.
   f. HIBISCUS esculentus, Okra or Gumbo, is an African plant cultivated widely for its mucilaginous pods used in soups. Records of it go back to 1216 when Abul-Abbas-el-Nebati, a native of Seville, visited Egypt and saw it there. Its seeds are said to form the best coffee substitute known.
   g. GOSSYPIUM, Cotton, has seeds covered with wool. There are many varieties of 2 - 3 species. It was cultivated long before Christ. From 1804 to 1904 the crop increased from 130,000 bales valued at $13,000,014 to 13,693,279 bales valued at $557,147,306. Formerly the growers were troubled

in getting rid of the seeds but for 1904 its value was $90,258,227. The root is a powerful abortifacient that acts like ergot.

B. TILIACEAE.

1. Affinities: These stand on a different line from the last and well illustrate how certain characters may lag while others go forward. For the TILIACEAE are trees (a primitive feature) with the mucilage and fibrous phloem of the MALVACEAE but the stamens are free and 2-celled while the ovary is completely 5-celled and syncarpous. The leaves are oblique. The fruit of TILIA is 1 to 2 seeded and these seeds enlarge so as to crush the sterile carpels aside. The stamens tend to be bound into bundles. It has a curious samara. It is a famous bee plant. The wood was used by the ancients for bucklers according to Pliny; while the inner bark was used for mats and paper.

2. TILIA europea often becomes of great age and girth. One in Wirtemberg is 54 ft., in circumference, spreads 100 feet and must be sustained by 108 pillars.

C. STERCULIACEAE.

1. Affinities: This family lies close to the MALVACEAE but the carpels are practically free and have 2-celled anthers. The stamens are often very odd. This family is important because through the BUTTNERIACEAE it seems to run over to the EUPHORBIACEAE.

2. Genera.

a. THEOBROMA cacao is a native tree of Central and South America. Its brownish flowers come out in bunches on the old wood. The fruit is a pod a foot or less long and some 4 inches in diameter with 5 cells containing beans imbedded in acid pulp. The name of the plant means "food of the Gods" while the species name is pronounced ka-kow, cocoa being the manufactured product. The means are washed or fermented. Chocolate is the sweetened preparation of the roasted and ground cacoa bean with most of its fat retained; while cocoa is a fine powder of the same with the fat extracted. The fat is much used in pharmaceutical preparations. It is white and about as hard as beeswax. Cocoa has been known since the time of the Aztecs. The seeds contain about 1.5% theobromin.

b. COLA acuminata of West Africa now cultivated inn Brazil and in the West Indies, furnishes the cola nut, a muscle stimulant. The "cola" habit is increasing especially among alpine climbers. Fresh cola nuts do not contain caffeine but a glucoside kolanin which converts to kolarea of the formula $C_{14}H_{13}(OH)_5$.

D. ELEOCARPACEAE is a genus to which E. sphaericus belongs whose drupe furnishes the vegetable ivory.

E. BOMBACEAE are very close to the MALVACEAE but differ in having smooth pollen and several-celled anthers. To this family belong several interesting plants. ADANSONIA digitata, the Baobab or Monkey bread tree of Africa, grows to an enourmous size. BOMBAX itself and particularly CEIBA pentandra, the Cotton tree, have the inside of the carpels beset with wool but this cannot be spun. They are found throughout the tropics.

ORDER GERANIALES - According to Engler this order is diagnosed as follows: The flowers are cyclic, heterochlamydeous or apetalous, seldom naked, and usually five-parted, the androecium alternating with the corolla. The five to two carpels are united and superior. At maturity they often break apart thus showing a probable Ranalian ancestry. The seeds are usually one to two in number, anatropous and hanging with ventral raphe and micropyle directed upward (rarely reversed).

Wettstein, on the other hand, derives them from the MALVALES. He considers that a Tilia form could give rise to the Oranges. These have many stamens but this may be due to chorisis. From them by reduction he derives the LINACEAE and others. Hallier on the contrary sees in the disc-forming Saxifrages the ancestral state since the RUTACEAE have a large disc. Engler without committing himself as to ancestry starts the order with the GERANIACEAE and derives the RUTACEAE by chorisis. We will follow his general plan and attach the order to the RANALES realizing that there are ROSALIAN and MALVALIAN features in the order which would likely be the case in an old Ranalian stock common to all. (For amplification see p.

A. GERANIACEAE

1. Affinities: They are typically P 5 # 5 A 5 # 5 G (5) though this varies for the stamens may run from 5 - 15 and may be united at the base. The carpels are united above to a "schnabelartigen Verlaengerung" of the torus from which the name of Stork's bill has arisen. This suggests a primitive Ranalian idea but it may be due to specialization. The carpels commonly split at maturity (also primitive and significant of forms higher up). There is a weak zygomorphy also which leads over to the TROPAEOLACEAE. GERANIUM has 10 stamens with anthers while in ERODIUM the outer row has none. Likewise some anthers in PELARGONIUM are lacking. ERODIUM and GERANIUM have interesting seed dispersal mechanisms.

2. Genera.

a. GERANIUM, the Stork's bill, has about 160 species found particularly in the northern hemisphere. Some have beautiful flowers of scarlet, crimson or purple and are therefore cultivated. G. maculatum is the common wild one of Massachusetts fields. G. Robertianum is found both in Europe and America.

b. PELARGONIUM has 232 species according to Knuth in "Pflanzenfamilien". They are nearly all from South Africa. It differs from GERANIUM in its spurred nectariferous sepal adherent to the pedicel. They are weakly zygomorphic and probably lead to the TROPAEOLACEAE with their strong zygomorphy and long spur. Bailey says: "The person who wishes to study the contemporaneous evolution of plants may find his heart's desire in Pelargonium. With great numbers of species and many of them variable and confusing in the wild state, with plant breeding in many places and continued thru two centuries, and with a large special literature the genus offers exceptional advantages and perplexities to the student."

B. LINACEAE.

1. Affinities: The flaxes stand on about the same level as the Geraniums. and have the same general flower. A significant feature is its tendency to form false septa in its capsules which was observed in NIGELLA among the RANUNCULACEAE. This feature is perhaps carried into the TUBIFLORALES. Histologically, the abundance of slime cells in the epidermis is notable.

2. LINUM usitatissimum, an annual, is the economically important flax. There are two forms in cultivation: forma vulgare, the closed flax whose capsules does not crack open and whose carpel walls are smooth; and forma humile, the openn flax whose capsule cracks open and whose carpel walls are hairy. Flax grows wild today between the Persian Gulf and the Caspian and Black Seas. It was probably carried by the Finns from there into Europe. It is supposed to have originated from the perennial L. angustifolium which grows along the Mediterranean. This species has been found in the Swiss Lake dwellings and in Lombardy peat moors. The old Egyptian linen came from L. usitatissimum. The bast fibres are .2 - 1.4 meters long and about .0241 millemeters thick, pale in color with a silky sheen and with hardly any lumen. The fibres are obtained from the plant by retting viz letting the stems decay in water. The seeds of flax produce linseed oil.

C. OXALIDACEAE.

This is another basal family with the genus OXALIS which is often very sour because of calcium oxalate. AVERRHOA which belongs to this family is cultivated in the tropics for its edible fruits which taste like gooseberries.

D. TROPAEOLACEAE-

The spur which began to appear in PELARGONIUM has carried over to this family where it is well developed. It differs in having 8 stamens and a tricarpellary gynoecium. The carpels fall apart as a schizocarp when ripe. Since these plants contain myrosin, the seeds may be used as capers. T. majus and T. minus are the cultivated "nasturtiums". The above families of this order have formed a plexus of herbaceous forms probably evolving each into zygomorphy. The Balsaminaceae seem to end this line.

E. BALSAMINACEAE

This is another zygomorphic family of herbs with usually watery stems. The irritable 5-carpeled fruits hurl out their seeds is characteristic. The wild forms around Massachusetts are IMPATIENS biflora and I. pallida, while I. noli-me-tangere is found in Europe. The garden and greenhouse plants which come from the East Indies are I. balsamina, I. Sultani and I. Hostii. Some produce cleistogamous flowers.

F. ERYTHROXYLACEAE- P 5 # 5 A (5 # 5) G (3 - 4)

1. Affinities:: Since this family is woody and has actinomorphic flowers, one must go back for an ancestry to the Linaceous actinomorphic types. Usually only one carpel develops to maturity as a drupe.

2. ERYTHROXYLON cacao furnishes folia coca from which cocaine ($C_{17}H_{21}NO_4$) is obtained. The Indians chew the leaves when

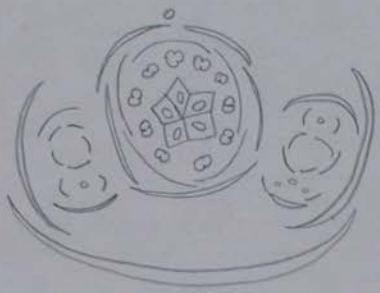
flower

DINEMANDRA

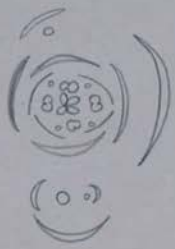
TETRAPTERIS

FRUITS

TRIBULUS fruits



TRIBULUS dichasium



RUTA inflorescences

on journeys as it wards off the sense of fatigue. If used excessively it produces similar effects as opium. Cocaine produces local insensibility to pain.

G. MALPIGHIACEAE - P 5 # 5 A 5 # 5 G (2 - 5)
To this family belong 650 species in 55 genera. They are all tropical and found particularly in the New World. They are closely allied to the last family. They are woody or lianes with commonly cleaved woods. The most beautiful tropical lianes belong in this family. The petals are commonly fimbriate and the fruit is usually a schizocarp of nutlets. Bulbs are produced by some, while the fruits are commonly winged.

H. ZYGOPHYLLACEAE-
These are usually woody plants often growing in salty desert soils, but our only form which sometimes gets in from the Old World is the herbaceous TRIBULUS terrestris which grows on dumps and is also found in Illinois, Nebraska and Kansas. It is a spreading herb having fruits covered with spines so as to become disseminated by animals. Another fact of interest about this plant is its dichasial inflorescence which is in line with the Euphorbias. NITRARIA grows on salt soils in Southern Russia to Eastern Asia. GUAJACUM officinale of Central America produces gum guiac while PEGANUM Harmala of Central Asia and the eastern Mediterranean countries furnishes Turkey-red, a dye, from the seed shell.

I. RUTACEAE- P 5 # 5 A 5 # 5 G (5)

1. Affinities: This family of 910 species is placed by Wettstein in the order TEREBINTHALES because of its ethereal oils etc., as is well illustrated by DICTAMNUS, the gas plant. Hallier, however, considers them Saxifrage derivatives because of their usually pinnate leaves and the presence of a big floral disc. Engler, on the other hand, divides them into 6 subfamilies of which the RUTOIDEAE, TODDALOIDEAE, and AURANTOIDEAE interest us chiefly.

2. Subfamilies:

a. RUTOIDEAE.

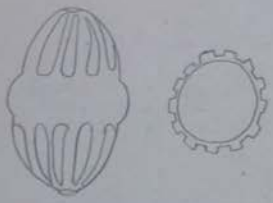
1. DICTAMNUS fraxinifolia, the Gas plant, Burning-bush or Dittany, has a strong odor of lemon due to ethereal oils, and it even flashes on sultry evenings when lighted. It is a very hardy beautiful plant. "Instances are known in which it has outlived father, son, and grandson in the same spot."

2. XANTHOXYLON americanum, the prickly ash sometimes also called "toothache tree", is a low shrub with pinnate l leaves, prickly twigs and small greenish flowers in axillary-umbellate clusters. It has been found in the Amherst region at Sunderland and also in Norwottock. Emerson says: "I have found it growing in only one place, on a southern slope in Medford."

3. RUTA graveolus is a strong scented European plant used in folk medicine. The flowers are cymose, the terminal one being pentamerous while the laterals are tetramerous. Baillon says the seeds are sudorific, antispasmodic, anthelmintic and antidotal. One species is used by the Egyptian women to make the hair grow while still another species is used to make a vinegar called "quatre voleurs"

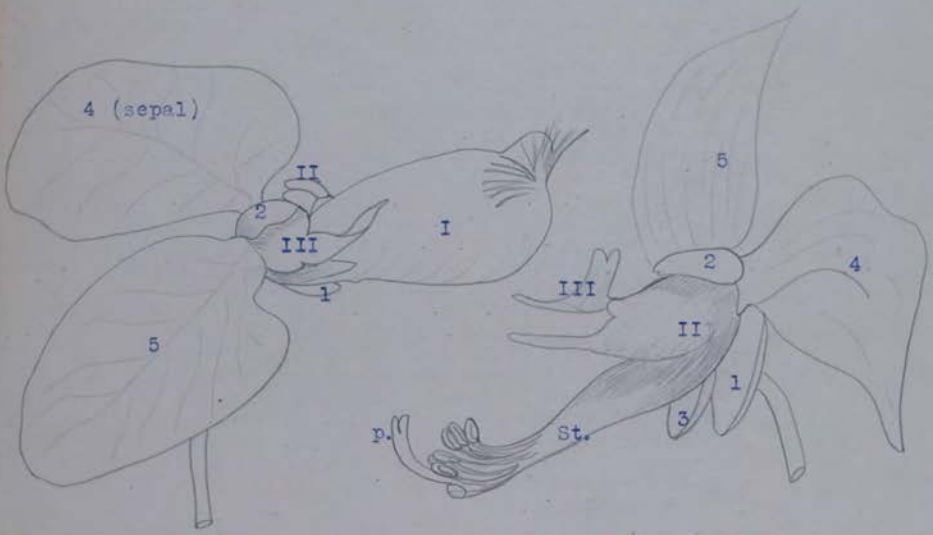
b. TODDALOIDEAE- genera:
   1. PTELIA trifoliata, the Hop tree.
   2. PHELLODENDRON amurense, the Cork tree.

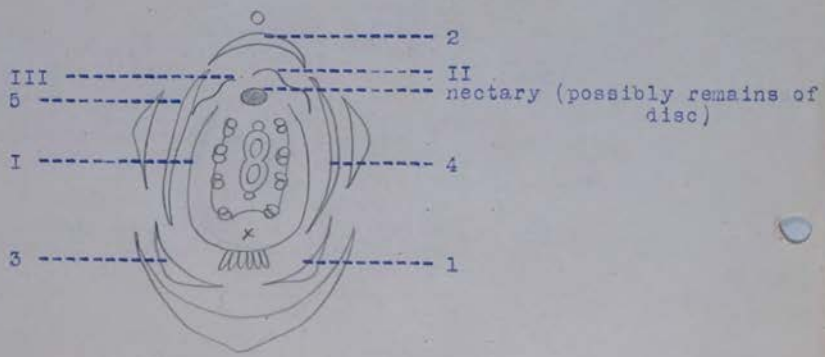
c. AURANTOIDEAE-
   1. Affinities: Here belongs the great genus CITRUS. They are evergreen more or less spiny trees, having leaves dotted with oil cysts and unifoliolate compound with winged petioles. The usually white flowers are axillary or in small inflorescences. Their floral formula is P 5 # 5 A many G several, derived probably from the more primitive genus LIMONIA which is P5 # 5 A5 #5G (5) by chorisis. This is evident because in CITRUS the stamens are united around the hypogynous disc into bundles of very unequal members, and in fact sometimes such a bundle consists of but one stamen. The pulp of the orange is composed of internal hairs. The seeds often have several embryos, a fact discovered by Leeuwenhoek as early as 1719. The extra ones arise from the nucellar cells above the megaspore. There is great confusion of species among CITRUS and some of the hybrids are so well established as to be called species. Linnaeus recognized only two species: C. aurantium, the orange; and C. medica, the lime, lemon and citron. Swingle recognizes 9 species.
   2. History of CITRUS: C. aurantium was brought from India to Arabia in the 9th Century and then carried westward by the Moors in the 12th Century to be cultivated in Seville and Palermo. St. Dominic planted an orange tree for the convent of S. Sabina innRome in the year 1200. The Crusaders found many growing in Palestine. One of the first shipments to England was from Spain in 1290, and the Queen of Edward I bought 7. These early oranges were all of the sour or bitter variety. America may have possessed these as natives but it is more likely that the Spaniards introduced them. They run wild in the South where they are used for grafting stock.
   3. Genus CITRUS:
      a. C. aurantium is the early known bitter orange.
      b. C. aurantium var. sinensis (sometimes called C. sinensis) is the sweet orange. There are many varieties and it is extensively cultivated. Sometimes it produces 2 or 3 whorls of carpels, one above another.
      c. C. decumana or C. grandis is the grape fruit, native of tropical Asia. It was carried from China to the West Indies early in the 18th Century.
      d. C. japonica, the Kumquat, is a little, sweet orange about the size of a gooseberry with 5 carpels and thin skin.
      e. C. limonia, the lemon, was probably introduced by the Moors who carried it to Palestine about the 10th Century. Engler figures 2 curious chimaeras of lemon crossed with orange. They are rough lemon on some segments and smooth orange on others. Such have been known 200 years.
      f. C. ichangensis is a recent addition from the highlands of southwest China. It is the northernmost plant of genus and grows at altitudes of 3000 - 5000 feet where it must stand considerable cold. It may become very important in breeding.



pollen grain

seed of POLYGALA vulgaris





POLYGALA sp.

g. C.medica, the citron, gets its name from Media whence it is derived. It was the only plant of the genus known to the Greeks. It is much cultivated along the Mediterranean and particularly in Corsica from where it is shipped in brine to America to be candied. A very odd variety is var. sarcodactyla which has its fleshy carpels separated into fingers. It is very fragrant and therefore used by the Chinese and Japanese for perfuming clothing and rooms.

J. SIMARUBACEAE-
This family differs from the RUTACEAE in dioecism and absence of oil. Here belongs AILANTHUS glandulosa, the Tree of Heaven, which got its name because of its tall growing habit. It is planted as an ornamental although it suckers freely. The fruit is a samara.

K. Burseraceae-
1. Affinity: This family has resin and balsam canals in the bark and so yields aromatic woods and gums of value.
2. Genera.
a. COMMIPHORA (BALSAMEA of Gleditsch, BALSAMODENDRON of Kunth.) of which there are 63 species contains many valuable plants. C.abyssinica is a 10 meter tree of southern Arabia and northern Abyssinia growing at an elevation of 300 - 2000 m. From it the true Myrrh (gummi Myrrhae) is obtained by making cuts in the green bark from which a milky yellow juice flows which hardens into myrrh resin. This is aromatic and bitter. The wood when heated produces a strong perfumed smoke. From other species myrrh is also obtained.
b. BOSWELLIA species produce olibanum or frankincense.

L. MELIACEAE-
1. Affinities: There is some union of filaments, and petaloid members often occur between the anthers on the edge of the stamen tube.
2. Subfamilies.
a. CEDRELEOIDEAE to which belong CEDRELA of Central andx South America of which C.odorata is the "duftende haeufig zu Zigarrenkisten und Zuckerkisten etc., verarbeitete Zedernholz".
b. SWIETENIOIDEAE to which belongs the true mahogony, SWIETENIA Mahogoni of the West Indies.

M. POLYGALACEAE-
1. Affinities: According to Wettstein's definition these are woody plants or herbs having a median zygomorphic calyx with 2 of its 5 leaves often petaloid. There are 5 or 3 (2 not developing) petals, the median below usually concave and with a fimbriate appendage; stamens 8 (rarely fewer) and usually with the filaments united to a tube open above. Carpels usually 2 and the fruit a capsule, nut or drupe. The anthers open by a sickle-shaped flap at the top though this is resorbed later so that they seem to have a terminal pore.
This is an odd family standing sharply off the other GERANIALES. The relation to them is seen in the fact that in MURALTIA the 5 sepals are all alike, 2 not having developed to petaloid bodies or wings. The seed is caruncled. Then XANTHOPHYLLUM has 8 free stamens and a very highly developed disc.

ACTEPHILA excelsa

MOUTABEA has 5 carpels like the typical GERANIALES.
The safest character of the family for recognition is seen in the pollen grains. These are ellipsoid and have at both poles a great pit. From one pole to the other run thickened lines which are divided in the middle by a thin equatorial zone. Thus the grain looks constricted in the middle when flaccid, or with a ring when turgid.

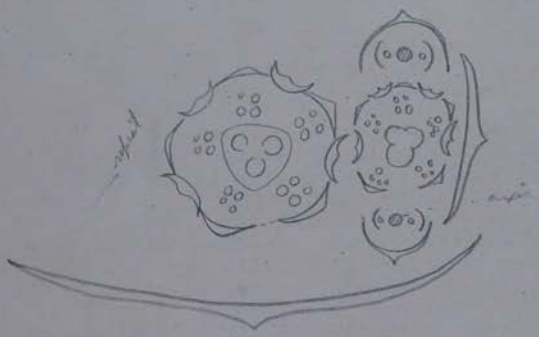
2. Genera.
   a. XANTHOPHYLLUM is a genus of trees of India, Ceylon and Australia.
   b. POLYGALA is the only genus of New England. P. paucifolia is our pretty fringed polygala which is orchid-like and also produces cleistogamous flowers. P. polygama found on sandy soil has many cleistogamous flowers. P. sanguinea is often mistaken for a clover.
   c. POLYGALA Senega is the Seneca snakeroot. Its dried root contains an acrid principle, senegrin, which is similar to saponin. It produces vertigo, weakness of the eyes, lachrymation, sneezing, ptyalism, burning in the stomach, vomiting, and colic.

N. EUPHORBIACEAE-

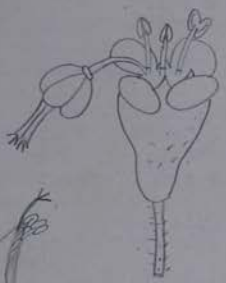
1. Affinity: Their systematic position is in doubt. On one hand they show relationship to the GERANIALES and MALVALES, and on the other to the URTICALES. They can always be recognized by their unisexual flowers and form of fruits and seeds. Their relationship to the GERANIALES is seen in the structure of the gynoecium which falls away from the column and ventral raphe. There is progressive reduction in the family from a Geranium-like unisexual flower as exemplified by ACTEPHILA excelsa, an Australian plant. This plant has three 2-forked stigmas and a glandular disc at the base of the carpels. The staminate flower has an abortive ovary. There are 208 genera and 4000 species of which 700 belong to EUPHORBIA and 500 - 600 to CROTON. This family offers many economic members although in general it is a family of poisonous plants.
2. General characters: They are usually woody but also herbs, and often cactus-like (EUPHORBIA) or with phylloclades (PHYLLANTHUS). The leaves are usually simple and stipulate. Milk canals are abundant and so rubber, CH, can often be obtained. The flowers are always unisexual and of great variety, often in catkins, heads, etc. Some have no perianth, some have a simple perianth which is most common, while some have calyx and corolla, especially in the staminate flower. The staminate flowers possess the same number of stamens as of perianth leaves, or more to very many, or less. There is probably some chorisis as RICINUS seems to show. The staminate inflorescence usually produces a tricarpellary trilocular ovary with one ovule in each cavity. Rarely are 2 or more ovules found per loculus. The stigmas are 3 and split. The fruit is usually a capsule falling into 3 parts to leave a central column. The seeds are usually caruncled, have endosperm and a ventral raphe.
3. Subfamilies.
   a. PHYLLANTHOIDEAE, which have 2 ovules per loculus and no milk tubes.
      1. PHYLLANTHUS tends to produce cladodes which look like leaves and from which the flowers spring. P. Niuri has

male flower

ANTHOSTEMA senegalense



EUPHORBIA Peplus dichasium



EUPHORBIA
platyphyllos

male flower

PEDILANTHUS

leaves but these are sessile thus giving the effect of compound leaves. P. speciosus has strict phyllocladia.

b. CROTONOIDEAE, which have 1 ovule per loculus and milk tubes.

1. Development of the cyathium: The cyathium is really composed of small inflorescences which simulate flowers in the highest group, the EUPHORBIAE. It can be traced from complete inflorescences to conditions where they simulate flowers very closely. Thus in ANTHOSTEMA a single pistillate flower has been shoved to one side by the development of many small staminate flowers which stand in the axils of bracts. Each staminate flower produces a tiny tubular calyx but is reduced to 1 stamen. In EUPHORBIA itself the staminate flowers lose the calyx and the result is a naked stamen borne on a pedicel. The staminate flowers can be distinguished from stamens by the fact that they have a joint, the lower part being the pedicel while the upper is the filament. PEDILANTHUS perhaps carries things to the extreme. The regular cyathium of a EUPHORBIA becomes very "zygomorphic", the 2 forward involucral leaves become larger and the 3 posterior smaller, while a last one becomes slipper-shaped and contains the nectaries. Thus it simulates a pouched flower. In some EUPHORBIAE the stamens may branch to produce 100 members.

2. HIPPOMANE Mancinella, the celebrated poison tree of tropical America, furnishes an arrow poison used by the Indians. The branches contain a milky juice which blisters the skin like a hot iron. It is a common belief that to sleep under the tree causes death.

3. CROTON Tiglium furnishes croton oil a drastic purgative which in large doses causes death. The plant is cultivated in southern India for its tiglinic acid, $C_5H_8O_2$.

4. EUPHORBIA resinifera of Morocco produces a milk which is used as a purgative and is so intensely acrid that people in collecting it are compelled to tie a cloth over mouth and nostrils. The resin produces sneezing, vomiting and diarrhoea and in large doses death. In fact where any Euphorbia drug is manufactured, the workmen must protect themselves, but even then get headache, dizziness and weakness.

5. EXCOECARIA Agallocha of tropical Asia furnishes the milky juice agallocha which is so acrid that it causes blindness if it gets into the eyes of the woodcutters.

6. EUPHORBIA Drummondii poisons sheep in New South Wales.

7. MANIHOT utilissima is one of the main tropical food plants. Its juice is so poisonous that the fresh juice causes the death of dogs and cats in 20 minutes. The poison is volatile, however, and by pressure and roasting is dissipated. Tapioca is the starch which settles out of the water in which cassava meal is washed. The meal is made into bread.

8. HEVEA braziliensis is the most important source of rubber. Gashes are made in the trunk, and the milk which exudes is allowed to harden. It is then collected and smeared over earthernware vessels, smoked and dried.

To this new layers are added until it is thick enough. Then it comes into the trade as raw caouchouc. The greatest source comes from Guyana, Brazil.

9. RICINUS is the castor bean plant. The oil is not poisonous but 3 seeds have produced death in man. The toxic substance, which is worse than strychnine or arsenic, has not been isolated. It causes vomiting and severe gastric pain. The plant is now of great importance as the oil is used for aeroplane engines.

10. HURA repitans, the Sandbox Tree, has a fruit 6 cm., in diameter containing 5 - 20 cells which explodes at maturity to hurl out its seeds. Boiled in oil and cut open, it is used as a sand box.

ORDER URTICALES- According to the regression theory, this order represents a degradation from some entomophilous form. Weddell derives them from the MALVALES through TILIA.
The flowers are apetalous, greenish and with no nectar and consequently anemophilous. The stamens stand before the perianth lobes. This is the position an outer row would assume of an old P 5 # 5 A 5 # 5 type whose inner row had disappeared. The calyx lobes are 4 - 6 while there are 2 or 1 carpel with 1 seed. The fruit is a drupe or nut. The seeds are often endospermous. Cystoliths are common. There are 1560 species.

A. MORACEAE-

These are woody plants with milky juice. There are two families:

1. MOROIDEAE.

a. MORUS, the mulberry, has aggregate fruits analogous to a blackberry into which sepals also enter. They are very sweet and of little value though birds are very fond of them. M. rubra runs from New England and Illinois southward. M. alba, a Chinese species, was introduced into Europe about 1400 for silkworm culture. Then during the silkworm craze it was brought to America. The poor people of Asia eat the fruit. M. nigra, a native of Persia and the Caucasus, was known to the Greeks and Persians. It was cultivated for silkworms under Justinian. Other species are found in Peru and in the East Indies.

b. MACLURA aurantiaca, the Osage orange, has a big green rough milky juiced fruit.

c. BROUSSONETA, the paper mulberry, is used in Japan and China for paper. The South Sea islanders make bark dresses from it.

2. ARTOCARPOIDEAE.

a. FICUS Carica, the fig, is one of 600 species. The flowers line the inside of a great vase-formed receptacle. The "seeds" of the fig are thus achenes. It is a tree of ancient cultivation, linked with legends of Dionysius and Zeus It has a remarkable method of pollenation for explanation of which see L. H. Bailey's "Cyclopedia".

b. FICUS benghalensis is the banyan. At the botanic gardens at Calcutta there is a banyan about 100 years old. The main trunk some years ago was 42 feet in circumference with 232 additional trunks many of them 8 - 10 feet in circumference The banyan under which Alexander camped 7000 men is now 2000 feet in circumference and has 3000 trunks.

c. FICUS elastica, the common rubber plant, is a big tree in the tropics. It does not produce as much rubber as the HEVEA species. The seeds often germinate on other trees to which they have been brought by birds.

d. FICUS religiosa, the Peepul Tree of India, has long caudate acuminate leaf tips.

e. FICUS sycamorus, the sycamore fig, was emplgyed by the Egyptians for mummy cases. The fruit was also eaten.

f. FICUS of many kinds are lianes of the tropics.

g. CASTILLOA elastica, of Central America, produces rubber.

h. ANTIARIS toxicaria, the famous Upas tree of the South Sea Islands, was fabled by the natives of Java to be so poisonous that the vapors from it would kill man and animals that came near it. It has been grown in gardens without killing the attendants. The juice, however, is very poisonous and is used for arrow poison by the savages.

i. BROSIMUM Galactodendron, the Venezuelan cow tree, was first noticed by Laet in 1633. From incisions in the bark, milk will flow in quantity. It is slightly astringent but is used by the natives. It is now grown in Ceylon and India where it is drunk extensively.

j. ARTOCARPUS communis and A. integrifolia are the bread-fruits. The former is not known in the wild state but is extensively cultivated in the tropics. Most of the varieties are seedless. The fruit is the size of a child's head with the surface reticulated not unlike a truffle, covered with a thin skin and having a core the size of a small knife handle. The edible part lies between skin and core and is as white as snow and somewhat of the consistency of new bread. It must be roasted before being eaten. Its taste is insipid with a slight sweetness, resembling wheat bread mixed with artichoke. If it is to be preserved it is scraped from the rind and buried in a pit where it is allowed to ferment, when it subsides into a mass somewhat of the consistency of cheese. These pits when opened emit a nauseous, fetid, sour odor, and the color of the contents is greenish yellow. It will keep several years and is cooked with coconut milk to produce an agreeable and nutritious food. Foster says 27 trees covering one acre willlsupport 10 - 12 people for 8 months.

k. ARTOCARPUS integrifolia, the Jack fruit of Cochin China and Southern China, was recently introduced to the Antilles. The fruit has a powerful odor of melon "and is quite unbearable to persons offa weak stomach, orthose not accustomed to it."

B. CANNABACEAE-

1. HUMULUS Lupulus is the hop, while H. Japonicus is cultivated as an ornamental.

2. CANNABIS sativa is the hemp of commerce.

3. CANNABIS indica produces hasheesh. The use of this drug spread through India, Persia and Arabia during the early Middle Ages. In the 11th and 12th Centuries the Hashishin, a sect of Moravians, while under the influence of the drug, used to kill many Crusaders. The plant is largely grown in India and Turkestan from where the leaves and stalks come into commerce as bhang. The resin contains the narcotic principle.

C. ULMACEAE-

1. The flowers of elm often become declinous by suppression. The perianth is composed of 4 - 6 leaves and 4 - 6 stamens. The ovary is unilocular with 2 carpels but 1 ovule.
2. CELTIS has a curved embryo while the pericarp tastes like date.

D. URTICACEAE-

These are mostly herbs often bearing stinging hairs, with watery juice and green unisexual flowers borne in catkins.

1. URTICA dioica is the common nettle. "Flogging with fresh nettles was formerly resorted to by doctors to produce a healthy counter-irritation of the skin. This practice named urtreation is still successfully adopted both in civilized countries and among savages."

ORDER SAPINDALES-

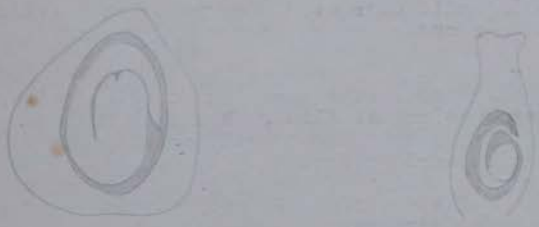
According to Engler they are like the GERANIALES and mostly woody except that the seeds either hang with dorsal raphe and micropyle directed upward, or ascend with ventral raphe and the micropyle underneath. Then Engler calmly points out that the seed features do not hold. He recognizes 11 suborders. Bessey defines them as follows: Flowers mostly actinomorphic, perfect or diclinous, pistil 1 to several celled, superior to inferior, ovules 1 to 2, erect or ascending, or pendulous, endosperm mostly none. He says the SAPINDALES lie wholly in a phyletic sideline and the order has been developed from some part of the intermediate order CELASTRALES, which constitutes a transition from the lower hypogynous cup flowers to those in which epigyny is fixed. In the lower SAPINDALES hypogyny still persists, but in the higher families this gives way to complete epygyny. But Bessey includes in the SAPINDALES the families JUGLANDACEAE, BETULACEAE, FAGACEAE, MYRICACEAE, JULIANIACEAE, PROTEACEAE of which some representatives have epigyny. Many authorities, however do not include these families in the order at all. It is thus best to follow Engler's plan.

A. BUXACEAE-

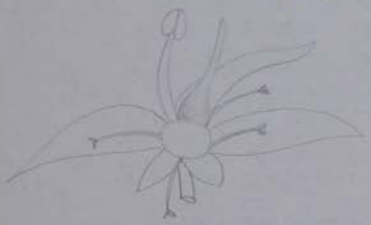
1. BUXUS sempervirens, the Box, is used as an ornamental. It has been substituted for hops in beer with serious results because of an acrid poison.

B. EMPETRACEAE-

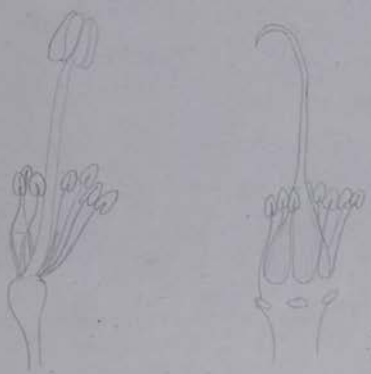
1. General characteristics: These are the crowberries. They bear a resemblance in habit to the heaths. The flowers are unisexual but often bear the rudiments of the other sex. They have both calyx and corolla. The staminate flowers have episepalous stamens while the pistillate have 2-3 or 6-9 united carpels. The seed has a ventral raphe and a single integument. The fruit is a drupe having 1 - 9 stones. These plants look very much like ERICAS with needle-like leaves, and Nuttall even tried to place them near the Conifers. The xerophilous leaves are furrowed below. In COREMA the furrows are lined with hair. There are only 5 species found in 3 genera.
2. Genera.
   a. COREMA Conradi has brilliant crimson anthers and later produces leathery drupes. It forms carpets on sand hills in New Jersey, Long Island, Matha's Vinyard, Nantucket, Cape Cod, Plymouth County, Prince Edward Island and Magdalen Island. It is also found on quartzites of the Shawangunk Mountains of New York and on the granites of Maine and Nova Scotia.



embryo condition



MANGIFERA staminate flower showing position of fertile stamen



ANACARDIUM pumilum

CASHEW

b. COREMA alba of Portugal and the Azores is the only other living species of this genus while a species called C. intermedia lived in Southern England and in Netherlands in the Pliocene.

c. EMPETRUM atropurpureum, which grows at the Gulf of St. Lawrence, has plum colored fruit and wooly branches.

d. EMPETRUM Eamesii, which grows from Newfoundland to southern Labrador, has translucent red fruits

e. EMPETRUM rubrum grows in Patagonia.

C. ANACARDIACEAE (TEREBINTHACEAE) -

1. Affinity: The flowers, which are usually small and massed into clusters, are perfect or unisexual through abortion, usually regular with 5 parted whorls. The torus is flat, concave or convex, and sometimes produces a columnar gynophor or a disc. The stamens are 3 - 5 and usually equal in number to the petals. The carpels, which are 3 - 1 and seldom 5, are free or several are united each containing 1 ovule which is inverted and has its raphe turned to the dorsal side of the carpel. The styles are usually united. The mesocarp is resinous but no endosperm exists. These plants are best developed in the tropics of both hemispheres though many run into the temperate regions.

2. Genera.

a. MANGIFERA indica, the mango which is now widely cultivated is a native of oriental tropics. The yellow fruits are the size of a goose-egg, but sometimes even get to weigh 1 kilogram. They are filled with sugar and citric acid. The mango is to the tropical peoples more important than the apple is to us. De Candolle says that it is in cultivation 4000 years. It is found today growing wild in the mountains of India. There are many references to it in Indian literature and the Indians even have annual celebrations in its honor. The emperor Akbar who reigned in the 16th Century planted an orchard of 100,000 mango trees. The Portugese probably carried the plant to Africa and then to South America where it was first grown in Brazil and then later in the West Indies. The trees are evergreen and often grow very large, one at Bahia, Brazil, has a trunk 25 feet around, is 70 feet heigh and has a spread of 125 feet. The leaves are leathery and 6 - 16 inches long and when crushed emit the odor of turpentine. The leaves are borne in "flushes; that is in periodic growth periods. The flowers are borne in panicles a foot or more long with 2000 or more to a cluster. They are polygamous. The staminate are more numerous and have but one pollen bearing stamen, the other 4 being abortive or staminodial. The fruits vary much in shape and size being reniform, heart shaped, ovoid, ellipsoid; with skin smooth, yellow or greenish yellow, sometimes flushed crimson and ver very beautiful. The aroma is often spicy. The stone is larg large, flattened and usually bears long tough fibers which extend into the juicy flesh. The flavor is hard to describe Some say it is like apricot and pineapple combined; others, like peach. Popenoe says: "Neither of these comparisons conveys an accurate idea of the delicious piquancy and fragrance of a perfect mango, rich and sweet, yet never cloying, and overrunning with lucious juice". Sometimes seedlings

produce fruit that smells of turpentine but Jumelle remarks: "there are those who do not like it because it smells of turpentine, there are others who come to like turpentine because it reminds them of the mango." The mango is really a dessert fruit, yet in India it is made into custards called "mango phul" and is spiced and dried into cakes while in Cuba it is used for jams and preserves.

b. PISTACIA lentiscus, the mastic tree, grows in southern Europe, northern Africa and western Asia. Mastic is the resin obtained from incisions in the bark. It comes mostly from the Island of Scio and from Asiatic Turkey. The Turkish ladies spend most of their time chewing mastic to sweeten the breath and strengthen the gums. Oil is derived from the seeds.

c. PISTACIA vera is the pistacia nut of the Mediterranean and the Orient. The fruit is ovoid, the size of an olive, and contains one seed with an oily, mild kernel. The nut is used in confections, in icecream, or is eaten raw.

d. PISTACIA Terebinthus produces Cypress Turpentine which was once much used in medecine.

e. SCHINUS molle of Central and Southern America produces the American mastic.

f. ANARCARDIUM occidentalis, the cashew, is closely related to the mango. In A. pumilum, the one fertile stamen is on a level with the stigma. The first species has a very queer fruit, the terminal nut being borne on a fleshy receptacle. Both are edible; the nut being the cashew-nut while the receptacle is the cashew apple. The nut is roasted and eaten, or its oil is extracted. The shell is very acrid and even the fumes from the roasting nut are very irritating, having the same effect as poison ivy. The sweetish sour apple according to Engler "wird von den Negern genossen". The tree yields a kind of varnish which repels white ants. The tree, which is very tender, grows 20 - 40 feet high. It is now cultivated in both tropics and at the extreme south of Florida.

g. SPONDIAS sp. produces the Brazilian plum, an edible fruit having the odor of a quince and the acid flavor of a poor mango.

h. RHUS, a genus of 120 species, is represented chiefly in the subtropics and in warmer regions. They are called TURPINIA by Rafinesque because of their resinous property. Engler divides them into four sections. The flowers are polygamous. The calyx is 5 parted and there are also 5 petals. The stamens are inserted on a disc with tubular filaments and ovoid anthers. The ovary is almost globose, with the hanging seed rising from the baseal funicle. The styles are three. The stone-fruit is often hairy while the mesocarp is resinous. "Lemonade" can be made from the crushed fruits of R. glabra and R. typhina. R. Toxicodendron is the poison ivy. For poisonous features see Pammel p. 608. R. Vernix and R. vernicifera both yield lacquer. R. vernicifera of Japan produces the best. The juice which is milky turns black when collected due to the enzyme laccase. Many plants of this genus produce dyes.

D. AQUIFOLIACEAE.

1. Affinity: This family is one of dioecious woody plants that are often evergreen with 4 - 8 merous flowers and with hanging anatropous ovules. The embryo is minute and enclosed in fleshy endosperm. A few species of this family are of economic interest.

2. Genera.

a. ILEX opaca, the American holly with red fruits much used at Christmas, runs from Massachusetts south near the coast. A yellow berried form, forma Xanthocarpa, is known. The wood was once much sought by turners, whip makers and engravers. "For these various uses the wood is brought into Boston in pieces usually 15 - 16 inches long and 1 - 6 inches thick. Emerson says: "A handsome low tree with nearly horizontal branches and thorny evergreen leaves. The erect trunk is clothed with a smooth bark of an ashy gray, resembling that of the beech but somewhat lighter. On the older trees it is usually overspread with grayish Parmelias and Lecanoras and other bluish, whitish and gray lichens." The plant is generally free from insects. The wood is white, hard and satiny. This is a species deserving cultivation.

b. ILEX Aquifolium, the European holly, has shinier leaves than the American species.

c. ILEX vomitoria was used by the North Carolina Indians for making the celebrated "Black Drink", called Cassena or Yaupon. This was an exhilerating beverage containing caffein prepared from the roasted leaves of the plant. Only men were permitted to drink it during religious ceremonies.

d. ILEX paraguariensis was used in a similar manner for the emetic effect produced by the Indians to form the South American drink Juno Matè or Yerba de Matè. It replaces tea in Brazil and Buenos Aires and is consumed by thousands of tons. The leaves contain caffein.

e. ILEX verticellata is the so-called black alder or winterberry of New England.

f. NEMOPANTHES mucronata, the mountain holly, grows in our cool woods with beautiful claret colored fruit.

E. CELASTRACEAE.

1. Affinity: This family differs from the AQUIFOLIACEAE in having a large disc, arillate seeds, a large embryo, and other technical points. This family is known since the Cretaceous, having run to Alaska, Greenland and Spitzbergen in Tertiary Times.

2. Genera.

a. EVONYMOUS is cultivated under the name Spindle Tree.

b. EVONYMUS atropurpureus, the Burning Bush or Wahoo, is very ornamental because of its copious crimson fruit.

c. EVONYMUS americanus, the Strawberry Bush, opens its crimson pods to expose the seeds with scarlet arils.

d. CELASTRUS, of which there are 27 species well scattered over the earth, is the Bitter Sweet. One of them is a native New England liane.

F. SALVADORACEAE.

1. Affinity: These are like the CELASTRACEAE except that they have 2 loculi, a weaker disc, and no aril.
2. SALVADORA persica, which runs from Eastern Africa to India, produces an edible drupe.

G. STAPHYLEACEAE.

1. Affinity: These differ from the above in having compound leaves, thus recalling the RUTACEAE. The ovary is trilocular.
2. Genera.
   a. STAPHYLEA trifoliata, the bladder nut, is not rare.
   b. STAPHYLEA pinnata grows in Southern Europe and in Asia Minor.
   c. STAPHYLEA colchica grows in the Caucasus, and S. Emodi in the Himalayas.

H. ACERACEAE.

1. Affinity: This family is closely allied to the last families. Thus they have perfect or unisexual flowers which seem to be running toward anemophily as exemplified by A. negundo. They seem to be reducing the flowering parts as is shown by the fact that they often abort. A large disc is present. The ovary is two-loculed yet trilocular ones are not rare as variants. This fact is significant since the STAPHYLEACEAE have triloculed ovules. The fruit is a samara. The seeds are without endosperm and have no arillus.
2. ACER is a genus of 100 species and many culture forms. Palaeontology supports the circumpolar origin of the genus. It is one of the most abundant Tertiary fossils and in the Oligocene there were many sections of the genus growing in the arctic realm of Greenland, Spitzbergen, Kamchatka, etc. Pax has sectioned the genus into TRIFOLIATA, several Chinese and Japanese species; NEGUNDO; INTEGRIFOLIA, laurel-like forms of Asia; INDIVISA; PALMATA; SPICATA; RUBRA; MACRANTHA; SACCHARINA; PLATANOIDIA; GLABRA; CAMPESTRIA; and LITHOCARPA. The fossils ACER trilobatum belonging to the section PALAEO-RUBRA, and a species belonging to PALAEO-SPICATA have been found. The following are common species:
   a. A. saccharum, the Sugar or Rock Maple.
   b. A. saccharum var. nigrum, the Black Sugar Maple.
   c. A. saccharinum, the White or Silver Maple, which is a fine ornamental tree.
   d. A. pennsylvanifum, the Striped Maple or Moosewood, a small and slender tree of rich woods.
   e. A. Pseudo-platanus, an introduced species, is the Sycamore Maple.
   f. A. platanoides, the Norway Maple.

I. SAPINDACEAE.

1. Affinity: These plants are trees, shrubs or lianes. The f flowers are often unisexual and strongly zygomorphic, have a big disc, and are 4- to 5-parted. The ovary has usually three loculi, a fact which is significant because of the locular structure of the two preceding families. The stamens are usually 8. This is a big tropical family of 1050 species. Many of them are lianes which have curiously cleaved stems due to peculiar cambial activity. Some yield woods of great hardness,

iron woods, and some produceedible fruits or nuts. Many of the plants are poisonous.

2. Genera.

a. LITCHI chinensis or NEPHELIUM litchi is a common Chinese fruit with 15 - 20 varieties that are very productive. In fact one tree may produce four bushels of nuts. They are cultivated in Bengal and in the West Indies. The fruit has the consistency and flavor of a muscat grape, and is nearly round, 1½ inches in diameter, and has a thin red shell covered with rough warts. When fresh, they are filled with a white jelly-like pulp surrounding a large shining brown seed. The dried fruit resembles a prune. "The importance of the Lychee in the eyes of the Chinese is evinced by the fact that there are no less than 9 treatises on the Lychee by famous authors beginning with that of Ts'ai Hsiang in 1059 A.D., and extending to that of Wu Ying K'nei in 1826."

b. NEPHELIUM lougana is the Lungan or "Dragon's Eye". It is smaller than the Lytchee, yellow brown, and has about the same flavor.

c. KOELREUTERIA paniculata has been introduced from China to be cultivated here as an ornamental.

d. SAPINDUS Drummondi, growing from Kansas, to Louisiana, is the only species here.

e. SERJANIA lethalis has nectar from which bees produce poisonous honey. This honey is used by the Brazil Indians as an arrow poison and also as a fish poison.

f. SERJANIA curassavica yields a poison used by murderers. Its nectar is also poisonous.

g. AESCULUS species are put into this family by Gray although most systematists place it into the family HIPPOCASTANACEAE. He says: "seeds farinaceous but imbued with a bitter and narcotic principle." Pammel says: "By washing and boiling, the starch in the seeds may be utilized and this is done in France." Dr. Rusby says that in the South the crushed seeds are thrown into the water to stupefy fish (cf. SERJANIA). Fatal cases of poisoning of children has been reported from Texas. The poison is aesculin, $C_{15}H_{16}O_9$ plus H_2O, a widespread glucoside among the SAPINDACEAE, also aesculetin, paviin, quercetrin, argyraescin, aphrodaescin, and saponin.

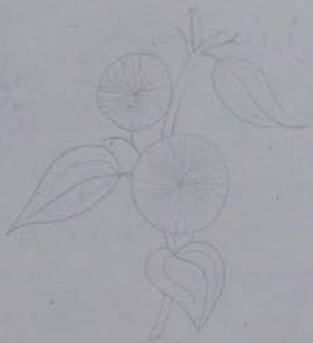
h. AESCULUS glabra, the buckeye, is used for making violins

RHAMNALES -

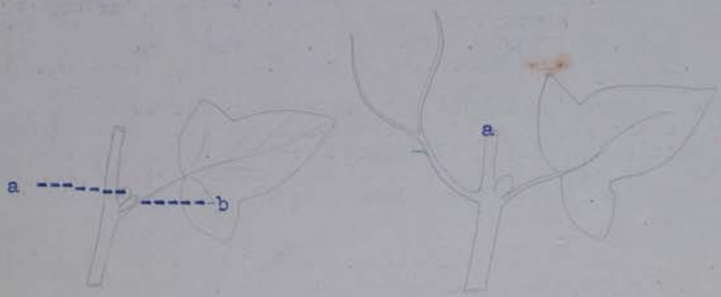
These are prominent woody plants with simple or compound leaves. The flowers have usually one whorl of stamens which stand opposite the petals and strong discs are developed. This small order attaches closely to the SAPINDALES and more particularly to the CELASTRACEAE. Epipetaly arises through abortion of the outer stamen whorl.

A. RHAMNACEAE -

1. General characteristics: This is the Buckthorn Family, a family of climbing lianes or shrubs, which are often thorny and have astringent or bitter qualities. The flowers are perfect or imperfect and have the following formula:
P 4 - 5 plus 4 - 5 A 4 - 5 G $(\frac{2 - 5}{})$ the calyx being usually synsepalous. The petals are borne on the calyx, while the stamens are on the disc opposite the petals. There is one ovule per cell.



CEANOTHUS americana



Brown's Theory

2. Genera.

a. RHAMNUS Carthartica is a hedge plant from the juice of which the "sap-green" of painters is made by the addition of alum and gum arabic. It is very purgative and now only used in veterinary medecine.

b. RHAMNUS Frangula of Europe furnishes charcoal used for making gunpowder.

c. ZIZYPHUS jujuba, one of a genus that furnishes edible fruit commonly called jujubi, is the Chinese date introduced more than 1200 years ago into China from Persia. There are many varieties. The pulp of the wild sorts is sweetish.

d. ZIZYPHUS lotus is the African date palm, Jew Thorn or Lotus. This is Tennyson's Lotus. "The purplish fruit resembles an olive." According to Theophrastus, the lotos was so common on Zerbi, the island of the Lotophagi, that a Roman army on its way to Carthage fed several days on the fruit. Homer mentions it as a lure from which Ulysses kept his companions. It forms an important food in Tunis and Barbary, and is now cultivated in southern Europe.

e. ZIZYPHUS sativa, a jujube cultivated in Spain, France and Italy, has scarlet fruit. It was introduced into South Carolina in 1837 and the seeds were sent out from the patent office in 1855.

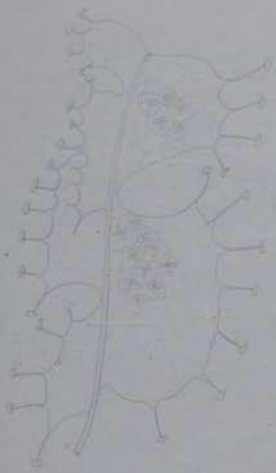
f. PALIURUS spina-Christi, the "Jew thorn", grows on dry stony soil in Southern Europe and through Asia Minor to China. This genus has odd horizontal wings arising from the receptacle that surround the fruit. It was common in Tertiary times.

g. CEANOTHUS americana, Red root or New Jersey Tea, is the Massachusetts representative of the family. It grows on dry sunny slopes. The minute white flowers in terminal clusters are followed by three-sided dry fruits. The leaves were used as a tea substitute during the Revolution.

B. VITACEAE-

1. General characteristics: These plants are generally thought to be climbers, yet LEEA is almost a tree. Most of them produce tendrils or cirrhi with fleshy discs for clinging. The tendrils are morphologically the same as the inflorescences and sometimes a tendril will produce berries, one half being an inflorescence while the other is tendrilar. Then also transitions from tendrils to discs may occur on the same plant. Thus Engler figures QUINARIA quinquefolia with an ordinary tendril wound around a nail while the others produce discs. The ontogenetic origin of the tendril has been interpreted by Brown. Each tendril has no leaf beneath it but stands opposite one. Furthermore in VITIS vinifera there is an alternation of 2 foliage leaves with tendrils and one without. The theory is that the axis growing forward develops a leaf on its side in the angle of which stand two buds: one growing forward and pushing the terminal axis into a lateral position as a tendril. The other bud then grows out into a so-called dwarf branch which is usually very small and dries up in autumn leaving only one of its own basal buds which the next spring develops into a long branch.

2. Genera.



PTERISANTHES

CISSUS cactiformis

inflorescences

seed

VITIS species

a. PTERISANTHES has a band-shaped and irregular floral axis upon which the flowers are strewn. The staminate are all stalked and stand on the edge of the plates while the pistilate sit on the flat surface or are sunken in it.

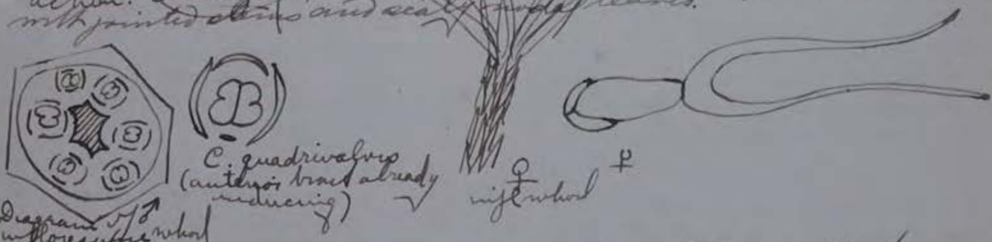
b. CISSUS tetragonia, C. cactiformis, and C. quadrangularis have fleshy green branches.

c. VITIS species throw off their perianths when they open. These tear away at the base while the tips are still coherent. V. labrusca is our northern grape, the parent of the Concord, Catawba, etc. V. vulpina is the northern fox grape. V. vinifera, the European wine grape, is much afflicted with PHYLLOXERA and for this reason is not grown on its own root stocks here. A small-fruited seedless race is much grown in Greece to produce the dried currants of commerce.

d. PSEDERA tricuspidata, the "Boston Ivy", is a Japanese species. It shows the modification of the inflorescence into clinging discs plainly.

Order Casuarinales After Parlin

This has always been a very questionable group of plants as to affinity. Engler considers it most primitive of all Dicots since they have as high as 20 megaspores in the nucellus. Their flowers are unisexual and anemophilous. The males consist of single stamen with an insignificant 2 leaved perianth and a pair of 2 bracts. These tiny flowers stand in whorls in the axils of webbed bracts and form catkins. The female fls are without perianth but produce 2 bracts. The ovary is 2 carpeled. Usually only 1 seed develops into a winged achene. Chalazog. The whole plant is often equisetum like with jointed stems and scaly [illegible] leaves.



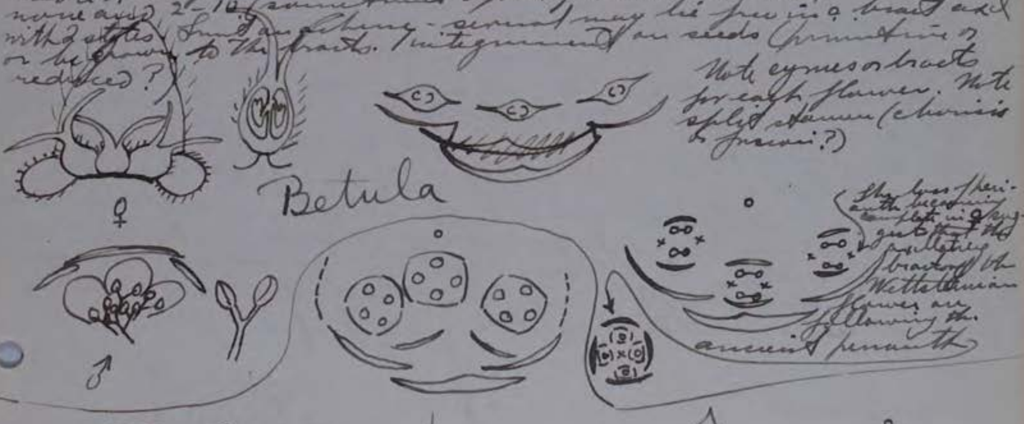
Order Fagales

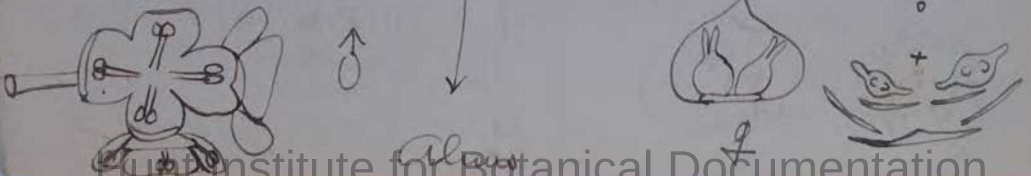
Woody plants usually unisexual and anemophilous without any perianth or else a bract-like calyx. Stamens same number as lobes and standing before them, or more. Carpels 2-6 and 1-6 loculed with 2-3 styles. Ovary inferior. Fruit a nut. Chalazogamy fairly prevalent.

Wettstein suggests an urticalian affinity

Betulaceae: Fls in catkins or heads, and these made up of secondary cymes (such compound infloresc. militate against a primitive phylogenetic position for such plants); monoecious. ♂ flo. more or less grown to the bract and with rudimentary perianth of none and 2-10 (sometimes split) stamens. Pistil 2-carpeled with 2 styles. Fruit an achene - samara may be free in ♀ bract axil or be grown to the bracts. 1 integument on seeds (primitive or reduced?)

Note cymes or bracts for each flower. Note split stamen (chorisis or fusion?)



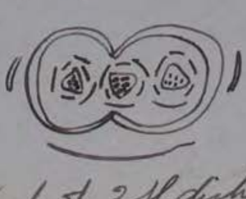


In Alnus note absence of 3rd carpel of dichasium (Betula has such) - Again note persistence of perianth in ♂ while ♀ has lost. The male is usually the conservative sex in plants - This supports the theory of great reduction.
The above [illegible] gives a hint of nature of inflorescences.
To the Betulaceae belong Corylus, the hazelnut, with achenes enclosed in a bristly involucre. Francy Smith comes up. C. americana, its northern limit being Middle N. England. C. rostrata (on the other hand) is a northern form even to Newfoundland. It is the hazel nut of northern markets. Rather more uncommon here. Ostrya, the hop hornbeam - has achenes in closed hop-like pods; valuable "iron-wood" when wood must compete with metal.
Carpinus carol., the Blue Beech, is small tree of stream banks with "muscular" trunks due to aggregate rays. Nuts in open involucres.
Alnus incana is common. Wood with aggregate rays. Much affected with Exoascus alni-incanae. There are 3 Black birches with us and several also in eastern Asia. B. lenta is the sweet or cherry birch from which oil of wintergreen is made frequently. Black birch of colder canadian zone is B. lutea with dull gray-yellow shaggy bark. B. lenta does not run north of S. Maine. B. nigra, the Red birch, has rhombic leaves. White birches vary from white to brown. These run farther north than any other deciduous tree. The birches are very much mixed up both systematically and geographically. On Anticosti for instance there grows a Balkan white birch; along Penobscot there is a weeping form known also in S. Russia; a white form identical with one in Japan grows in Green Mts.
B. populifolia is our common gray birch. Del. to P.E. Island in sterile soils. Bark is close and not exfoliating. It tends to die young particularly in swamps. Canoe birches have creamy or pinkish exfoliating bark. B. papyrifera when young has brown bark which in cold climates remains brown throughout life of plant. B. pumila is a little birch of the tundra which grows prostrate.
Fagaceae: Inflorescence similar to that of Birches. ♂s produce perianth but many stamens which are not split. This might be due to chorisis. There seem to be about 5 fls in dichasia but only middle one develops. Carpels are 3-6. Fruit is a nut in an involucre. This is really an outgrowth of the axis beset with tiny leaves (Well seen in young chestnut) Castanea sativa forms food of poor Italians etc. Meal is roasted, boiled, etc.

Chestnut

2

Quercus



Chestnut - 3 fl. dichasia

The beech (Fagus grandifolia), Chestnut (Castanea dentata), Nothofagus (which grows in antarctic S. Am., N. Zealand and Australia) should be mentioned.

Quercus is the big genus - famous since prehistoric time - sacred to Odin - mistletoe.

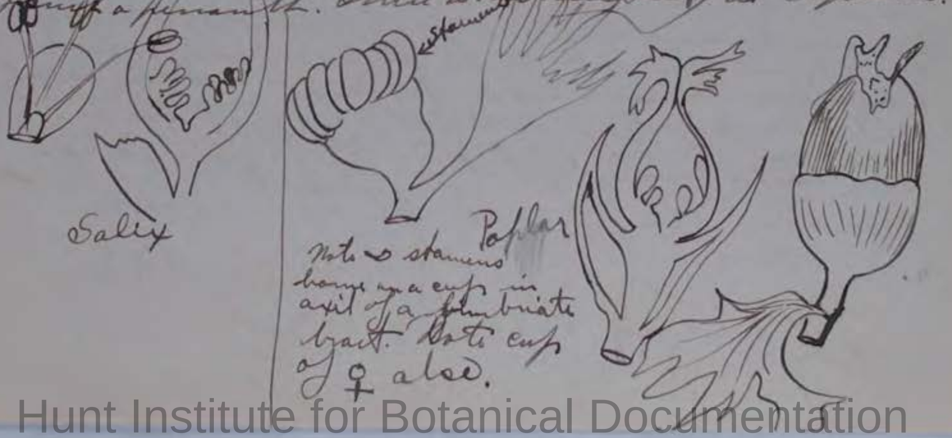
2 general groups: (1) White oaks produce pale flaky bark, 6-8 stamens with corky scales, sessile stigmas, abortive ovule at base of nut, shell smooth inside, flesh sweetish. (2) Reds (Erythrobalanus) have dark bark, bristle toothed leaves 4-6 stamens, thin scales, spreading stigma, abortive ovule(s) near top of shell, which is pubescent inside, flesh bitter. ¶ White oaks are all over Eurasia but red oaks are all American. In tertiary they ran through Eurasia. In South, Q. virginiana, etc. are evergreen. The deciduous habit is thus shown to be a recent acquisition. White oak acorns were much used by Indians for food. Baskets of parched acorns hid in the ground were found by the Pilgrims Dec 7, 1620. - Others used over world for humans and hogs.

Myricales: Here belongs the sweet fern of our pastures. M. asplenifolia, which has nitrogen fixing bacterial nodules on roots, and M. Gale are distributed throughout Eurasia and America in swamps, as well as the wax myrtles. M. caroliniana and M. cerifera were used to make bayberry candles.

Juglandales: Here there is a single loculus and 1 seed but 2 styles and an inferior ovary. Genera Juglans, Carya.

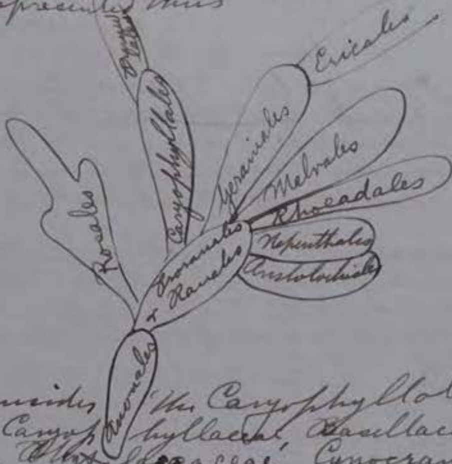
Salicales: Woody plants with unisexual, anemophilous or entomophilous fls. Perianth lacking or usually much reduced. Stamens 2-∞. Pistil 2 carpelled 1 loculus with ∞ ovules. There is little question but that the willows are a reduced group. In the axils of hairy bracts stands the 2 (one group for ♂) 2-5 stamens, or pistil accompanied by a nectary.

In a recently described Indian poplar, P. glauca, there are hermaphrodite flowers with perianth. This would tend to make Populus the older genus. All poplars produce a cup or disc around the pistil; this may be the remains of a perianth. There is no nectary in Populus.



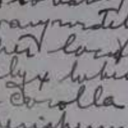
A few willows worth noting: S. nigra which is very characteristic of sandy stream banks - gets to be a tree 30 ft. high leaves long, lanceolate, shining above with large stipules. S. lucida, Shining Willow, rare with us but abundant in Vt. but hardly goes farther north. S. fragilis (introd) has branches that snap at trunk, thereby aiding propagation. S. babylonica is our weeping willow.
S. longifolia has linear leaves, is a sand bar willow of the interior not common here - forms dense clumps. S. cordata is another thicket former of rocky banks. Young foliage glaucous below, stems come out with leaves.
S. discolor - commonest "pussy willow" of swamps - it opens fruit before its leaves appear and in warm places it catkins almost all winter - twigs glabrous.
S. uva-ursi is another willow which gets to summit of Mt. Washington. Grows prostrate and spreads flat up to an area of a meter.
All in all willows are cooler land plants, none in tropics. We have some 10 spp. then are 2-3 along gulf, while in St. Lawrence and Fraser region there are 50, in Canadian Rockies 40-50 and very many in Alaska. S. lucida and discolor became true at July 1 St. Lawrence but dwindle with us. (read Algernon Blackwood "The Willows")
Populus has 2 subgenera: the Aspens and Cottonwoods: of the former we have two natives. P. tremuloides, a sterile land land tree is a "fire-weed" used in pulp making. Among the Cottonwoods are P. balsamifera with leaves brown beneath and resinous odor - a nice tall tree and pioneer on sand bars - good for pulp.
P. candicans, the "Balm of Gilead" differs in having twisty petioles and leaves silvery beneath. This is a queer tree with many a known indigenous home. Described 1780 by Aiton of Kew, as a tree brought from N.A., but early colonists brought it from England. It is not known native here but is naturalized abundantly along Conn. River. Several Chinese and Siberian spp are allied.
P. nigra var. italica - Lombardy poplar. Brought by French, Dutch, Eng. to America for timber wood. It was early naturalized and Michaux thought it a new species. It is a sexless sport from P. nigra and cultivated for 2-3 centuries by cuttings. Has best spp.

We have now considered the following Ranalian derivatives: Aristolochiales, Nepenthales, Rhoeadales, Malvales, Geraniales (with Anguliferae). All except the Geraniales seem to represent blind alleys, but these we shall hear of again when we come to the sympetalous Ericales. There remains two more direct Ranalian derivative orders to study: the Caryophyllales (Centrospermales) and the Rosales. Both are ancestral to higher orders. The linkage up to this time may be represented thus



We now consider the Caryophyllales:
Families: Caryophyllaceae, Basellaceae, Portulacaceae, Aizoaceae, Cactaceae, Phytolaccaceae, Cynocrambaceae, Batidaceae, Nyctaginaceae, Amarantaceae, Chenopodiaceae, Polygonaceae.
The following features make a fairly natural order: They are usually herbs. The primitive forms possess calyx and corolla but higher forms show much reduction ending in the green wind-pollinated Chenopods, etc. with tiny flowers massed in ball-shaped inflorescences. Primitively the floral formula was P_{5+5} A_{5+5} $G_{\underline{(5+5)}}$ or ∞ but it reduces to P_5 A_5 $G_{(\underline{2})}$ or 1. Certain features of the order are (1) tendency of carpel walls to break and to produce 1 loculus (2) Campylotropous ovules (3) Curved embryo (Once called by B & H. Curvembryae) (4) tend to live in extreme ecological conditions — salt soils, serpentines, rich garden soils.

Phytolaccaceae.
Probably nearest the base and closest to the Ranalian stock. Carpels rarely united and are sometimes even free, but seeds are reduced to 1 per loculus (cf. Buttercup), stamens either of same number as calyx lobes or ∞. In only Stegnosperma and Limeum is there a corolla. Have curved embryo and lead into Caryophylls. Produce perisperm.



Phytolacca decandra

The 10 stamens arise through splitting of outer set. Inner set is gone. In P. icosandra there are 20 stamens for the inner set is present and also splits.
So really P_5 + (5 [illegible]) A_{5+5} G_{5+5}. This formula leads on one hand to the Caryophylls and Portulaca, Aizoaceae and Nyctaginaceae; while another commonly type P_{5+0} A_5 G_5 (to less) leads to Chenopods

or Amaranthus. The Phytolaccaceae are of trifling importance economically. Anomalous is the Poke berry, P. decandra. The berries are poisonous but the young shoots blanched in the cellar are equal to asparagus. The relationship of Phytolaccaceae to the others is:

Caryophyllaceae
Amarantaceae — Phytolaccaceae — Aizoaceae
Chenopodiaceae — Portulacaceae — Nyctaginaceae

Nyctaginaceae. These have their calyx colored like a corolla and always investing the ovary with a hard leathery base to produce an "anthocarp". After the flower is a showy involucre associated. Stamens rarely 1 but carpel is 1 and with 1 ovule. Embryo curved.
In Mirabilis the calyx is gamosepalous. This is the famous 4 o'clock or Marvel of Peru. Pollen grains large. Bougainvillea a greenhouse plant, has bracts of magenta purple or red hues.

Aizoaceae. Resemble Phytolaccaceae through Mollugineae. Only difference is that carpels produce several seeds instead of one. But some genera produce 1 seed per locule and are by some classified with Phytolaccaceae. While Telephium sometimes has with Caryophyllaceae. In the Ficoideae the ovary is inferis.
The group should be remembered as one which is remarkably adapted to dry land habitats and related to Cacti. Leaves may reduce to scales or become succulent with a watery tissue in the middle and chlorenchyma superficial. In Mesembryanthemum the epidermis may be covered with waxy papillae or hairs etc., giving a grayish color to the plant. The stems of all the perennial forms are polydesmic.
Mesembryanthemum is the peculiar and big genus with 300 spp of dry desert S. Africa. 2 genera go to the Mediterranean region and the Canary Islands. Some have a remarkable distribution. M. crystallinum, the "Ice Plant" runs from Cape of G. Hope to Canary Isl., the whole Medit. region, S. and W. Australia and California. M. nodiflorum in Cape, Canaries, Medit, Arabia, Egypt. M. acinaciformis in Australia, Chili, Calif.
Bentham divides them into 64 groups.
The species are not well understood because of the difficulty of making herbarium specimens.
The flowers are very cactus like, and white, red or yellow, mostly terminal, usually opening in sunlight, but few expanding in evening.
Calyx lobes 5 petals very many, and linear in 1 to ∞ rows, united at base, stamens very ∞ in ∞ rows and united at base, ovary usually 5 celled, ∞ ovules, embryo curved in mealy endosperm.
Many are succulent. Some of the desert forms are colored like the earth for protection (?); others sink their great bumpy leaves almost under the earth and allow the light to penetrate through a transparent tissue at tip of leaf (window-leaves).
M. crystallinum covered with little vesicles resembles hoar frost.

Conclusion: Run into Phytolaccas through Mollugo on one side and on the other into Cactaceae through Mesembryanthemeae. Mesembryanthemum with its distribution, confusion in spp., sections of genus, odd ecolog. forms)

Cactaceae:

Through habit and flowers the Aizoaceae lead over to the Cactaceae. In fact as we have seen the Ficoideae of the Aizoaceae have half-inferior ovaries. The Cactaceae have reached full epigyny. Bessey who makes much of epigyny compares it to Rose derivatives and so attempts to derive Cactaceae from the Myrtales.

Cactaceae of course are remarkable plants ecologically. ~~[illegible]~~ Safford says "Scarcely any group in the whole vegetable kingdom is more remarkable for its strange and varied forms, the beauty of its flowers and wonderful adaptations to desert life." Not wholly a desert group for in moist forests of tropical America there are interesting forms which may be epiphytes or scramblers ~~with beautiful~~ - flowers beautiful and fruits often edible.

An American genus entirely. Painters frequently depict them in Biblical scenes. Rhipsalis, a plant with the habit of a mistletoe has spread to Africa and even Ceylon. They take kindly to foreign soils. The Opuntias have spread to Mediterranean Africa and Australia. Often great pest.

In general a southern group but a few run into British Columbia. Opuntia vulgaris reaches Nantucket and r. mo. south to South Carolina near the coast. The great center for the xerophytes is the S.W. United States and Mexican plateau and lower Calif. where there are cactus forests. Run south to Chile and Argentina. Giant columns and prickly globes are scattered over the pampas of Uruguay while melon-shaped echinocacti live amid the snows of Bolivia. The stems offer bewildering variations morphologically.

Lowest stand the Pereskioideae. They have cylindrical stems and flat green leaves - some are climbers. P. aculeata is cultivated as the Lemon vine, Blade apple or Barbados gooseberry. Its fruits are size of an olive, yellow, edible, and used in West Indies for preserving. Pereskia is used as a stock for grafting other cacti.

Opuntioideae: These have lost their flat leaves but the stems often flatten out to take their place. Really leaves are present in all cacti but in some species they are extremely vestigial. In the Opuntias they are often fleshy, awl-shaped and caducous. Pereskiopsis offers a transition from the flat feather-veined leaves of Pereskia to the awl-like uni-veined types. The curious cushions of spines in the axils of the leaves are probably abortive branch clusters. In Opuntia the cushions also bear glochidia, minute barbed bristles which enter skin easily and cause intense irritation. The ~~spines do~~ spines do not link up with the vascular system - vary much - simple and awl-like or conical; bent like hooks, curved into horns, sometimes downy or hairy, clustered like stars or in comb-like bundles, along 2 sides of an axis. The organ cactus, Myrtillocactus geometrizans has an erect spine like a dagger blade and radials like a guard for the hilt. [illegible]

Lophophora aselliformis whose spines look like soap bugs (Aselli)
among Opuntioideae. Opuntia is the big genus. Many have edible
fruits. Thurber A. Ficus-Indica (seems to be same plant
as A. vulgaris) is sold in markets as Indian fig. Red to orange,
prickly, pulpy eating because rough spines fall off. Nochidia
remain. The plant ranges from Georgia to Penn and is introduced
to southern Europe. In Sicily it flourishes on the bare lava hills
are very fine and sweet. Other species also produce edible fruits
C. cantachina of Am. S. W. is eaten by Indians and the leaves are
roasted. O. Engelmanni is treated in same manner. O. tuna is the
Indian fig of S. California, Mexico, Ecuador, W. I. Cultivated in
California for fruit and as a hedge plant - grows 15°-20° fruit much
used by Indians & Mexicans. Used by Cortez' Spaniards in
march upon Mexico in 1519. From the lava slopes of Mt Etna
the fruit is collected and sold in markets. In Texas they must
reasonably be used as cattle feed though not fruit foods rather
they are pithed in heaps and the spines burned off. Nopalea
coccinellifera is host for cochineal insect.

Cereoideae: These are the extreme forms among Cacti. They lose their
leaves and usually have columnar, globular, or angular stems
seldom flat. There are many important genera. The genus Rhipsalis
(rat-tail cactus) is sometimes epiphytic & has segmented stems
Mayenllana has tall-shaped stems. Their red fruits resemble
small chili-peppers and are called "chilitos."
Echinocactus longihamatus furnishes "cactus limes" - acid in taste.
Same Cephalocereus spp are trained over garden walls and produce
enormous juicy fruits of fair flavor. C. senilis has a "cephalium"
covered with white hair. To Cereus belongs the great C. giganteus as well as
the famous "Queen of the Night" and many spp. with edible fruit. The
fruit of Lophophora Williamsii is the famous "mezcal button."
Regarded by Indians with superstitious reverence - Produces effect of
hashish - visions - used in mysteries. Flower structure: In
Aizoaceae we found a structure and by the Sicyoideae of Ps + ∞ A ∞
G 5 or ∞ and half inferis. In Cacti this goes on to conclusion.
The perianth has 3 members and the outer leaves are often calyx-
like and grades into inner as in Nymphaea; stamens ∞ and
on perianth tube; style and a star-like stigma that is often
conspicuous. After the parietal ovules, the funiculi become
fleshy in fruit and produce a sugary pulp. This parietal
feature shows a strong resemblance to the order Parietales
supposed to the Rosaceae derivatives and may mean a
real affinity. Connection with Aizoaceae then becomes
a case of homoplasy. Ecologically the flowers of cacti vary
from white through pinks, reds, yellows, but never blue.
They are diurnal or nocturnal, some open at sunrise and
close at night or remain closed all day; others open at a
certain hour and close at another; fixed hours.

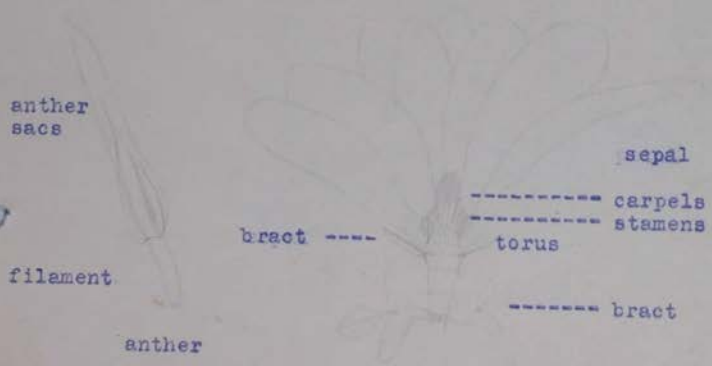
Last only a few hours, some for several days. Some fragrant, others ill-smelling, some odorless.
The odd structure of the cactus stem is result of adapt. to xerophytic habitats - Axis woody - broad cortex with water storing parenchyma. Stomata in depressions or grooves. Cell sap u. mucilaginous in some there are latex cells which hardens as gum when plants are wounded. Some Echinocacti are cut up and preserved — like watermelon rind. The reticulate skeleton of some Opuntias are made into walking sticks, legs of furniture or even veneering. In Lower Calif. Cacti are used for hedges - this is particularly true of the organ cactus Myrtillocactus geometrizans.
(Cactaceae: Confused in preceding treatment. As Aizoaceae (Ficoidiae derivatives) Structure of flower. Suggestion of Parietal affinity. Cactaceae - general: Geographic distribution (Note Rhipsalis & Opuntia). O. vulgaris in Mass. Anatomy of Cacti - use of stems in the arts. The Pereskioideae as basal members. P. aculeata (B. The Opuntioideae: Leaves of Cacti; spines of cacti and glochidia. The Cereoideae: general habit
(Read "Adventures of a modern occultist" for pleasure)) Sunday

OTTO DEGENER
BOTANY 58

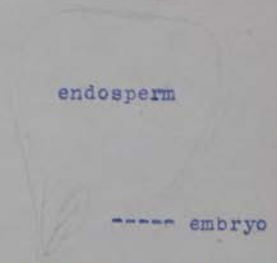
MAGNOLIACEAE

Magnolia leaf

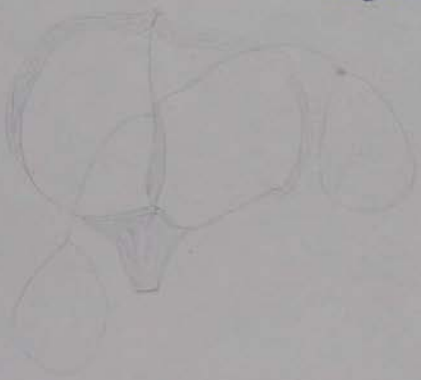
leaf of LIRIODENDRON Tulipifera

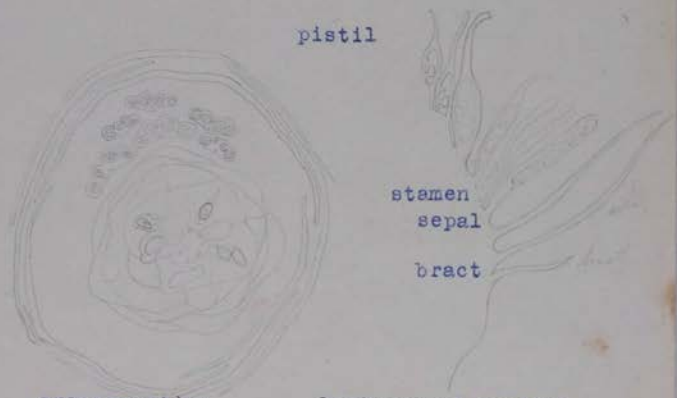


OTTO DEGENER
BOTANY 58



longisection of seed





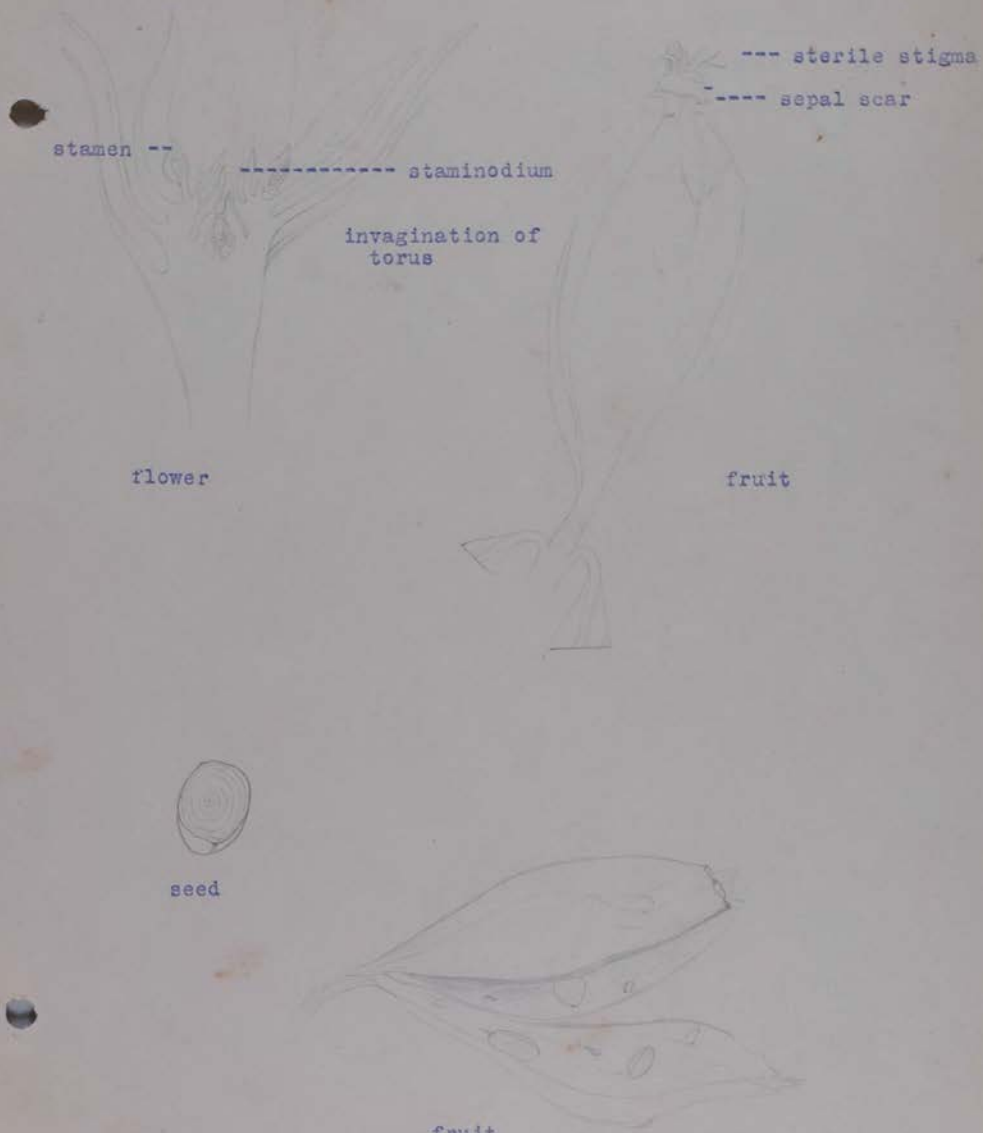
cross-section
LIRIODENDRON

logitudinal section

P 3 # 3 # 3 A∞ G ∞

CALYCANTHACEAE
CALYCANTHUS floridus

OTTO DEGENER
BOTANY 58.



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BOTANY 58

MONIMIACEAE

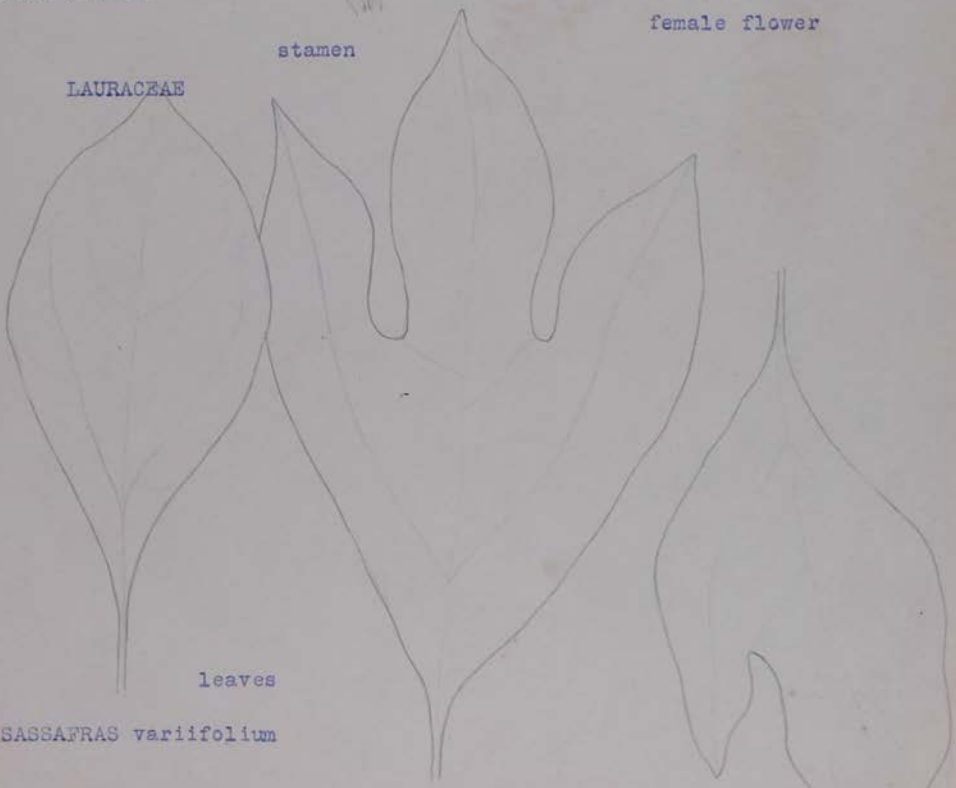
Male flower

valve

stamen

female flower

LAURACEAE



leaves

SASSAFRAS variifolium

OTTO DEGENER
BOTANY 58

G showing staminodia

fruit

SASSAFRAS variifolium

staminodia

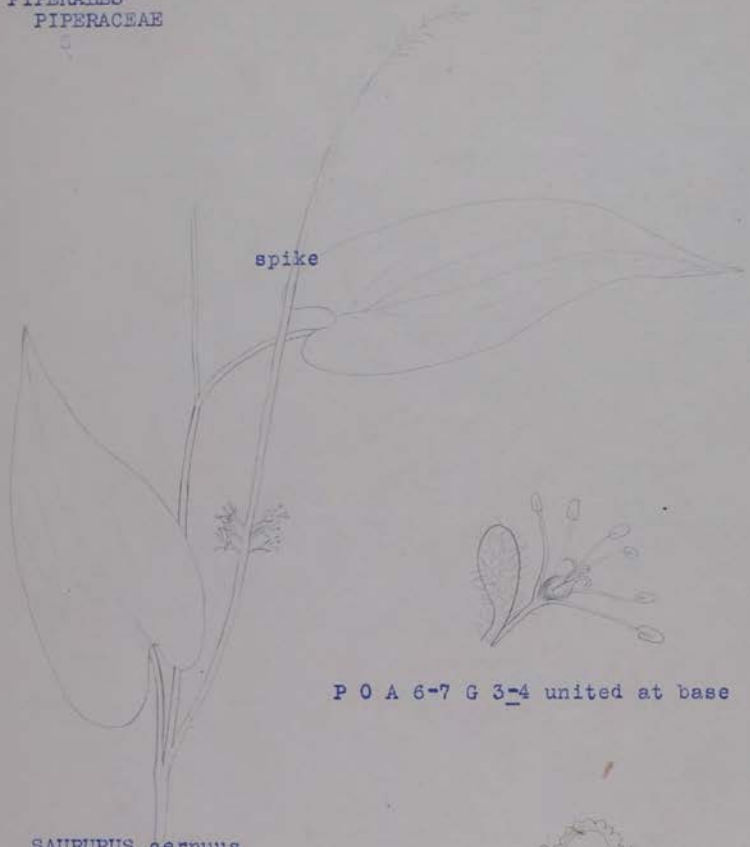
stamen

A showing staminodia and stamens

BENZOIN aestivale

OTTO DEGENER
BOTANY 58

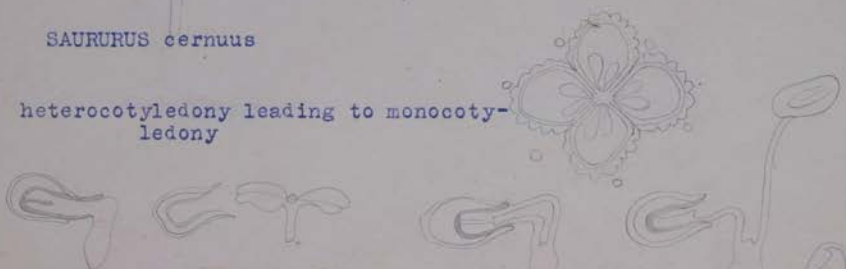
PIPERALES
PIPERACEAE



P O A 6-7 G 3-4 united at base

SAURURUS cernuus

heterocotyledony leading to monocotyledony



PEPEROMIA pellucida

PIPER peruviana

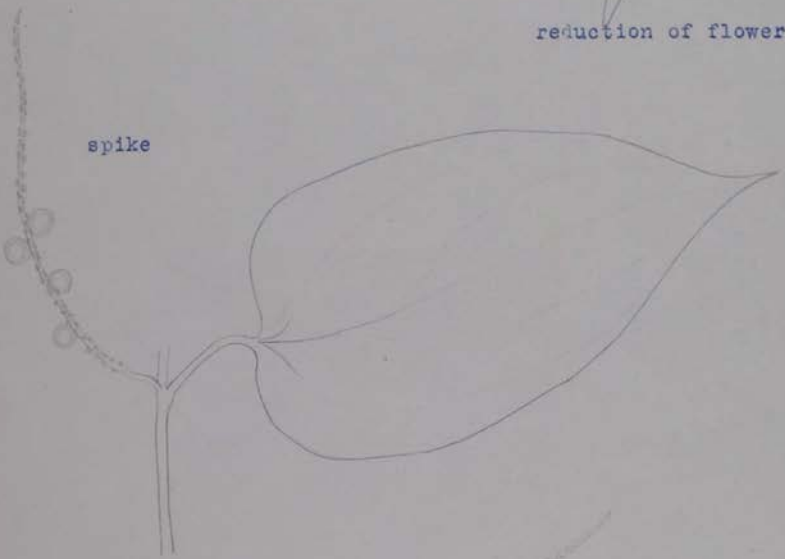
OTTO DEGENER
BOTANY 58

PIPERALES
Piperaceae

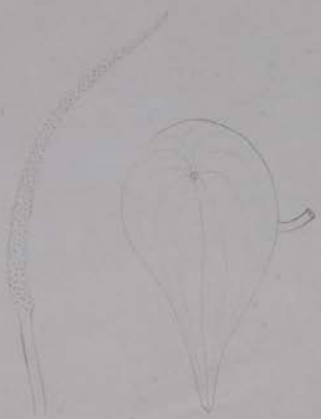
orthotropous
ovule

reduction of flower

spike



PIPER nigrum



PEPEROMIA pelucida

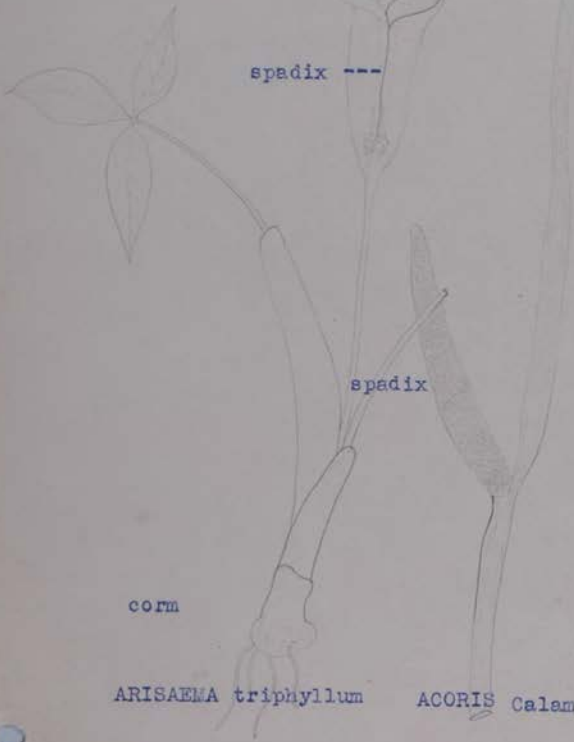
OTTO DEGENER
BOTANY 58

SPADICIFLORALES
ARACEAE

fruit

spathe

spadix ---



spadix

P 3 # 3 A 3 # 3 G $\underline{3}$

corm

ARISAEMA triphyllum

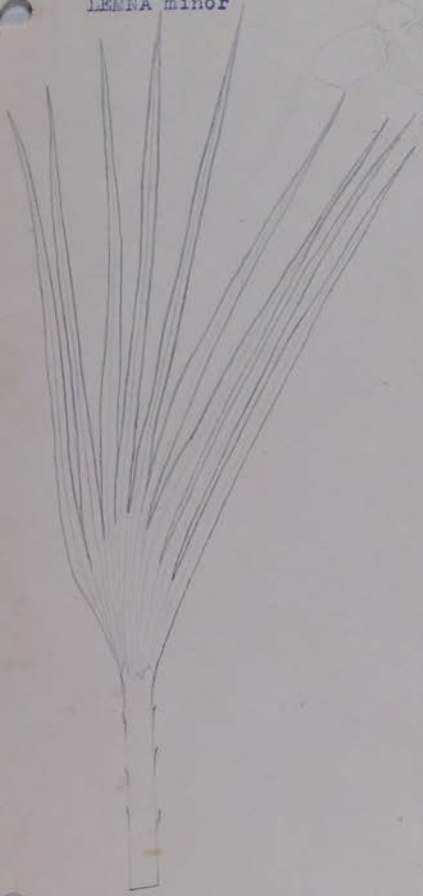
ACORIS Calamis

LEMNACEAE

OTTO DEGENER
BOTANY 58

L. trisulca

LEMNA minor



spathe

A

G

LIVISTONIA

PALMACEAE
LIVISTONIA sp

PHOENIX
A

OTTO DEGENER
BOTANY 58

SPARGANIACEAE

G A

---- endosperm
embryo

carpel

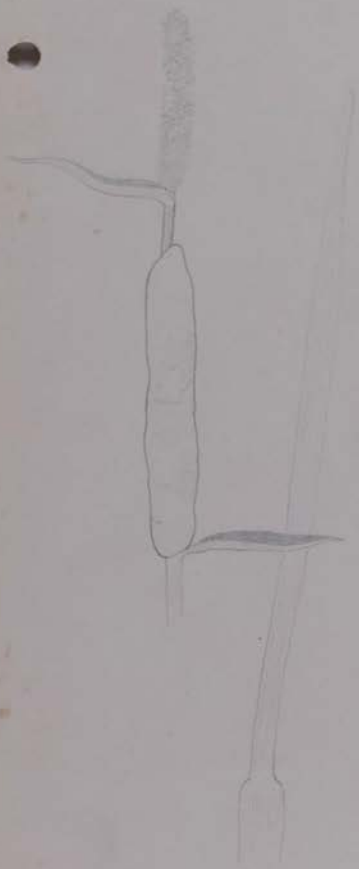
S. eurycarpum

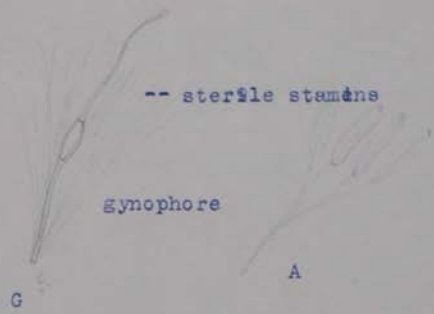
S. americanum

SPARGANIUM americanum

OTTO DEGENER
BOTANY 58

PHACEAE
TYPHA latifolia





tetrads of microspores

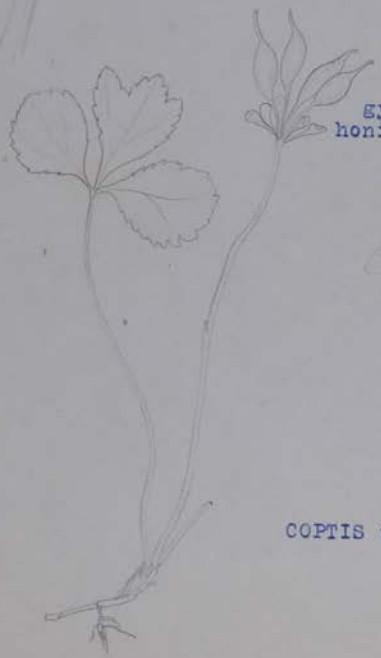
OTTO DEGENER
BOTANY 58

RANALES
RANUNCULACEAE

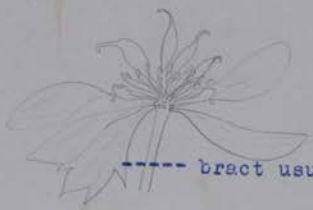
CALTHA palustris

carpels

stamen scars
sepal scars



gynophore
honigblaetter



staminodium

----- bract usually absent

COPTIS trifolia

OTTO DEGENER
BOTANY 58

XANTHORRHIZA apiifolia

---- honigblatt

follicle

petal

nectary --

achenes

RANUNCULUS sp.

OTTO DEGENER
BOTANY 58

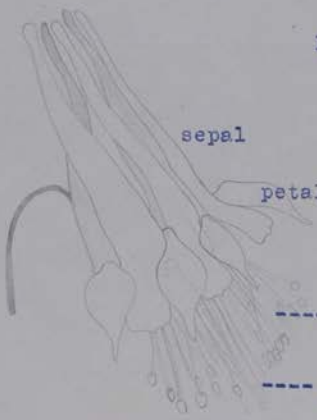
Development of spur from honigblatt:
(see Coptis, Ranunculus, etc.)

ISOPYRUM anemonoides

I. adaxoides

I. grandiflorum

AQUILEGIA hispanium

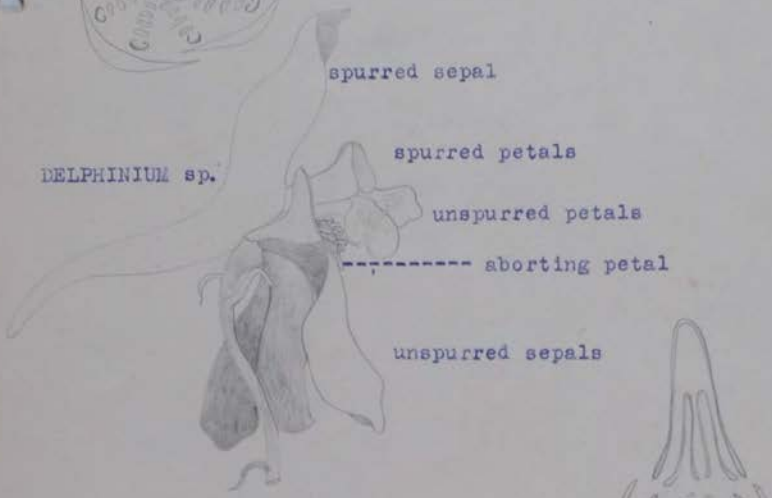


AQUILEGIA canadensis

OTTO DEGENER
BOTANY 58

NIGELLA hispanica

DELPHINIUM sp.



OTTO DEGENER
BOTANY 58

BERBERIDACEAE

petal

P_2 3 # 3 # 3 A 3 # 3 G $\underline{I}$

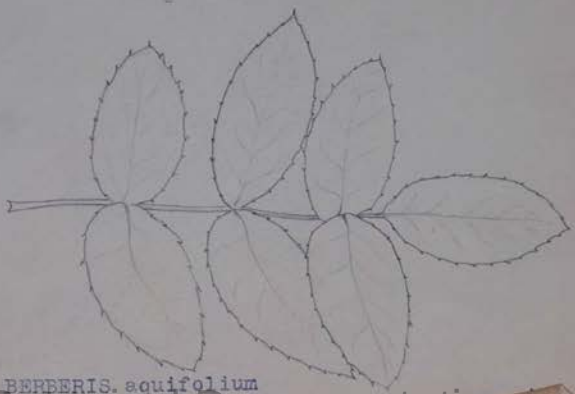
sepal

two-seeded carpel

unifoliolate compound leaf

BERBERIS vulgaris

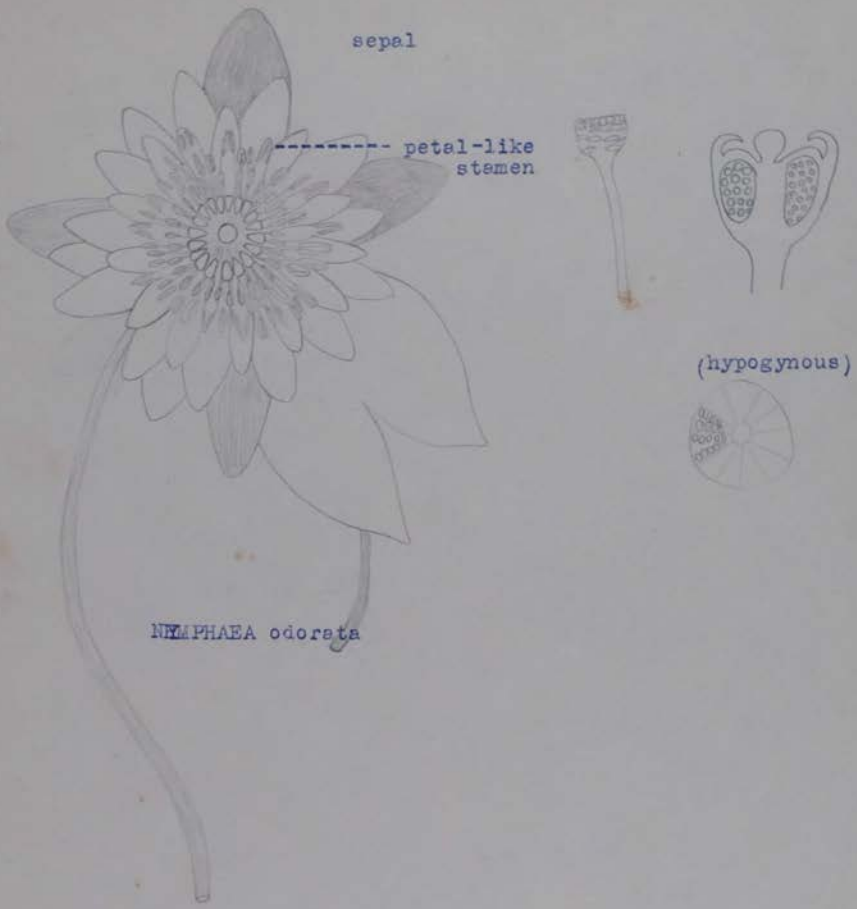
stamen



BERBERIS aquifolium

NYMPHAEACEAE

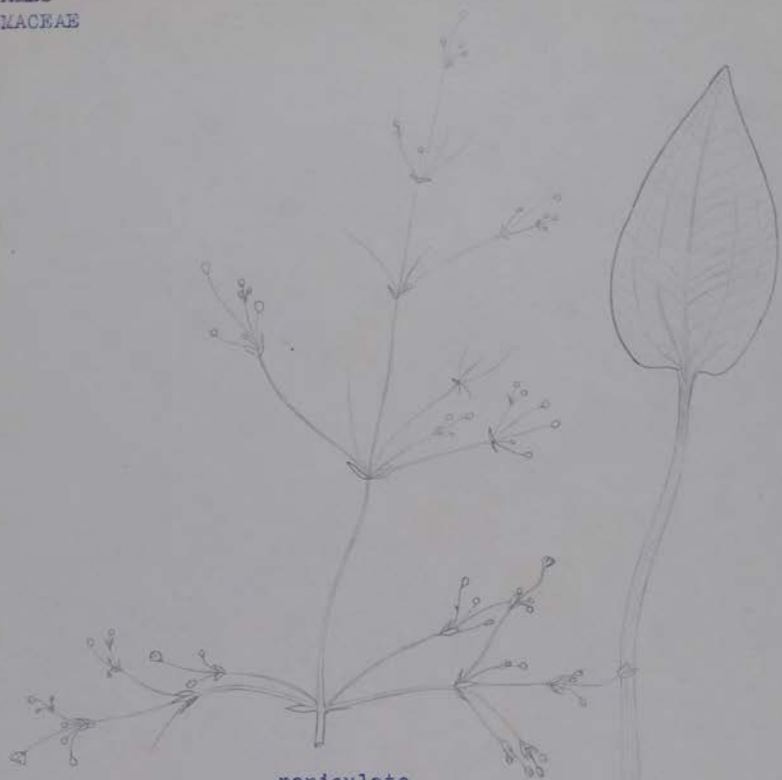
OTTO DEGENER
BOTANY 58



NYMPHAEA odorata

HELOBIALES
ALISMACEAE

OTTO DEGENER
BOTANY 58



paniculate
inflorescence

ALISMA Plantago-aquatica

A

G

coiled embryo

achene

SAGITTARIA latifolia

POTAMOGETONACEAE

OTTO DEGENER
BOTANY 58

spike

achene

POTAMEGETON epihydris

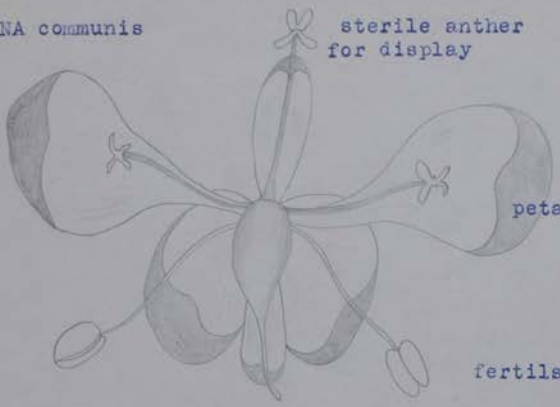
FARINALES
COMMELINACEAE

habit sketch

TRADESCANTIA

OTTO DEGENER
BOTANY 58

COMMELINA communis



LILIALES
JUNCACEAE

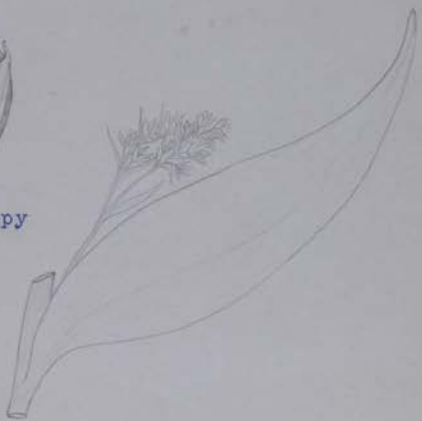
P 3 # 3 A ~~3~~ # 3 G (3)

OTTO DEGENER
BOTANY 58

LUZULA campestris var. umbellata

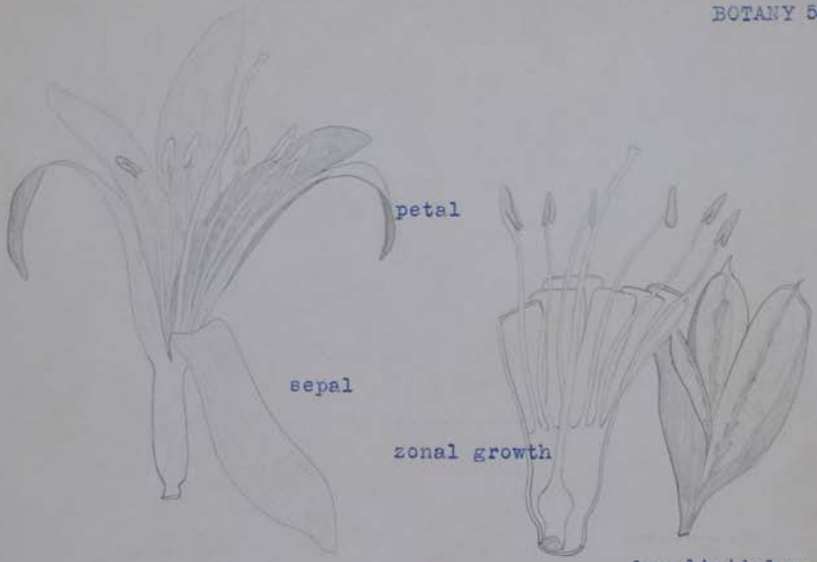
LILIACEAE
MELANTHOIDEAE

tendency toward syncarpy



VERATRUM viride

OTTO DEGENER
BOTANY 58

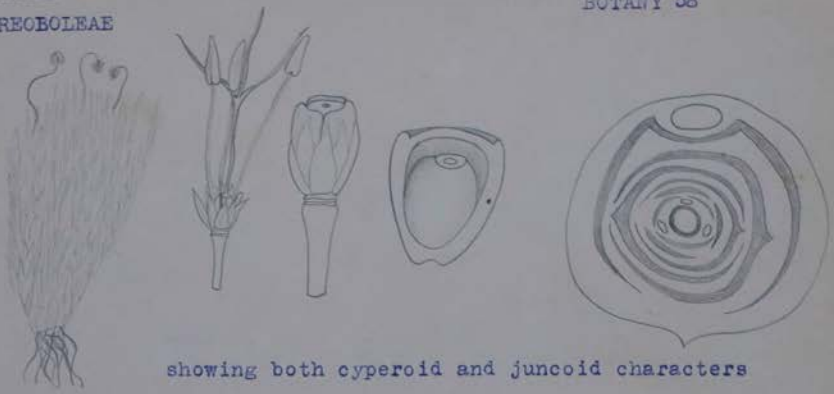


LILIACEAE
ASPHODELOIDEAE

HEMEROCALLIS flava

GLUMALES
CYPERACEAE
OREOBOLEAE

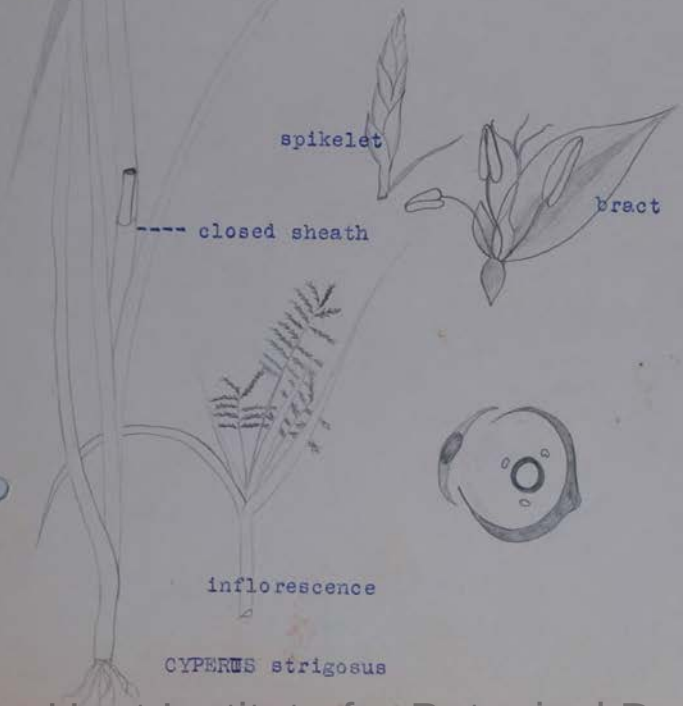
OTTO DEGENER
BOTANY 58



showing both cyperoid and juncoid characters

OREOBOLUS Pumilio

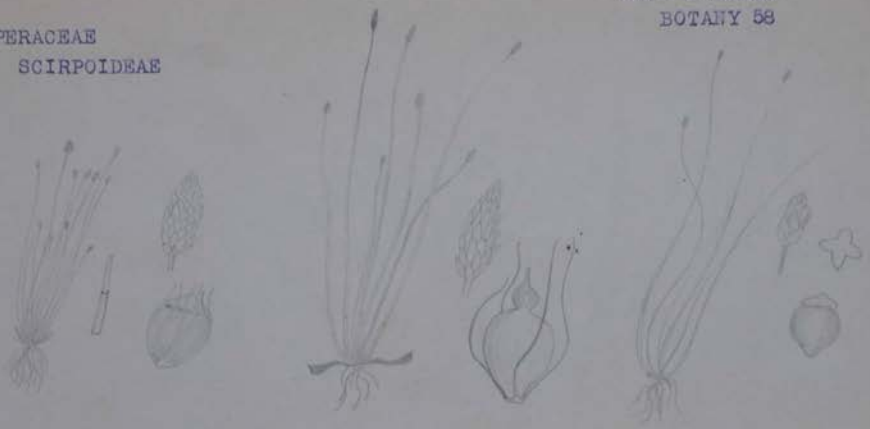
CYPERACEAE
CYPEROIDEAE



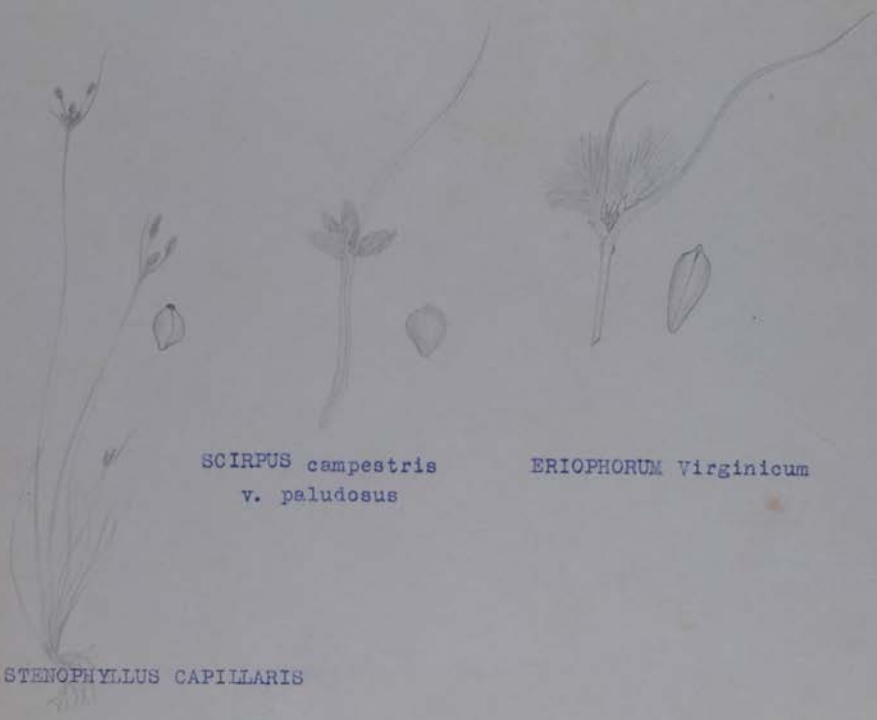
CYPERUS strigosus

OTTO DEGENER
BOTANY 58

CYPERACEAE
SCIRPOIDEAE



ELEOCHARIS obtusa E. palustris E. tenuis



SCIRPUS campestris
v. paludosus

ERIOPHORUM Virginicum

STENOPHYLLUS CAPILLARIS

OTTO DEGENER
BOTANY 58

achene

SCLERIA reticularis

RYNCHOSPORA glomerata

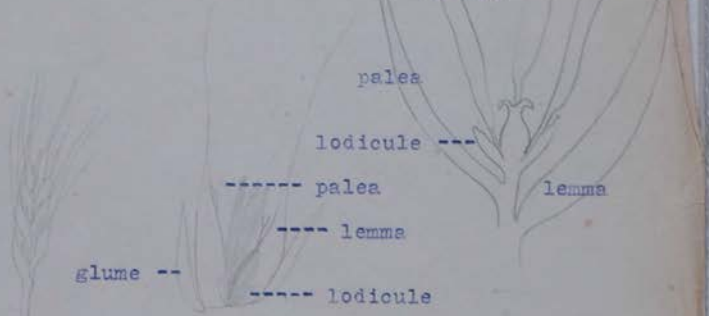
HYPOLYTRUM

hermaphrodite

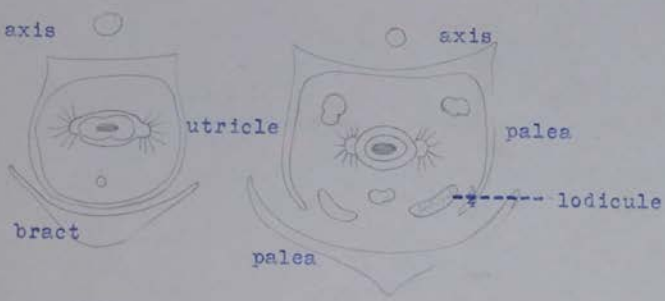
G

A

ununited bracts



CAREX vestita SECALE cereale



CAREX GRAMINEA

Massachusetts Agricultural College

Botany 58 and 59

LABORATORY OUTLINE

SYSTEMATIC BOTANY OF FLOWERING PLANTS

Family CALYCANTHACEAE

2. Calycanthus floridus

Note how the bracts of the pedicel gradually run into the perianth members. Split the flower lengthwise. Is there a definite number of perianth leaves? Are all the stamens alike and fertile or are sterile staminodia to be found? If the latter condition, what does it signify? What has happened to the position of the carpels? How could this flower be derived from one like Magnolia?

A. Draw a sectioned flower.

B. Draw the fruit and also its longisection.

Family MONIMIACEAE

3. The transition to the next family which we have in our flora - the Lauraceae-is effected thru the tropical Monimiaceae.

A. From chart sketch figures of the male and female flowers and also a stamen with its uplifted valves.

Family LAURACEAE

4. Sassafras variifolium.

A. Observe and sketch the three kinds of leaves.
Boil (any odor) and study the male and female flowers. In the male note nine stamens with the anthers opening by uplifted valves. Can you detect glands at the base of the inner ones.

B. Sketch the male flower on an enlarged scale.
Female flower. Is there any trace of stamens?. Is the stigma simple or lobed?

C. Sketch the female flower and the drupe (blue when mature) which results from the matured ovary.
Benzoin aestivale may be substituted for sassafras.
What modifications of the Monimiaceous flower would be necessary to produce the laurel type. Some laurels have the pistil evidently three-lobed and sunken into the receptacle.

Order PIPERALES

Family PIPERACEAE

The Piperaceae according to Hallier's theory effect the transition from Magnoliaceae to Araceae. If they are Magnolia descendants they represent a state of extreme reduction.

5. Saururus cernuus. The Lizard's Tail.

This plant is sometimes put into the Family Saururaceae. Observe the new type of inflorescence. Can it be correlated with the reduced size of the new individual flowers. (Handle the specimen with care)

A. Make a habit sketch of the plant

B. From book or chart copy figures of the flower and its diagram

6. Piper nigrum. The Black Pepper

A. Sketch living specimen or from Herbarium sheet. If latter, handle with care.

B. Copy figures from books as for Saururus

7. Peperomia sp.

A. Habit sketch of inflorescence and leaves.

Order SPADICIFLORALES

Family ARACEAE

With the Araceae we come to a family of Monocotyledons its affinities with the last family seem to be close.

Observe the net veined leaves of Arisaema. Is this a typical Monocot feature? Note the inflorescence of Acorus and of Anthurium and compare with Peperomia. (Some Peperomias actually have spathes)

A. Draw a habit sketch of Anthurium - Repeat for Arisaema or Richardia or Monstera. Observa sterile part of Spadix in the two former and elaborate spathe.

8. Acorus Calamus

Work out the structure of the Acorus flower. Note its strong trimerous tendency. Was Saururus also inclining that way?

B. Draw the Acorus spadix and diagram its flower. Write its floral formula. 3
C. Draw fruit of Arisaema.
D. Copy diagrams from chart to show the origin of heterocotyly or monocotyly in the Peperomia-Aracean series.

Family LEMNACEAE

9. Draw the frond of Lemna minor under the lens. The Lemnaceae are the smallest seed plants.

Family PALMACEAE

10. Phoenix dactylifera:

A preserved staminate inflorescence is available. Note its large size branching habit and enclosure in the spathe.

A. Sketch the inflorescence

11. Male flowers of a Livistonia are also available for study. How does the anatomy compare with that of the aroid flower?

B. Draw the staminate flower.

12. Pistillate inflorescences of Rhapis flabelliforme are available. Study the pistillate flower. How many carpels? 3 with 2 ovules in each.

C. Sketch a small portion under lens.
D. Observe and sketch such palm fruits as are available. Often only one carpel matures.

Germinating date seedlings. Review previous study of this seedling and compare the seedling leaf with the later "character leaves".

Family PANDANACEAE

From greenhouse specimens observe curious 3-spiral arrangement of the leaves and the many prop roots.

Family SPARGANIACEAE

13. Sparganium sp.

A. Sketch the specimen available. If any show the supra-axillary position of the inflorescence, bring this out.
B. Boil out staminate and pistillate flowers and sketch under lens. Is there any evidence of a perianth?
C. Section a carpel longitudinally with a sharp razor and observe the ~~single~~ hanging ovules. Sketch.
D. Sketch mature fruits of S. eurycarpum and of S. americanum.

Family TYPHACEAE

14. Typha latifolia.

Interpret curious terminal inflorescence by reference to the supra-axillary inflorescence of Sparganium.

A. Habit sketch.

Boil out male and female flowers. Any perianth or anything that might be so interpreted. How many stamens per flower? Note gynophore and curious stigma of pistil.

B. Sketch both flowers.
C. Study the mature parachute-like fruit. What change has the ovary undergone?

Order RANALES

Family RANUNCULACEAE

15. Caltha palustris

Study the structure of this primitive magnoliaceous derivative and see if it does not mean more now than when you first studied it. What is the probable origin of its perianth? gradual creeping up of stem leaves

A. Draw on a large scale in sectional aspect.
B. Draw fruit sliced open lengthwise. Is this fruit more or less primitive than that of Magnolia?

16. Coptis trifolia.

This flower shows the beginnings of corolla formation its so-called nectaries or "honey-leaves" which are believed to be sterilized stamens. One flower available preserved in a small vial has one very significant sepal.

A. Draw flower enlarged to show the nectaries.
B. Draw the curious sepal of the flower in vial.
C. Draw the head of carpels and show their gynophores.

17. Xanthorrhiza apiifolia.

Note the cupped honey-leaves of this flower.

A. Sketch habit and one flower enlarged.
B. Sketch mature gynoecium

18. Ranunculus sp.

Is the perianth haplo- or diplochlamydeous? Note the nectapiferous scale at base of petal. What is the probable origin of the petal?

A. Draw flower from back.
B. Draw one petal.
C. Study and draw head of carpels enlarged.
D. Section mature achene and draw. How many ovules?

19. Aquilegia.

Study the flower of Aquilegia canadensis or of A. vulgaris. Which parts are the sepas? Which petals? What is the use of the spur? Are the stamens and pistils still in the familiar Ranunculus condition? To understand how the curious spurred bodies arose refer to chart. Here is a striking line of evolution from Helleborus niger thru Isopyrum anemonoides l. adoxoides, l. grandiflora, Aquilegia hispanica to A. vulgaris or A. canadense.

A. Copy the chart.

Can you see how the Ranunculus petal probably arose from some condition similar to that of Isopyrum?

20. Nigella.

Study this flower if available and note the number of petals and the number of sets of stamens? If not available, copy from chart.

21. Delphinium.

Examine the very curious flower of Delphinium. It was probably originally of the Nigella type but reduction of parts and introduction of spurs has produced a much involved zygmorphic flower. As a hint the four lower petals are wholly lost or represented by mere rudiments.

A. Draw flower from side and face.
B. Remove sepals and draw parts remaining.
C. Remove petals and draw androecium and gynoecium.
D. Construct a floral diagram.

Family BERBERIDACEAE

22. Berberis vulgaris

About the only constant difference between the Berberidaceae and the Ranunculaceae is the single carpel in the former. Study the Berberis flower with this in mind. Note petals in same state as in Coptis. Note how stamens open. Where seen before? Section ovary longitudinally. How many seeds?

A. Draw flower spread open.
B. Draw sepal and petal.
C. Draw opening stamen.
D. Draw opened carpel.

Refer to the genus Mahonia. What are the leaves like? Compare with the unifoliolate compound leaf of Berberis. Explain derivation of the latter.

A. Sketch the two side by side.

Family NYMPHAEACEAE

23. Nuphar advena - Cow Lily

How is this plant adapted to the water life? Were any of the buttercups inclining the same way? Note the obvious resemblance of the flower to that of the buttercups. How do the petals differ from the sepals? How does the gynoecium differ from that of Ranunculus?

A. Sketch a leaf and a flower from the face enlarged.
B. Remove enough of perianth and androecium to show pistil and sketch.
C. Cut pistil transversely.
Observe number of carpels and placentation.
D. Section pistil longitudinally and sketch inner face of a carpel.
The placentation is similar to that possessed by the poppies.

24. Nymphaea odorata. The white water-lily.

What adaptation of the leaves to the aquatic life? Study the flower. How many sepals? Follow petals inward. Into what do they merge? Interpret from previous work on Ranunculaceae. How many carpels? How many petals and stamens and how are they inserted? Interpret.

A. Draw the opened flower and leaf.
B. Draw a transitional series from stamens to petals.
C. Remove petals and stamens and draw ovary with scars.

Section pistil longitudinally thru center. Interpret the central hummock. How are the ovules borne.

D. Sketch the longisection of pistil.
E. Section pistil across and sketch.

MONOCOTYLEDONS WITH THE EXCEPTION OF THE SPADICIFLORALES.
Order HELOBIALES

Family ALISMACEAE

25. Alisma Plantago.

The Helobiales seem to be Ranunculus derivatives. Note resemblance in great number of stamens and of free carpels. Does the perianth show monocot affinities in the number of its parts?

A. Sketch leaf.
B. Sketch the paniculate inflorescence.
C. Sketch longisection of flower and also construct diagram of same.

Section fruit and note particularly the absence of endosperm and the massive club-shaped hypocotyl of the embryo. The last two features are the only two which really differentiate the Helobiales.

D. Sketch the section of the achene.

26. Sagittaria latifolia.
The flower shows advance over Alisma in what respect?

A. Sketch a few of the many leaf types.
B. Sketch flower.

Family POTAMOGETONACEAE

27. Potamogeton sp.
Observe oecological polymorphism of leaves.

A. Habit sketch of the plant.

Boil out flower and fruit.

B. Sketch flower and fruit magnified.
C. Section fruit parallel to the broad face. Observe and draw the sectioned achene and coiled embryo.

Order FARINALES

Family COMMELINACEAE.

28. Tradescantia

Note actinomorphy and the syncarpous gynoecium. The latter differentiates the family from the Helobiales as does also the mealy endosperm.

A. Sketch habit of plant and also the flower enlarged.

29. Commelina communis.

This member of the family exhibits remarkable zygomorphy. Two petals become elongate into wings; three stamens transform into yellow staminodia, while the median stamen below is different from the other two.

B. If available, make habit sketch and drawing of flower enlarged.

Order LILIALES

Family JUNCACEAE

30. Juncus sps.

Study a species of Juncus in the flowering condition and note its typical lily formula. Is it probably anemophilous or entomophilous? Is it a member of the Prophyllatae or Eprophyllatae? (See Gray p. 270)

A. Sketch habit of the plant and the flower magnified.

Many of the species identifications of Junci depend on the fruit characters and on the seed.

B. Sketch habit of inflorescence and a single capsule of several species and determine by aid of the Manual.

31. Luzula campestris var. umbellata.

Note flat leaves and arachnoid pubescence. Study flower with lens. How many seeds in the ovary? The latter character is the main one which separates the genus from Juncus.

A. Sketch a part of the plant.
B. Sketch a flower to show the lily structure.
C. Diagram the flower.

Family LILIACEAE

Tribe Melanthoideae

32. Veratrum viride.

The flower of this plant may be looked upon as advanced over the Juncaceae in the direction of entomophily.

A. Sketch leaf and a portion of the inflorescence.

Study the flower and note that the carpels are passing from an apocarpous to a syncarpous condition.

B. Sketch the flower and also the septicidal capsule and seed.

Tribe Asphodeloideae.

33. Hemerocallis fulva or H. flava.

What has happened to the perianth at its base and how has this affected the position of the stamens? Full entomophily is attained. How has the compounding of the ovary advanced over the condition in Veratrum? The capsule is loculicidal with several seeds.

A. Sketch flowers and also androecium and gynoecium with perianth split along one side and turned back.
B. Sketch the capsule.

Tribe Allioideae.

34. Allium sp.

Observe scarious spathe and umbelliform inflorescence, scarious perianth, complete snycarpy and loculicidal capsules.

A. Draw umbel, single flower and fruit.
B. If viviparous specimens are available (onion sets) make sketches.

Tribe Lilioideae

35. Tulipa.

The tulip is known to be extensively hybridized and it will be interesting to see the condition of the pollen grains. Stamens of various varieties have been dried. Soak out in potash solution and examine the pollen grains in water-mount with compound microscope. Compare with pollen grains of a native lily.

A. Make sketches of both types.

Tribe Asparagoideae

36. This is a tribe with berry fruits. Sketch habit of Asparagus, Smilacina or other genus.

Tribe Smilacoideae
A vine tribe with berries.

37. A. Sketch of habit and fruit.

Order GLUMALES

Family CYPERACEAE

Tribe Oreoboleae

This most primitive tribe seems to have been derived from the Juncaceae.

A. Copy figures of Oreobolus from chart.

Tribe Cyperoideae

You are later to make a key to the species of Cyperaceae studied hence it will probably be necessary to take notes on each species studied in addition to making the drawings.

38. Cyperus sp.

Observe the typical vegetative sedge features: solid stem, grass-like leaves with closed sheaths, non-tumid nodes, flattened two ranked spikelets and leafy involucre.

A. Habit sketch of plant.

Dissect out the flowers. Note scale and number of stamens. What is the shape of the achene and how is it correlated with number of styles?

B. Draw the spikelet enlarged.
C. Draw single flower with the scale turned back. Diagram the flower.
D. Determine the species by aid of Manual.

Tribe Scirpoideae

39. Eleocharis sps.
This is an exquisite genus of plants. Observe habit; any leaves? How does the head differ in shape from that of Cyperus?

A. Habit sketch and drawing of head magnified.

Remove scale and achene. How does latter differ from that of Cyperus? Note perianth. How is it barbed?

B. Draw achene on a large scale and label tubercle and bristles.
C. Repeat for other species available.
D. Determine by aid of Manual.

40. Stenophyllus capillaris.
Work out as for Eleocharis and make necessary sketches.

Scirpus. This genus runs into Eleocharis. See if you can determine the main point of difference in the achenes.

A. Work thru the species given as for Eleocharis and determine each one by use of Manual.

41. Eriophorum (Etym.) As for Eleocharis
42. Rynchospora (Etym.) " " "
43. Cladium mariscoides " " "
44. Scleria. A rare plant with us having most beautiful achenes. Do not lose

Tribe Caricoideae

The rare genus Hypolytrum seems to effect the transition from some primitive member of the Scirpoideae. See chart. What change would be necessary to convert the Scirpus flower into the Hypolytrum flower?

A. Copy the diagrams from chart.

Kobresia carries us one step nearer to Carex. What is happening to the two scales?

A. Copy the Kobresia diagrams from chart.

45. Carex sps. This is the dominant genus of the Cyperaceae. Start with a large-headed species in the flowering condition. Note that the plant is obviously monoecious. Are the spikes strictly male or female?

Boil out a few of both kinds of flowers. The scale is in the same position as usual, but how will you interpret the bladdery perigynium (utriculus)? Open it and observe the pistil. How many styles? Is it of the Eleocharis or Scirpus type? Study the matured achene. Is it lenticular or trigonous?

A. Draw habit sketch of inflorescence.
B. Sketch a single perigynium with its scale.
C. Sketch the pistil and mature achene.

Study the staminate flower. How many stamens? How could such a flower be derived from one like that of Scirpus?

D. Draw the male flower with its scale and stamens.
E. By use of Manual determine several species of Carex.
F. Construct an artificial key to the Genera and species of Cyperaceae which you have studied.

Family GRAMINEAE

46. First to become acquainted with the structural features of grasses work out the Rye- Secale cerale.

1. How do the stems and their nodes differ from those of the Cyperaceae? How do leaf sheaths differ? Observe ligule at junction of blade and sheath.

2. Study the inflorescence - a spike; in this case made of spikelets. Separate the florets of a spikelet and look between them. What is seen? What does it suggest as to the original spikelet condition of Rye?

3. Study the heads of the teratological specimens available. How many florets per spikelet?

Observe that each spikelet bears two basal glumes inside which stand normally two fertile flowers. Each flower consists of an outer nerved and hispid-awned lemma and an inner more membraneous 2-keeled palea.

Next come two delicate lodicules. How many stamens and pistils? How many styles and ovaries?

A. Draw the spicate inflorescence.
B. Draw one normal spikelet and also the teratological one.
C. Draw the structure of one floret rather diagrammatically as though it had an extended axis.

Study chart to see how the grass floret can be derived from a Juncus type and how it can also be homologized with that of Carex.

A. Copy figures from chart.

The fruit of Grasses - a caryopsis.

47. The Maize fruit:

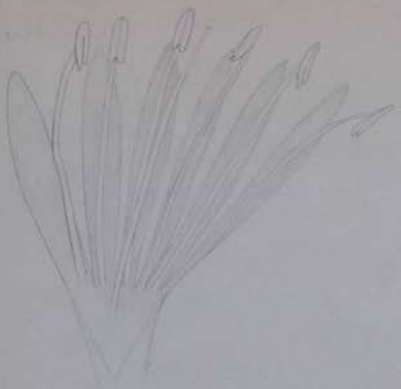
Study the sections of corn grains available. The scutellum probably represents the cotyledonary lamina, while the sheath around the plumule (Coleoptile) has been interpreted as the ligule of the same leaf. It comes out of the seed in germination but does not turn green.

A. Sketch the section.

48. Wheat - Triticum sativum.

Most grass embryos have a small upgrowth - the epiblast - on the face opposite the cotyledon. This seems to be a second reduced cotyledon. What significance? See if you can find it on the embryo of soaked wheat grain.

A. Remove and sketch the wheat embryo with the epiblast.
B. Determine several grasses and familiarize yourself with the use of the Manual key.



Family AMARYLLIDACEAE

49. Use whatever member of this family that is available. In what single feature does its structure differ from that of the lily?

A. Draw and diagram the flower and write its floral formula.

Family IRIDACEAE

50. Preserved flowers of the Iris are available for study. What essential difference from the amaryllid flower? Note curious petaloid modification of the styles. How is cross-pollination effected?

A. Habit sketch of Iris.

Teratological flowers of I. japonica are also available. Observe what is happening to the stamens.

B. Sketch one of the partial staminodia.

One specimen shows a curious tubular outgrowth from the angle of a sepal. Does this give any suggestion as to the morphology of a sepal?

C. Sketch to show this feature.

Family BROMELIACEAE

51. Tillandsia - the Spanish Moss.

A. Habit sketch of a small portion.

Remove a leaf to a slide and examine with the compound microscope. Observe the curious scales which absorb rain water.

B. Sketch a small portion.

Other Bromeliads: Observe evident adaptation to holding water.

52. The Pineapple.
This great aggregate fruit consists of a whole inflorescence whose axis, ovaries and bracts all become a fleshy mass. The cultivated pineapple is seedless. Note proliferation of the axis. Shred the leaf and observe the tough fibers; they are used in the textile industry.

A. Sketch the whole fruit.

Order Scitaminales
An extravagant order with intense zygomorphy.

Family MUSACEAE

53. Strelitzia regina or S. augusta.
This flower is so highly modified that a description will be necessary. It is still based on the Lily formula. The two sepals are obvious; two petals are fused and enclose five stamens; the petals are bright blue in S. regina. The third petal is reduced to a curious 3-corned, broad, short leaf. Between the fused petals is thrust the style.

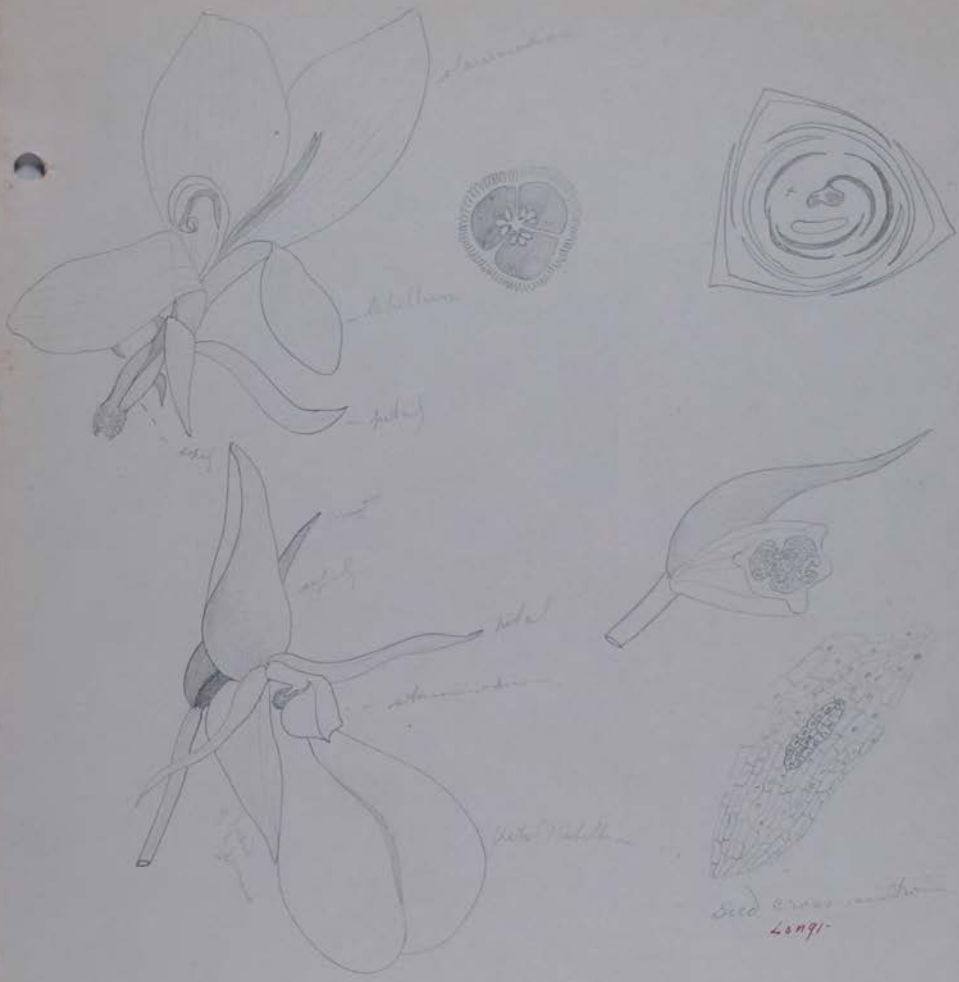
A. Draw the flower.
B. Remove the sepals and loosen the style and stamens from the petal sheath. Draw.
C. Diagram the flower.

54. Musa - the banana.
Note that the flowers of the inflorescence are unisexual. What is found in place of the ovary in the male flower? The perianth parts with the exception of the median inner petal are fused into a single strap - How many points? How many stamens?

A. Draw and diagram the male and female flowers.

Family CANNACEAE

55. Canna
The canna family shows advance over the Musaceae. Its stamens are largely changed into staminodia. Remember that it is based on the lily formula.



The inferior ovary, 3 sepals and 3 petals are evident. Only the inner members demand interpretation. The member which curls outward is called the labellum - it is a modified stamen. The three broad, banner shaped members are three more staminodia. This accounts for 4 stamens. One of the others is slender and tongue shaped, while the 6th is also leaf-like, but bears a half anther.

A. Draw the flower slightly spread apart if necessary to show these features. Label sepals petals and staminodia.
B. Diagram the flower.
C. Section the ovary transversely and sketch.

Family ORCHIDACEAE

We still deal with the lily ground plan.

56. Cypripddium:

How account for the seeming two sepals? The three petals are obvious. Note the position of the anthers and explain the mechanism of pollination. What is the morphology of the triangular flap above the pouch?

A. Draw the flower from the side and by arrows suggest the course of an insect.
B. Remove the pouched labellum. Observe the column (gynostemium), the two stamens with short filaments, the staminodium and the obscurely 3-lobed stigma.

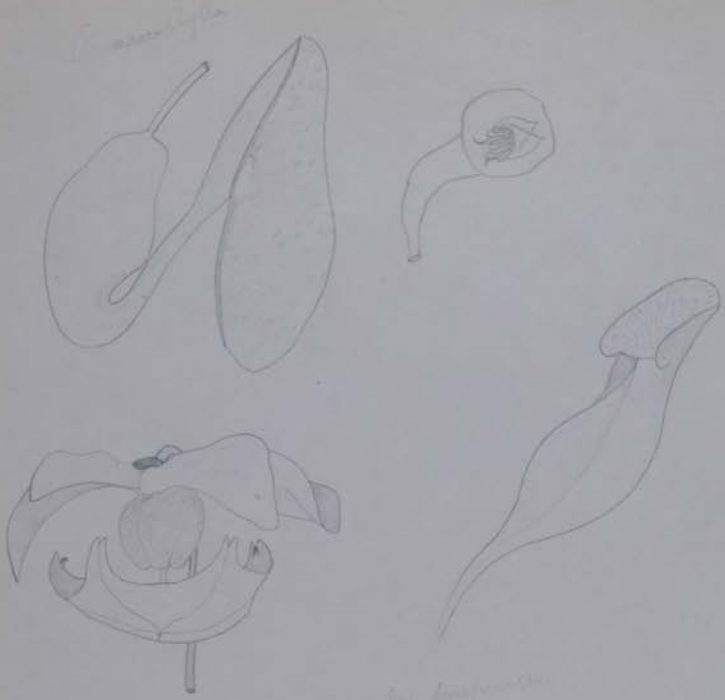
What is the morphology of the column?

C. Draw the flower with the labellum removed.

If orchid seeds are available, study with compound microscope. Note loose testa and poor development of embryo.

D. Draw seed with embryo,
E. If orchid seeds are available, study with compound microscope. Note loose testa and poor development of embryo.
F. Draw seed with embryo.

We shall also probably study and interpret one of the complicated tropical orchids.



DICOTYLEDONEAE

Order ARISTOLOCHIALES

ARISTOLOCHIACEAE

57. Asarum
Note trimerous actinomorphic flower. If preserved flowers are available, dissect off perianth. Is there any evidence of corolla?

A. Habit sketch of flower and drawing of flower with perianth removed.

58. Aristolochia
Habit sketch of flowers of A. macrophylla and A. elegans.

Order SARRACENIALES

Family SARRACENIACEAE

59. Habit sketch of leaf and flower of Sarracenia purpurea and of Darlingtonia californica.

B. Under lens sketch a portion of the inner hairy surface of the leaf of Sarracenia.

Family NEPENTHACEAE

60. A. Sketch preserved leaf of Nepenthes.

Order PAPAVERALES

This order is ideal to teach the modifications which a basic form may undergo in its evolution.

Family PAPAVERACEAE

61. Papaver Rhoeas
Note 2 fugacious sepals; 2 plus 2 petals; many stamens and syncarpous gynoecium. How many stigmas? How would you derive such a flower from a Ranalian ancestry? Section the pistil transversely. Do the septa reach the center? What kind of placentation? Where have we seen a similar gynoecium before? What is the shape of the seed?

A. Habit sketch of plant.
B. Sketch of pistil.
C. Sketch transverse section and single seed magnified.
D. Diagram the flower.

62. Chelidonium majus.
How does its pistil differ from that of the poppy? This is the more typical Papaveraceous gynoecium.

A. Diagram the Chelidonium flower and sketch the pistil matured.

Family FUMARIACEAE.

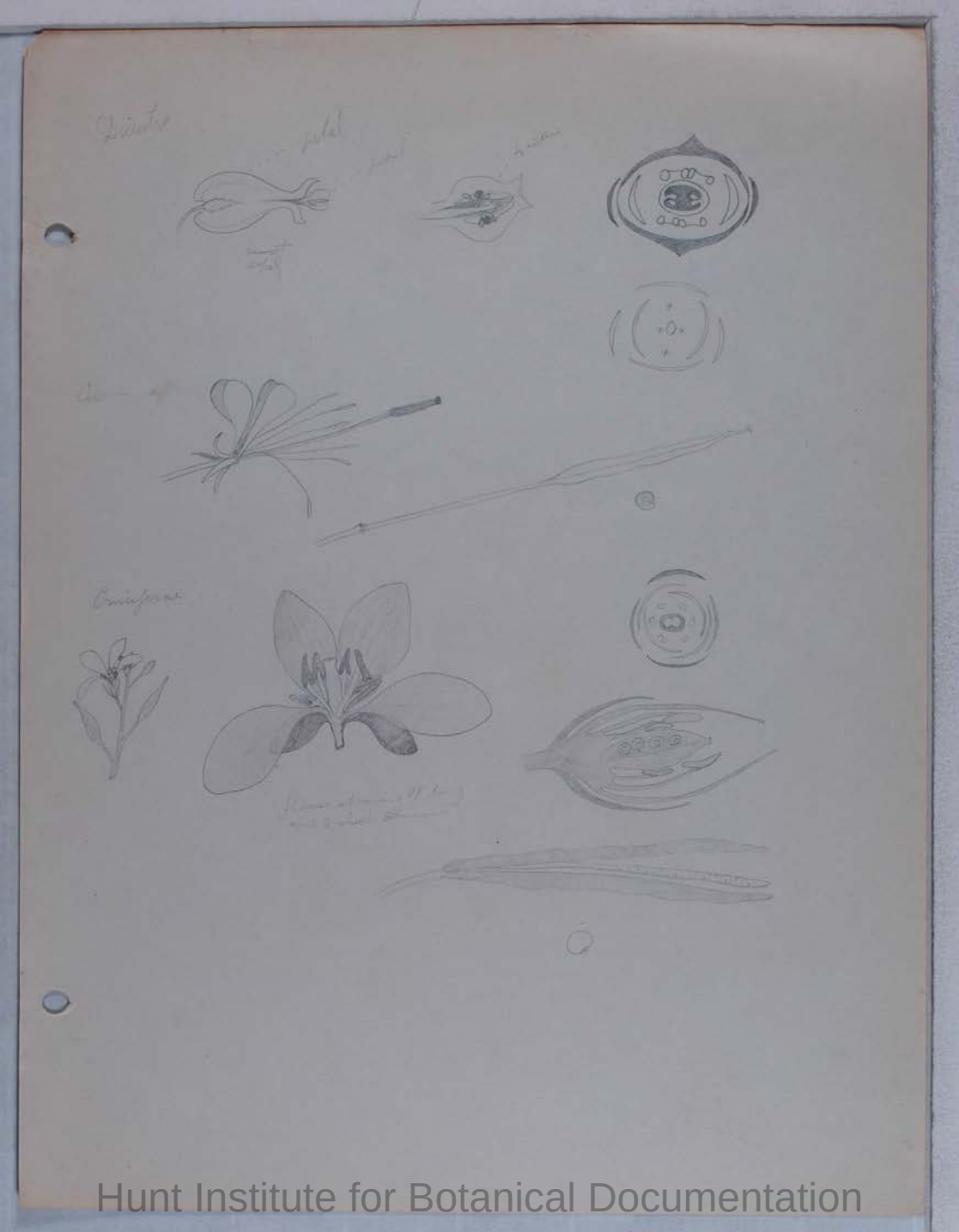
Dicentra:
63. Keeping the poppy structure in mind see what has happened to the various parts here. At the base lie two bracteoles; then follow the other parts as in poppy, but the petals are curiously modified. What remarkable fact do you observe about the two stamens? How may they have arisen from an original 2 plus 2 condition? How many carpels in the gynoecium?

A. Draw the flower.
B. Remove the two outer petals and draw the parts remaining.
C. Draw one stamen.
D. Draw the pistil.
E. Diagram the flower.
F. Diagram the flower of a hypothetical ancestor of Dicentra.

Family CAPARIDACEAE

64. Cleome spinosa
How many sepals, petals, stamens? Starting with the hypothetical ancestor of Dicentra how can you derive the stamen condition of Cleome? What has happened to the insertion of the pistil? What term can you use for its stalk (female plus to bear). See if you can detect a glandular disc behind the ovary. This develops remarkably in certain Capparids.

A. Draw the flower.
B. Construct cross and longitudinal diagrams.
C. If mature fruits are available, draw with and without valves.



Family CRUCIFERAE

65. On the specimen furnished observe the absence of bracts in the inflorescence. Is this likely to be a primitive character?

Work out the structure of the flower. See if you understand what Eichler means when he says that the four longer stamens have arisen by chorisis of the two median inner ones. This structure, then, recalls what ancestry? How many carpels? Note false septum in mature fruit.

A. Draw bit of inflorescence to show absence of bracts.
B. Draw single flower on large scale.
C. Remove perianth - sketch stamens and pistil.
D. Diagram flower.
E. Sketch fruit (Silique) with and without valves.
F. Draw the campylotropous seed under lens. Note curved embryo.
G. Identify a few crucifers by use of Manual.

Order MALVALES

With this order we leave the Papaver line and go back for an ancestry to the Ranales once more.

Family TILIACEAE

66. Tilia: This would seem to be a foundational form of the order Malvales except in the high development of its gynoecium. Note the inflorescence attached to bract. What does the latter become at maturity? Observe the slightly oblique cordate leaf. Turn to the flower. How many sepals and petals and stamens? Does this suggest the old Ranalian type? How many carpels? Are they still in the Ranalian condition? How many cells with ovules matured? (Cut fruit across).

A. Draw twig with inflorescence.
B. Draw flower enlarged.
C. Draw mature fruit and a section of it.
D. Construct a floral diagram.

A strong vegetative character of the order Malvales is the presence of gum cavities (containing "marshmallow") in pith and bark. Examine cross sections of Tilia stem and see if these appear. Compare with the cross-section of a true mallow.

A. Sketch a bit of the latter.

The flower which we think of as typically malvaceous however is not that of Tilia but is more like the next:

Family Malvaceae

67. Abutilon
What is the most striking feature of this flower? How could it be derived from that of Tilia?

A Draw habit.
B. Draw flower with two petals removed.
Remove the stamens. Is the gynoecium nearer or farther from the ranalian type than in Tilia? Compare the immature gynoecium with the mature condition of Althaea. It is very similar.

C. Draw both gynoecia.
D. Diagram the Abutilon flower.

68. The other sub-family has capsular fruits. Note fruit of Hibiscus. Is it loculicidal or septicidal? Gossypium belongs here also.

A. Draw the fruit of Hibiscus.

Family STERCULIACEAE

69. Theobroma Cacao.
Sketch twig of the plant and its fruit with seeds.

Order GERANIALES

70. Here we come to a definite floral plan which is well seen in Pelargonium. Study the flower and first determine and write the floral formula. How could it be derived from Tilia? (The orange flower forms an almost perfect transition)

A. Habit sketch of Pelargonium.

Study now for details. How does the upper calyx lobe differ from the others? Split the flower and follow the tube. What does it adhere to? (The flaxes and oxalids are perfectly actinomorphic but the Pelargonium is running toward zygomorphy. This becomes extreme in the balsams and polygalas) Are all the stamens fertile?

A. Draw a flower from the side to show the spur.
B. Draw as if sectioned thru the spur.

Study the fruit of Pelargonium or Geranium. What dispersive mechanism? How many seeds in a carpel mature? Observe long beak of receptacle.

C. Draw the fruit as if in the act of dispersing seeds.

71. Observe fruits of Erodium. Breathe on them and what happens? What advantage?

D. Sketch the Erodium fruit.

Family EUPHORBIACEAE

72. Euphorbia cyparissias or other species.
The apparent flowers of this plant are really curious inflorescences beset with colored bracts. Study one of the ultimate bracteal cups and observe the single female flower raised on a long curved podicel. How many carpels, styles, and stigmas? Around the female flower stand many male flowers, each consisting of a single stamen borne on a pedicel and standing in the axil of a bract. To prove that these are not stamens, carefully remove a few and note the joint where the pedicel joins the filament. Sometimes, in other species a calyx is found at the point of union. Observe the curious calloused nectaries on the bracts themselves alternating with small hairy lobes.

A. Draw the cyathium from the side on a large scale.
B. Draw with the front of the involucre removed.
C. Draw a single stamen with its pedicel and bract.
D. Draw the mature fruit - Observe how it breaks apart at maturity.

E. Draw mature fruit of Ricinus and also one of its odd stamens. It has undergone profound chorisis.
F. Draw the seed of Ricinus or other Euphorbian. The possession of caruncle is an important family character.

Order SAPINDALES

This order is closely allied to the Geraniales, only differing in the orientation of the ovule. Even this is not an absolute character to distinguish the two orders.

Family ANACARDIACEAE

73. Rhus Toxicodendron.

A. Habit sketch of the plant.

74. Rhus Vernix.
A. Habit sketch of the plant.

Family ACERACEAE

75. Acer species.
Work out floral structure and note dioecism or polygamo-dioecism. Are the stamens definite in number? How many carpels?

A. Habit sketch.
B. Draw staminate and pistillate flower.
C. Dissect out ovule from a half-grown ovary and see if you can make out the orientation of the ovule.
D. Draw ovary in various stages of development to fruit.
E. Boil samara. Remove and draw embryo. This is an illustration of how to pack much material in a samll space.

Order RHAMNALES

Family RHAMNACEAE

76. Ceanothus americana.
Study the tiny flowers and note particularly the position of the stamens in regard to the petals. This is the distinctive rhamnalian character. Observe disc united to the calyx tube. How many carpels?

A. Habit sketch.
B. Sketch flower from face on a large scale.
C. Sketch fruit. What happens to calyx lobes in fruit?

Family VITACEAE

77. Vitis species.
Study structure of the flower. Note polygam-dioecism. Note tetramery and rhamnalian stamen position. The petals are thrown off as the flower opens.

A. Sketch flower.

Order URTICALES

Family URTICACEAE

Among the Geraniaceae etc. we have seen evidence of regression. With the next few orders we may trace the same principle progressively at work and leading to green anemophilous flowers much reduced in number of parts.

78. Ulmus Americana - The American Elm.
Note inflorescence. Is there any significance in the compacted form? Study a single flower. How many floral envelopes? Are the parts wholly free? How many stamens and are they opposite the perianth lobes or alternate with them? How many carpels? Are all the flowers alike? (The elm is usually polygamous)

A. Habit sketch.
B. Draw the flower and also a longisection.
C. Diagram the flower.

Study the mature fruit. What is it called? Do both carpels mature? What is the morphology of the wing?

D. Draw the fruit.

79. Urtica gracilis:
Compare with the elm. Note strict monoecism of the inflorescence. How many sepals and stamens in the male flowe.? How many carpels? Note odd brush-like stigma. Section the half-grown fruit. How many ovules? See if you can detect that it is orthotropous. Does this suggest a primitive or degraded position for the nettle?

A. Habit sketch.
B. Draw the two types of flower.
C. Diagram both types.
D. Draw the fruit.

Order FAGALES.

Family BETULACEAE

Perhaps allied to Urticales and may be primitive instead of reduced. We have seen the flowers of the Urticales begin to compact into multiflorous inflorescences. In the Fagales this has been followed by curious dichasial conditions.

80. Alnus incana.
Work out the structure of the male flower of the alder. As a help the following is suggested: The big reddish first scale has two sets of smaller bracts attached to it. In the axil of all stands three flowers. Each has four sepals and four stamens.

Order CARYOPHYLLALES

Family PHYTOLACCACEAE

83. Phytolacca decandra - The Poke- Weed
This family is not far removed from the old ranalian stock. Note its perianth. Is it haplo-or diplochlamydeous? The ten stamens are said to arise thru chorisis of the outer whorl of five. How many carpels?

A. Habit sketch.
B. Drawing of one flower.

How many seeds per carpel? Note campylotropy. Section a seed parallel to the flat face. What is the shape of the embryo?

C. Draw seed and embryo.

Family NYCTAGINACEAE

84. Mirabilis jalapa: Four o'clock or Marvel of Peru.

A. Observe habit and sketch.

Section the flower lengthwise. We are dealing with one of the cases of gamosepaly among the Archichlamydeae. The important point to note is the investiture of the ovary by the hardened calyx base.

Family AIZOACEAE

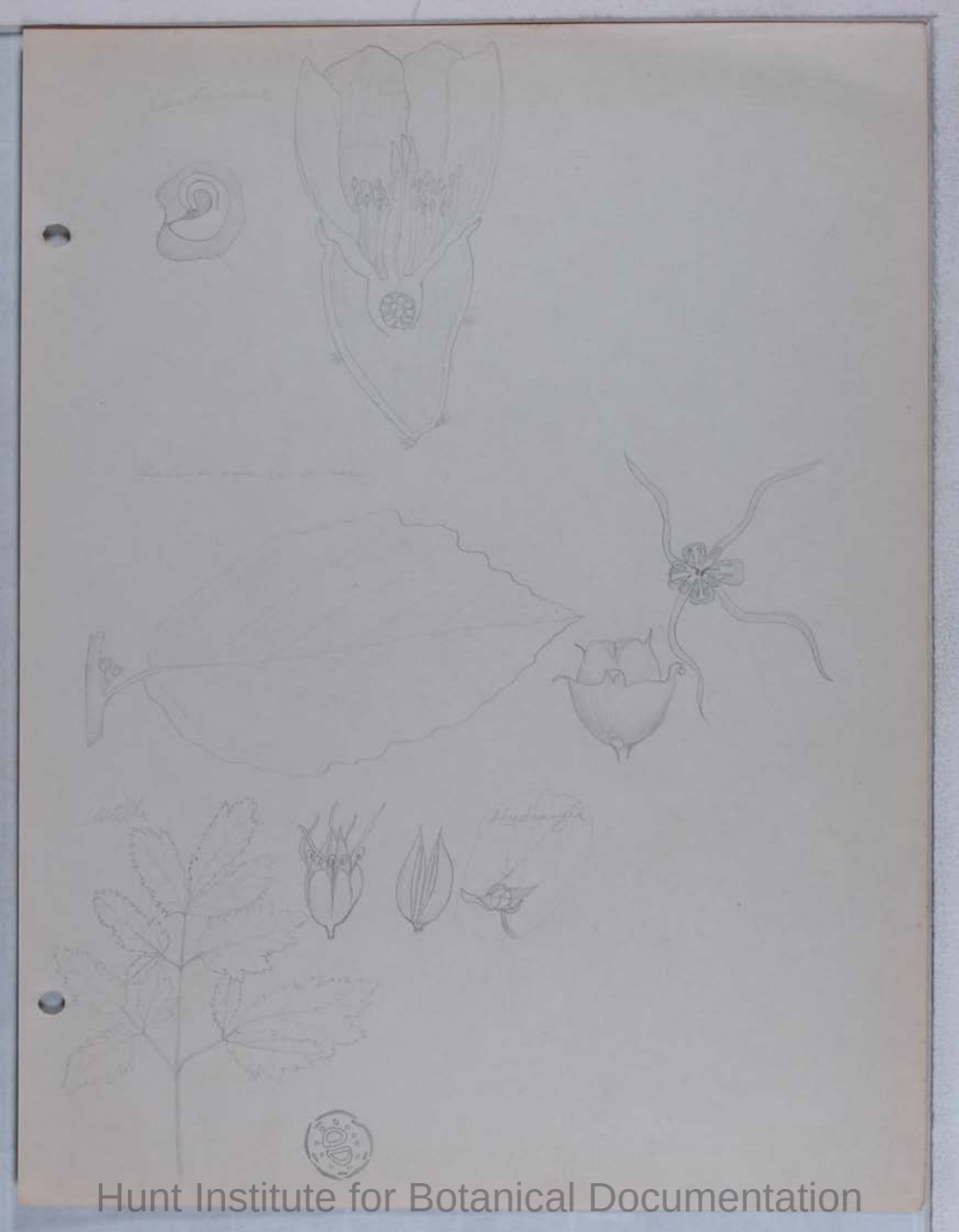
This family of which we have but one aberrant genus (Mollugo) effects the transition to the Cactales thru its Tribe Ficoideae.

Mollugo verticillata: Note habit and work out flower detail of this plant. The only real character which separates it from the Phytolaccaceae is the many seeded carpel.

A. Draw small portion of the habit material.
B. Draw flower enlarged and construct diagram.
C. Copy figure of section of the seed. The Caryophyllales were once called Curvembryae - what significance?

The Mesembryanthemums represent the extremes of the Family. They have arisen from the Mollugo type thru chorisis of stamens and epigyny.

A. Copy a figure of Mesembryanthemum and its floral diagram.



Family CARYOPHYLLACEAE
Tribe ALSINEAE
Cerastium or Stellaria
Probably fresh material of one of these plants is available. Study the flower and work out structure. How many carpels? How many loculi in the fruits? What is the shape of the seed?

A. Sketch habit, flower, fruit and seed.

Tribe SILENEAE
Study habit of Dianthus species. Observe synsepaly, clawed and appendaged petals. How many carpels? Loculi?

A. Habit sketch of cyme.
B. Longisection of flower.

Order CACTALES

Family CACTACEAE

These seem to be Aizoalian derivatives though Bessey tries to attach them to the Roaales because of their prevalent epigyny. If cactus flowers are available, study and compare with the flower of Mesembryanthemum.

A. Sketch flower.
B. Sketch longisection of flower.

Order HAMAMELIDALES

Family HAMAMELIDACEAE

Hallier considers this plant transitional from the Magnolias to the Saxifrages. Observe the involucre of bractlets around the flowers. Note curious linear petals inserted on calyx. What is the numerical plan of the flowers? How many stamens? How do the anthers open? What other families have same opening method? Are the stamens all alike? How many carpels in the gynoecium? Are they wholly superior? To produce such a type what would be the necessary modification of the Anonalian flower? How does the habit of the plant bear out the magnolia theory?

A. Draw leafy twig with flowers and fruit.
B. Draw one flower magnified.
C. Construct cross and longitudinal diagrams; write the floral formula.
D. Draw the mature fruit.

Liquidambar Styraciflua belongs to the Hamamelidaceae also. Observe habit of the tree and its composite fruits.

Family PLATANACEAE.

Draw leafy twig and fruit of Platanus occidentalis.

Order ROSALES

Family SAXIFRAGACEAE

The order Rosales, according to Hallier is basic to all the remainder of the Dicotyledons and hence its families demand a rather careful study. Bearing the structure of the Hamamelis flower in mind we turn to the first member of the Saxifrage family.

Astilbe japonica:
This important genus is ancestral to the saxifrages and runs over to the rosaceous genus Spiraea.

A. Sketch leaf and panicle habit.

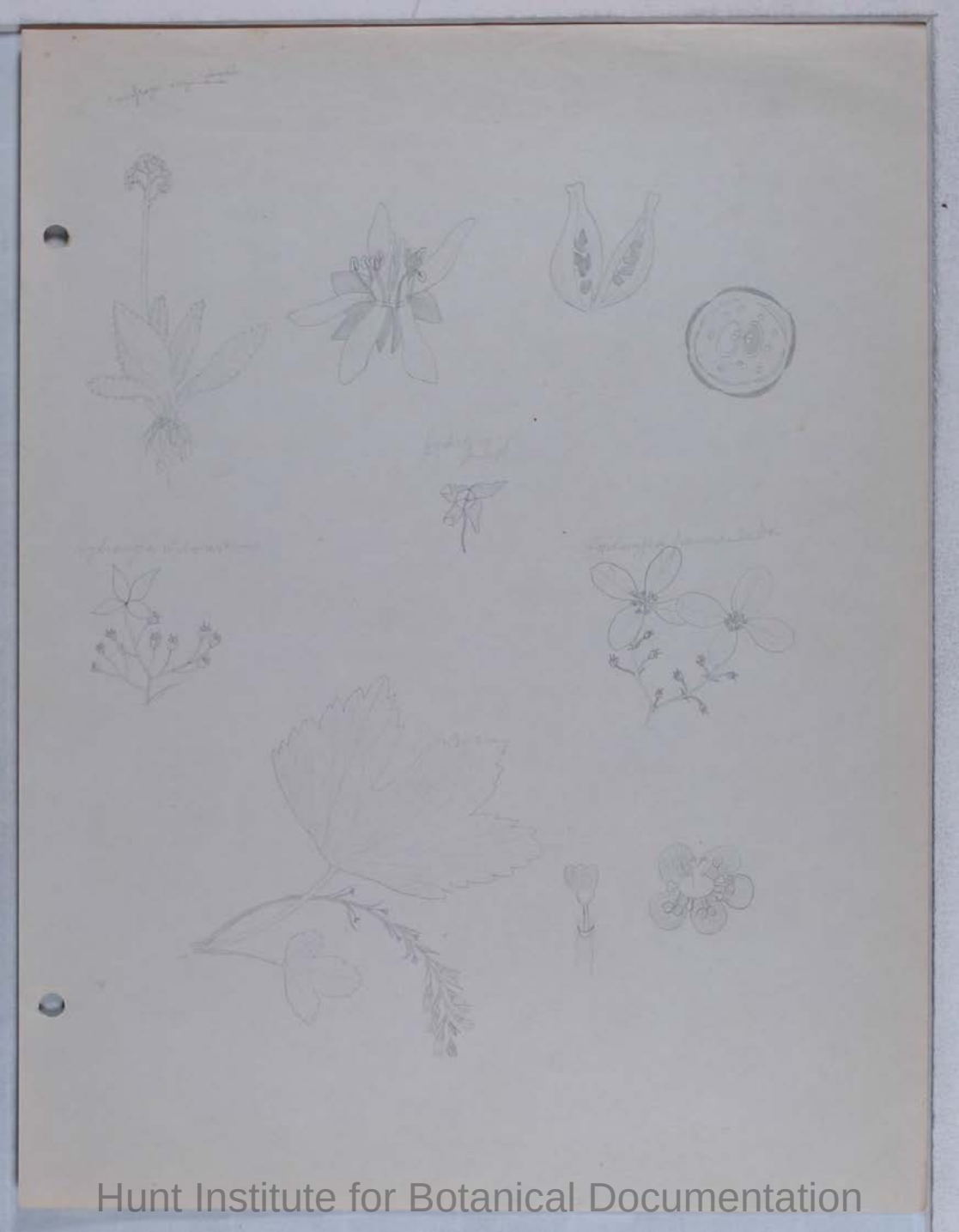
Study the flower and compare with that of Hamamelis. Could it be a direct derivative?

B. Draw flower as spread open and magnified.
C. Draw more mature gynoecium. Is the receptacle at all depressed?
E. Diagram the flower in cross and longisection.

Saxifragoideae: Saxifraga
This is the type genus of the family.

A. Make drawings as for Astilbe
B. If S. sarmentosa - the "Goat's Beard" is available, note its odd zygmorphy and sketch.

Hydrangeoideae
Philadelphus coronarius:
If flowers are available, observe many stamens. If only fruits are available, note disc and advance in ovary toward an inferior position. How many carpels?



A. Draw fruit.

Write the floral formula and cf. with that of Hamamelis.

Philadelphus then is a woody plant, had many stamens, and four carpels united. Would you place it in a more or less primitive position than Saxifraga?

Hydrangea arborescens.
Observe a mounted specimen of the wild species. What curious adaptation to entomophily? Compare with the cultivated variety called "Hills of Snow". What has happened? Are the show flowers fertile?

A. Sketch a bit of the cyme of the two plants.

Hydrangea paniculata.
This is our more common Hydrangea of lawns.

A. Draw a flower of the two types found in its inflorescence.

Ribesoideae.
Ribes vulgare.
Compare with Saxifragas to structure of flower. Note disc and two-carpeled INFERIOR ovary. In this tribe then the ovary has reached its ultimate position.

A. Draw the flower from face and side.

From preserved material remove seeds. Bite them and note abundant fleshy endosperm. Section seed in parafin and search for embryo.

A. Sketch longisection of seed.

Family CRASSULACEAE
These have been called pentamerous fleshy saxifrages.
Note habit of the forms at our disposal. The leaves are obviously adapted to what function?

A. Make sketch of Cotyledon (Echeveria) and of Sedum.

Study flower of Sedum roseum or of Cotyledon. It was the "ideal type" of flower of the old botanies. Why?

Sketch a bit of the plant and draw the flower.

Bryophyllum. This plant may also be studied. It is tetramerous instead of pentamerous and shows a modification of its calyx. How?

A. Draw and diagram the flower.

Family ROSACEAE
Sub-family SPIRAEOIDEAE

Spiraea species.
Compare the habit of the species given with that of Astilbe.

A. Draw leaf and portion of inflorescence.

Work out the floral structure noting insertion of petals and stamens (how many?) and the free carpels slightly sunken. Can you see why the Rosaceae have been called "perigynous buttercups"?

A. Draw the flower in longisection.
B. Diagram the flower.
C. Draw the mature gynoecium.

Physocarpus. This genus used to be included in Spiraea.

A. Draw mature gynoecium and also a carpel opened to show seeds.

The Rosaceae is a family whose perianth and stamen conditions all adhere pretty well to the Spiraea type, but in the relations of carpels to receptacle there is the widest variation. Hence we shall study mostly the gynoecia and receptacle of the remaining sub-families and tribes.

Sub-family Rosoideae.
Tribe Kerrieae.
Kerria japonica or Rhodotypus kerrioides.
Note the general buttercup-like appearance of Kerria. What is the nature of the receptacle and how many carpels are there? How many seeds in each carpel? What name is applied to a small indehiscent, one-seed fruit suich as this?

A. Draw the mature gynoecium.

Tribe Potentilleae.
Potentilla. Section flower longitudinally through torus. Is torus modified over the condition in Kerrieae? How many achenes? How would the strawberry be derived from this condition?

A. Sketch habit of the plant and the longisection of the flower.

Tribe Rubinae. Section lengthwise as before. How about receptacle? How do the fruits differ from those of Potentilla? What name can be applied to the individual granules?

A. Sketch as for Potentilla.

Tribe Dryadinae.
Geum. How could this also be derived from the Potentillas? What is the morphology of the tail and what is its ecological use?

A. Sketch habit and also a single achene magnified.

Tribe Sanguisorbeae.
Agrimonia. Compare the habit and leaf with that of Ranunculus sceleratus. Is the phrase "perigynous buttercup" again suggested? Examine and interpret the odd little fruits. What are the prickles morphologically? What advantage?
Cut open the fruit longitudinally. What about the position of the carpels? How many? Do all mature? Note the dry receptacle wall. If it should become fleshy we would pass to the next tribe.

A. Sketch leaf and bit of inflorescence.
B. Sketch fruit enlarged.
C. Sketch longisection of fruit.

Tribe Roseae.
Rosa - Study the fruit. Cut open lengthwise. It is obviously an Agrimonia with a fleshy receptacle wall and bony achenes.

A. Sketch the rose-hip and also its longisection.

Sub-family Pomoideae.
Tribe Pomariae.
These have been called Spiraeas with capsular fruits sunken into the receptacle. Section the apple pome longitudinally and transversely and see if you agree with this statement.

A. Draw the longi- and cross sections.

Tribe Crategoideae.
Crataegus. Scrape away the flesh from the mass of so-called nutlets. They are one-seeded carpels comparable to the same in apple but the walls have become stony.

A. Draw the "nest of nutlets" with basal flesh adhering (See Gray's Manual)

Sub-family Prunoideae.
Study a flower of a member of this sub-family. How does it differ from the last in relation of carpel to receptacle?

A. Draw the flower in longisection.

Study the mature drupe of any species available. Identify exocarp, endocarp and seed.

B. Draw the drupe as though in longisection.

Compare with the almond (Prunus amygdalus). What is the almond nut? What is the edible part?

C. Sketch the almond fruit from chart.

Since we have gone into the rose family in some detail it is easy to become confused on the many tribes, etc. Construct a hypothetical phylogenetic tree of the Rosaceae to include the Tribes you have studied and also the genera. Affix to the connecting lines the principle of gynoecial and receptacular modification which has been introduced.

Family CONNARIACEAE

112. Connaria
Copy a figure of the habit and a flower of this plant. Note its evident synthetic features.

Family LEGUMINOSAE
Sub-family Mimosoideae

113. Acacia sp.
Note leaf type and cf. with that of Connaria. Observe actinomorphy, many elongate stamens and 1 carpel which matures to a legume.

A. Sketch leaf, flower and fruit.

Sub-family Caesalpinoideae

114. Cassia sp.
Boil out the flower. Is it at all zygomorphic? Is the calyx apo- or synsepalous? How many stamens and are they all alike? How do the anthers open? Is there any tendency to approximate the two lower petals?

A. Sketch leaf and habit.
B. Sketch flower from the face.
C. Sketch fruit of same or allied species.

Sub-family Papilionoideae.

115. Study flower of any one available and see how it has advanced beyond the Caesalpinoideae. Note synsepaly and standard, wings, keel of corolla. Are stamens monadelphous or diadelphous?

A. Draw habit and single flower.
B. Draw androecium and gynoecium on a large scale.
C. Draw fruit.

116. Desmodium species.
The fruit of this legume is a loment adapted to animal dispersal.

A. Study fruit with compound microscope and observe the distribution mechanism.

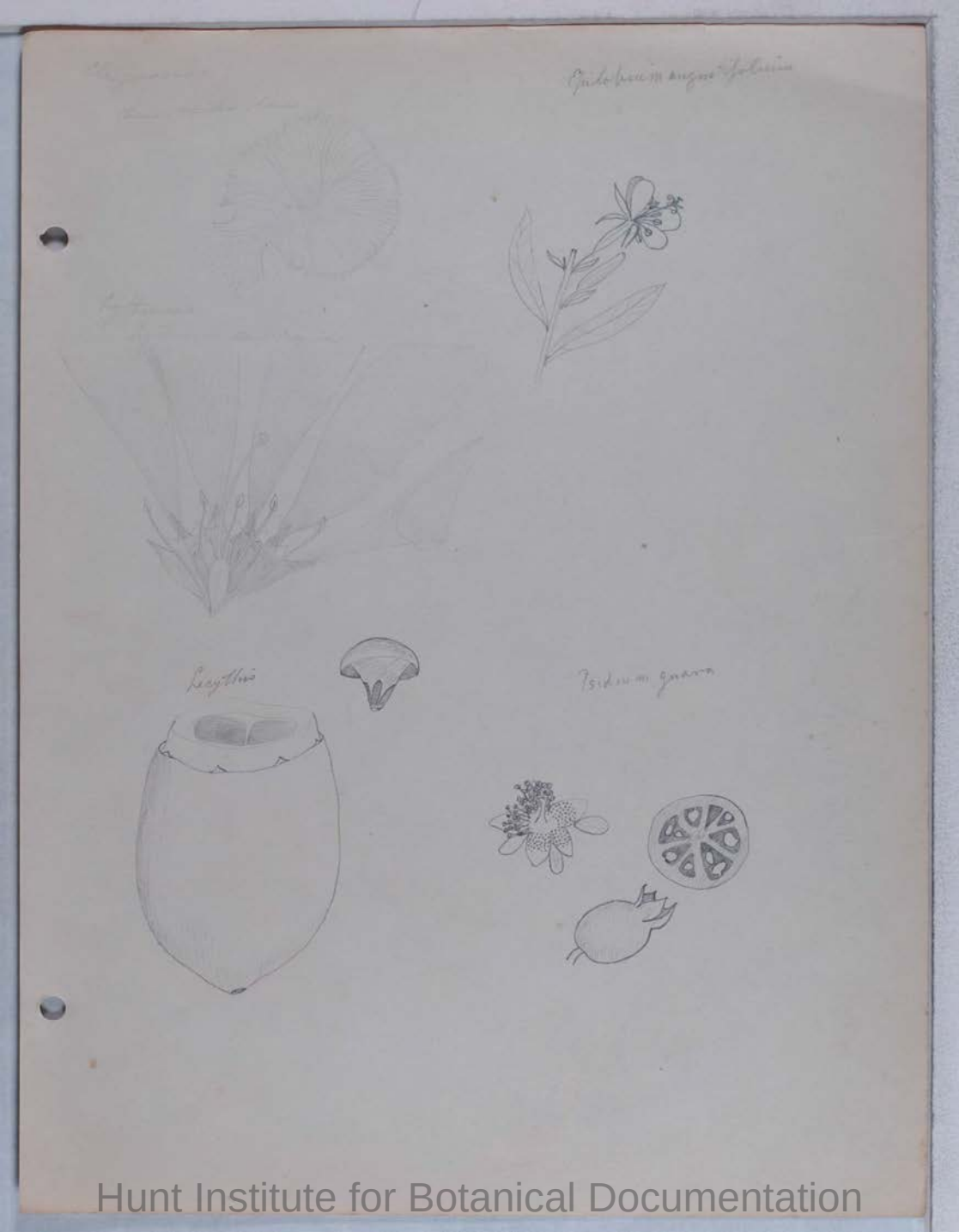
A. Sketch fruit enlarged twice.
B. Sketch bit of surface under l. p.











Order MYRTALES

Another rosalian line characterized by ruling tetramery, single style and carpels tending to sink into torus.

Family ELEAGNACEAE

This family is characterized by the fact that its members possess silvery hairs on stems and leaves. Study with the compound microscope.

A. Sketch a bit of the surface.

Family LYTHRACEAE

118. Lythrum salicaria
What numerical plan? What about length of stamens and style in the different flowers? Is ovary superior or inferior?

A. Draw flower of two types.

Family RHIZOPHORACEAE

119. Rhizophora Mangle.
Draw habit from herbarium sheet and also the viviparous fruit.

Family LECYTHIDACEAE

120. Draw fruit of Lecythis and of Bertholletia.

Family MYRTACEAE

121. Psidium guava
Study flower. Note chorisis of stamens - is there any proof of this? Observe strong epigyny.

A. Draw flower and fruit.

122. Eugenia caryophyllata.

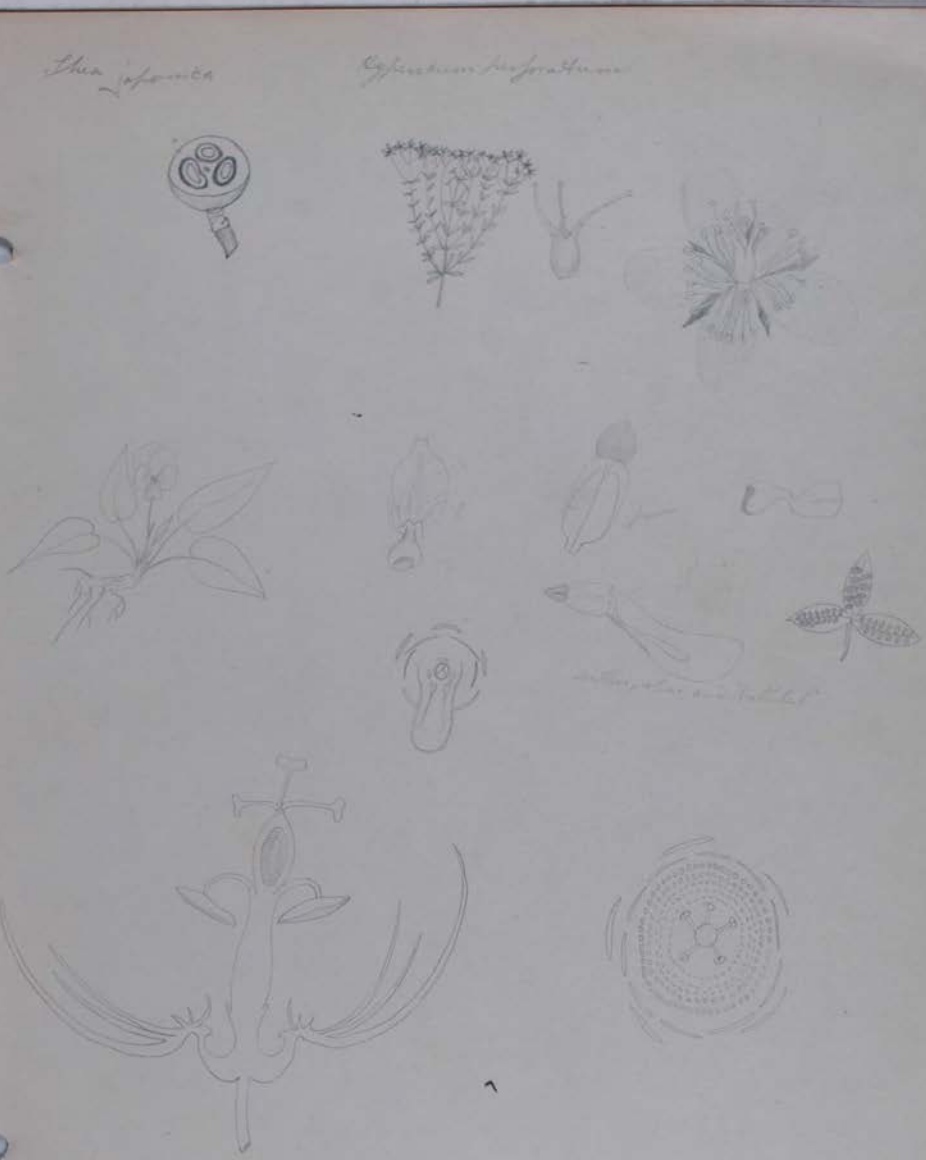
A. Draw the flower bud. Try boiling and dissection.

Family MELASTOMACEAE

123. Habit and flower of Rhexia virginica.

Family ONAGRACEAE

Habit of flower and fruit of Epilobium or of Oenothera.



Order PARIETALES

Part I (Guttiferales of Wettstein)

Family THEACEAE

125. Thea japonica
If in flower, study living material; note the leathery green leaves, bracted flowers - are the petals wholly free? Do the stamens evidence chorisis? How many whorls? How many styles? ovules? What is the fruit?

A. Draw flower and its longitudinal section.
B. Diagram the flower.
C. Draw fruit.

Family HYPERICACEAE

126. Hypericum perforatum or other sp.
What term is applied to the inflorescence? Hold leaf to light and observe dots. What causes them? Boil out the flower. How many sepals and petals? What shape to the latter and how marked? How many stamens and is there any evidence of chorisis? How many styles?

A. Sketch habit.
B. Sketch single flower from the face.
C. Sketch fruit.

Part II. (Parietales s. str. of Wettstein)

Family VIOLACEAE

127. Viola sp.
By probing the flower as it lies in the natural position see if you can determine how the pollination mechanism functions. Dissect flower. Note the spurred petal and appendaged stamens. If cleistogamous flowers are available, study and see how they differ from the vernal ones.

A. Draw habit.
B. Sketch androecium and gynoecium.
C. Sketch a stamen from the inner face.
D. Sketch gynoecium alone.
E. Diagram the flower.

Observe the fruiting capsule, method of dehiscence, placentation and dispersal mechanism. If several species are available, how do the seeds vary in color?

F. Draw the fruit after dehiscence.

Family PASSIFLORACEAE

128. Passiflora sp.

Sketch one of the preserved flowers and also draw the cross-section of the ovary to bring out the parietal placentation. Label corona and androgynophore.

B. Diagram the flower.

Family BEGONIACEAE

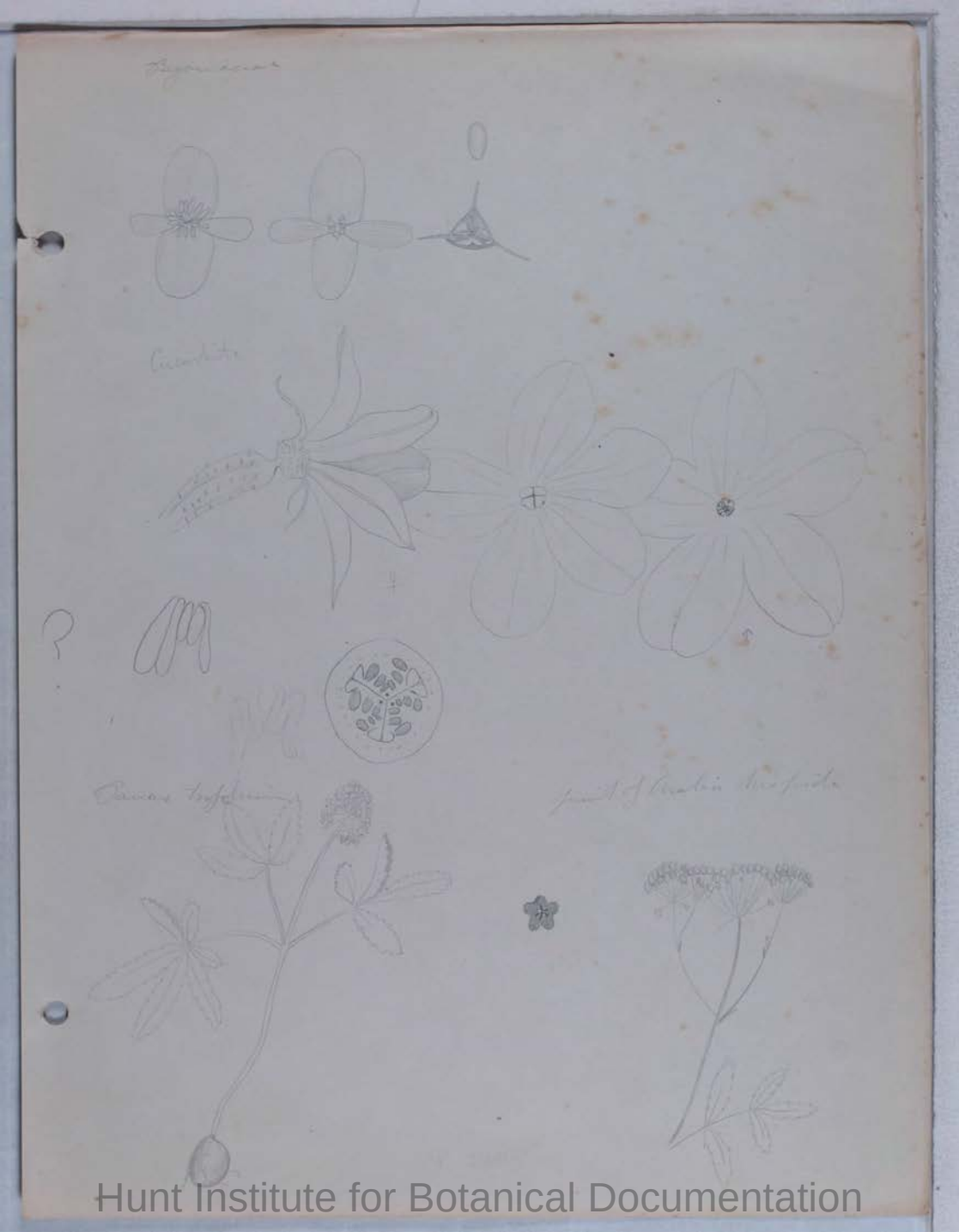
Habit sketch of the living material - note oblique leaf and fleshy habit. As to flowers, observe monoecism.

A. Sketch both staminate and pistillate flowers.
B. Sketch cross-section of the ovary.
C. Observe seeds with the lens and draw.
D. Diagram each flower.

Family CUCURBITACEAE

129. Cucurbita sp.

A. Habit sketch of any form available.



Study stained section of the stem with compound microscope. What striking vascular feature?

E. Diagram the cross-section.

In the flower what calyx and corolla condition is anomalous for an archichlamydean family? Note monoecism. In the staminate flower what has happened to the individual stamens? Is there any evidence of the original state in the column? If the species is one of the cucurbits, what is the shape of the anthers? See if you can determine that one of the anthers has but one loculus (two microsporangia) while the others have two loculi. How did such a state arise?

B. Draw the androecium on a large scale before dehiscence has taken place and mussed things up with pollen.

In the pistillate flower what is the position of the ovary? How many stigmas?

C. Draw the gynoecium.
Section the ovary and observe the placentation.

D. Draw the cross-section.
E. If mature fruit of a cucurbit is available, make a sketch of it. It is called a peop. Define.
F. Draw habit and fruit of Echinocystis lobator. What other genus has the netted pericarp layer so played up that it comes to be of economic importance?

Order UMBELLALES

Family ARALIACEAE

130 Aralia or Panax sps.

A. Sketch habit and fruit of any member of the family. How many carpels?

Family UMBELLIFERAE

131. Take any large flowered form available and make habit sketch. Note reason for the family name. If fresh crush and note odor. Study the flower. What about the symmetry and are all the flowers in the inflorescence alike in this respect? What is the position of the ovary? What is the condition of the calyx? How many petals, stamens and styles? Is there a swollen stylopodium?

A. Draw the flower; diagram it and write the floral formula.

Study fruits which are complete ripe: [illegible]e if you can rightly use the terms: schizocarp, mericarp, carpophore, stylopodium, primary ribs, valleculae.

B. Draw the fruit before and after splitting.

Cut a thin cross-section of the mericarp in pith or paraffin and under lens observe the location of the vittae and also the mass of endosperm.

C. Draw the cross-section.
D. Determine the species and also several others by the use of the Manual.

Family CORNACEAE

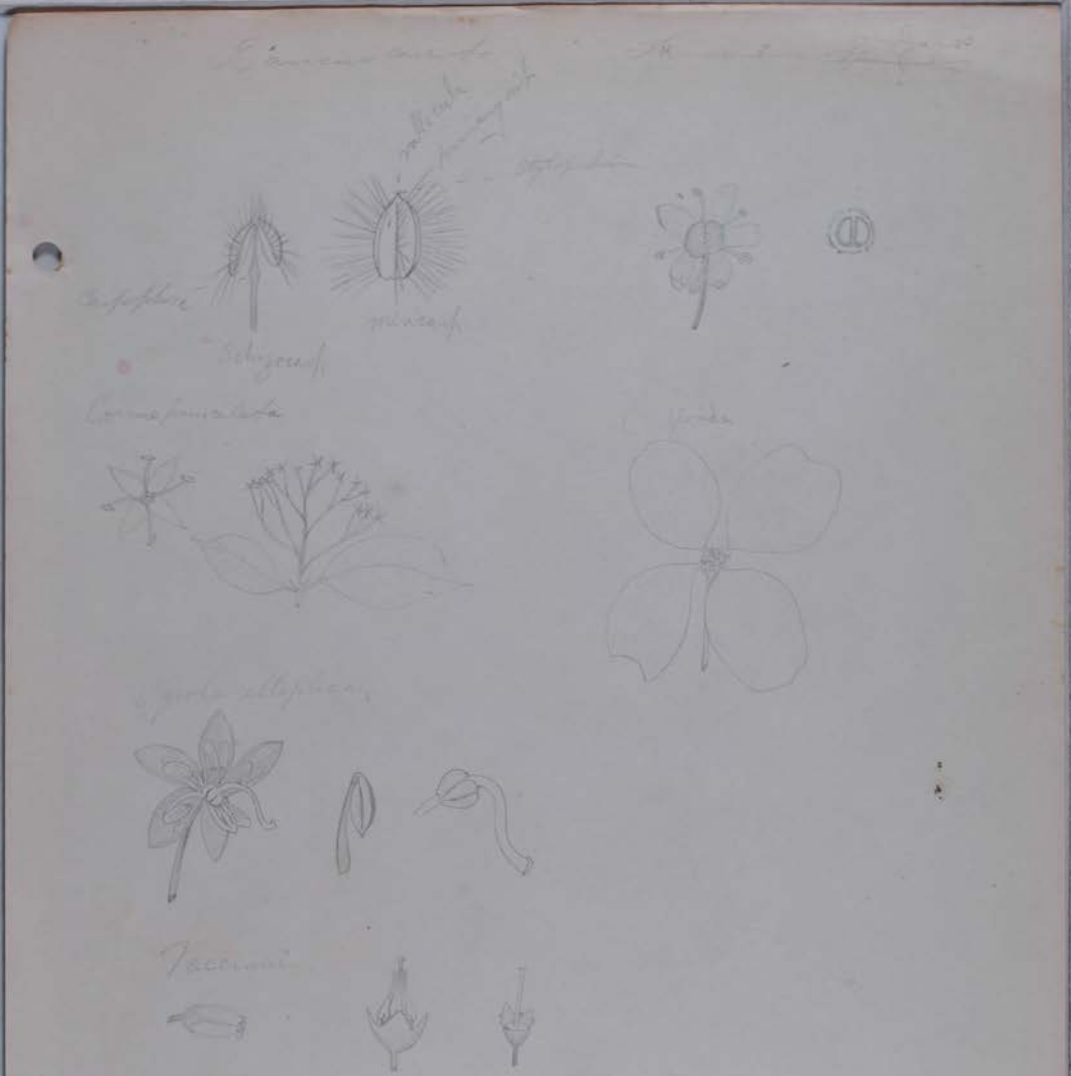
132. Cornus.
Draw inflorescence and fruit of a Cornus sp. which is without the showy bracts. Repeat for C. florida. Any relation between size of flowers and the possession of bracts for display?

THE SYMPETALAE

Order ERICALES

Family ERICACEAE

133. Pyroloideae. Pyrola.
This genus is given because its corolla harks back to a primitive condition anomalous among sympetalian forms. How? Determine floral formula.



A. Habit sketch.

Study the stamen - How does the anther open?

B. Draw a single stamen.
C. Draw pistil.

Remove the seed from the capsule and observe with the compound microscope. Where have we seen such before and with what nutritive feature do we associate it?

D. Draw the seed.

134. Ericoidae:
Almost any genus will answer. Work out the structure and draw what you deem important. In cases where the corolla is sympetalous it is often a good plan to draw it as though split open and rolled out on a flat plane.

Vaccinoideae.

135. Gaylussacia or Vaccinium sp.
How does the ovary differ in position from that of the other Ericaceae?

A. Draw flower in longisection.
B. Draw fruit.

Order PRIMULALES

Family PRIMULACEAE

136. Steironema ciliatum or Primula sp.
This flower again attests its affinity with the Pentacyclidae. In what respect?

A. Habit sketch.
B. Draw corolla as if split open.

Section the pistil. How many loculi and what kind of placentation? Where seen before? Observe mature and dehiscing fruit. How many carpels are probably represented?

C. Draw longisection of pistil on large scale.
D. Draw mature opening capsule.

TETRACYCLIDAE

Order GENTIANIALES

Family OLEACEAE

137. Syringa, Ligustrum or Forsythia.
A very definite and easily remembered structure characterizes the flowers of this family. Dissect and determine.

A. Habit sketch.
B. Sketch single flower and also one split open.
C. Draw bicarpellate fruit.
D. Construct floral diagram.

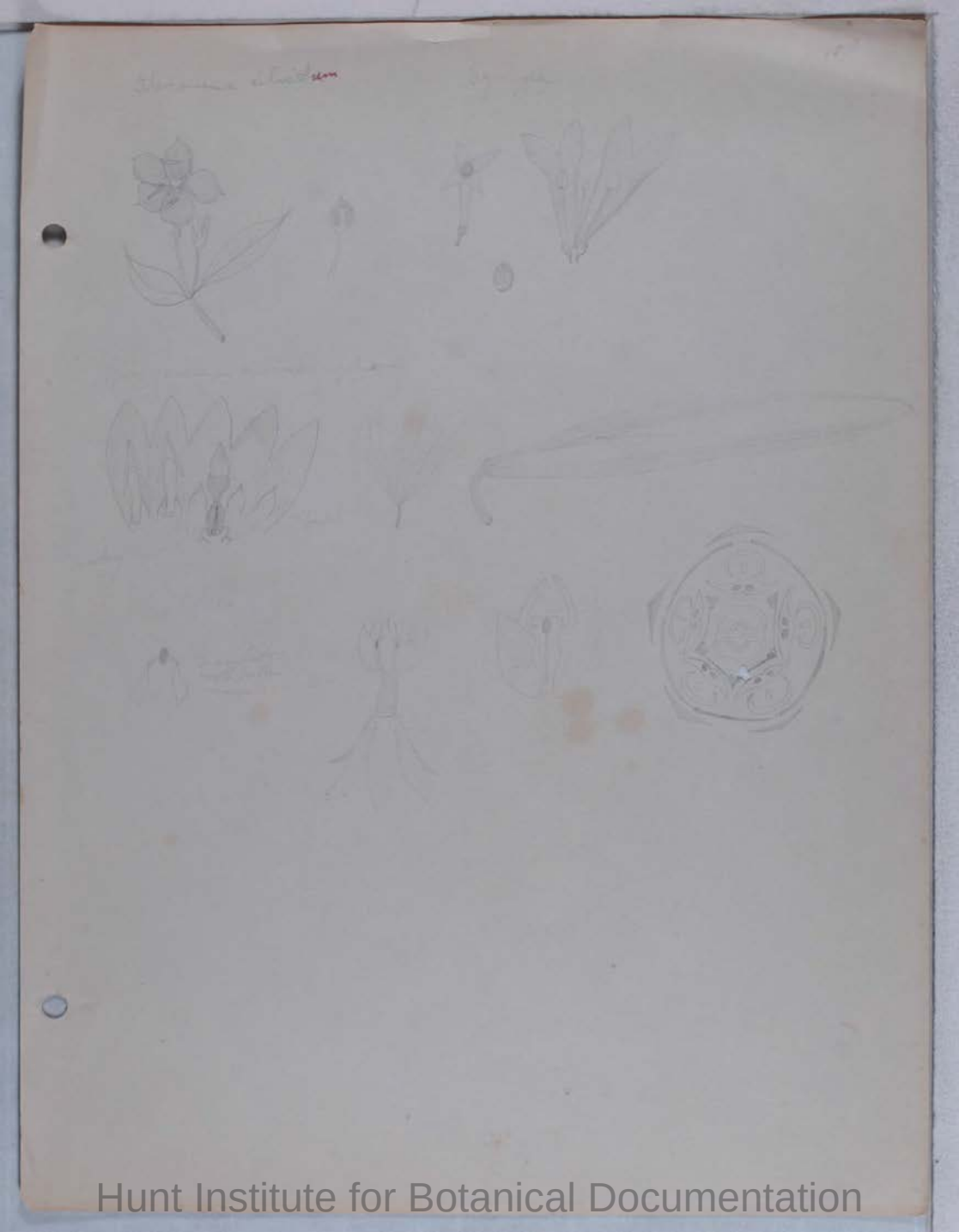
Family APOCYNACEAE

138. Apocynum androsaemifolium.
Remember that this family begins to move toward the mildweeds. Dissect flower. Note coronal scales and the position of the anthers. How about the modification of the stigma? How many ovaries?

A. Habit sketch.
B. Draw flower cut open.
C. Draw single stamen to show sagittate tailed anther.
D. Draw mature dehiscing fruit and also seed.

Family ASCLEPIADACEAE

139. Asclepias sp.
Review from your notes the morphology of this remarkable flower and then work it out from specimen. The following sketches will be a safe minimum.



A. Habit sketch.
B. Whole flower x 2 or 3. Label gynostegium.
C. Single stamen forcibly removed with staminal and nectarial corona.
D. Two stamens in place to show relation of translator to their loculi and to stigma.
E. Pistil freed from stamens.
F. Single translator.
G. View of pollen grains under compound microscope.
H. Partly grown fruit.
I. Schizocarpous mature dehiscing follicles.
J. Seed.
K. Floral diagram.

TETRACYCLIDAE

(TUBIFLORALES)

POLEMONIALES

Family CONVOLVULACEAE

140. Convolvulus sp.
Note habit and tubular actinomorphic corolla with epipetalous stamens. How many? What is the character of the ovary or fruit and how many ovules per carpel? To what final terminus did the Convolvulaceae lead?

A. Habit sketch.
B. Corolla shown opened on one side.
C. Sketch of the fruit and its section.

Family POLEMONIACEAE

141. Phlox sp.
Note actinomorphy, stamen features. How many carpels?

A. Sketches similar to last.

Family SOLANACEAE

142. Nicotiana Tabacum.
Fresh material is usually available. Note the primitive tubifloralian character.

A. Make sketches to show floral parts.