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

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

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

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The Hunt Institute Archives contains hundreds of thousands of pages of historical content, writing and images, created by thousands of individuals connected to the botanical sciences.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of time and social context in which these materials were created, some of the collections contain material that reflect outdated, biased, offensive and possibly violent views, opinions and actions.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 Archival records are historical documents, and the Hunt Institute keeps such records unaltered to maintain their integrity and to foster accountability for the actions and views of the collections'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

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

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

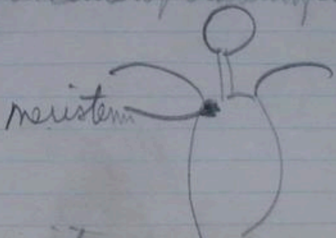
Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the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

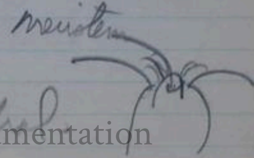
1/5/49
Gymnosperms-
*Cycadofilicales-
*Bennettitales
Cycadales
*Cordaitales
Ginkgoales
Coniferales
Gnetales
*Known only from fossil record.

Cycadales-
Cycadaceae
Dioon - Mex. - 3 spp.
Ceratozamia - S. Mex + Guat. 2 spp.
Microcycas - W. end of Cuba. 1 sp.
Zamia - S. Fla. + Ind. Occ. 26 sp. Schuster Das Pfl. Reich
Bowenia - N.E. Australia 1 sp
Macrozamia - E. + W. " 9 sp
Cycas - S.E. Asia + Ind. Ocean. 8 spp
Stangeria - 1 sp - S.E. Africa.
Encephalartos - 14 spp. Central + S. Africa.

Stangeria paradoxa - from Zulu-land, 1st descr. as a fern genus <u>Lomaria</u>. (looks like a fern)

Habit of Cycads-
1. Unbranched stem. (not invariable)
2. Crown of leaves
3. Stem from subterranean → aerial - (18 meters)
4. Cones borne in center of crown of leaves (axillary or terminal)
5. Dioecious-





in genus <u>Cycas</u> ~~meristem~~ cone is central.

Most Cycads has musilaginous substance.

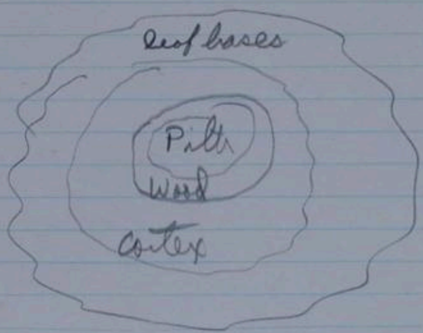
Male strobilus - compact.

1 sp. of Microzamia has poisonous leaves.

Habitat - mostly in ~~trop~~ semi-arid, open, park like terrain. but one (D. spinulosa) grows in tropical rain-forest.

Characteristic - leaf bases left after abscission of leaf. ∮ in leaf-base, further devel. of ~~leaf~~ abscission layer which chops off more & more of the leaf base, giving a narrowing effect of the trunk toward the base \ /.

X-sec. of stem



Cambium present, but activity is slow - not annual rings, or many at all -
If growth rings present, not related to season, but related ~~the~~ to prod. of leaves or cones.
Cambium may remain inactive for more than 1 year. Production of cone may take so much energy that it causes a dormancy.

Cycads - variable durability - usually set of leaves last 2 years. age from
If you can get estimate of duration of crown, count no. of leaves in crown, then multiply by no. of leaf bases - on this basis, some plants found to be at least 1000 yrs. old.

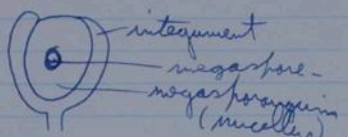
Sketch - habit of
Cycas or Dioon -
Zamia
Encephalartos -
Single leaf of each of Cycas + 1 of Encephalartos.

1/7/49 - Life history of cycads -

1. Dioecious - ♀ or ♂ Both have sporophylls arranged in a spiral.
2. Largest ♀ cones in Macrozamia, 1 m. long & 5 pounds.
3. Type of cone variable - sporophylls of zamia computed, modified; in Dioon, sporophyll has more tissue than Zamia; extreme of leaf like sporophyll w/ more than 2 ovules per sporophyll (Cycas).
   Usually 2 ~~sporophylls~~ ovules per sporophyll.
4. Staminate strobilus is always cone-like, never loose arrangement - always compact. Cone elongates considerably just before spores are ripe.
5. Microsporangia on under surface (abaxial) of sporophyll. Supposedly in sori, with 5 - 2 sporangia per sorus - indistinct.
6. No of ♂ sporangia / sporophyll from 12 10 in Cycas to 35 / sporophyll in Zamia.
7. Sporangia massive, walls several cells thick. Very closely looks like Marattiaceae - Primitive.

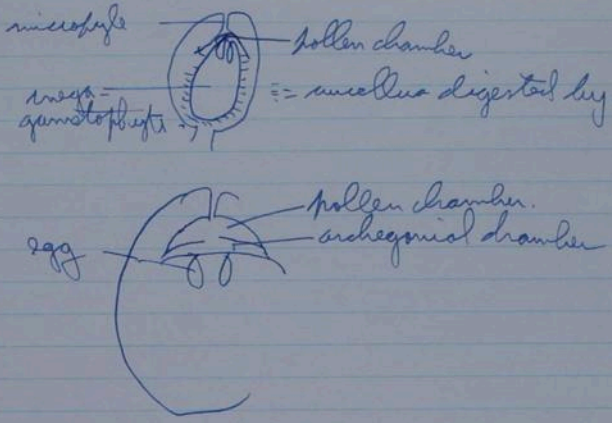
Ovule development -

1. Young ovule - megaspore in megasporangium

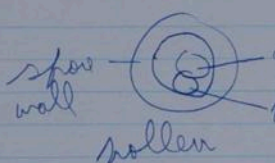


2. Usually 4 megaspores started, 1 only develops

3. Ovule expands + megagametophyte enlarges + integuments meet.



4. Microsporangium produces microspores much the same as in ferns - plus a generative cell and a prothallial cell and rest of microspore (3 celled condition within microspore wall) and in this condition pollen is shed + pollination takes place.



an exudation thru micropyle to catch pollen

4-6 months from time of pollination to fertilization.
Pollen grain germinates on tissues

Pollen tube penetrates archegonial chamber.
~~Pollination~~ takes place at time of maturity of ovules.
Fertilization

Pollen tubes break at end and drop shematozoids (ciliate) 3-400 μ. Two spermatazoa formed in pollen tube. in liquid above eggs. ↗ !!

1 single spermatozoid fert. egg. 3-5 eggs per gametophyte.

Suspensor pushes developing embryo into megagametophyte tissue, on which it is dependent. As many suspensors as embryos which develop, but only one embryo makes it.

At later stage of development a coleorhiza, 2 cotyledons, (Coleorhiza is protective structure over hypocotyl)
Seeds have no resting period — do not maintain viability to a great extent.

Seed on ground - 1st an extension of coleorhiza, breaks thru seed coat. (Coat has outer fleshy layer, stony inner layer) then hypocotyl pushes thru developing roots, then developing stem + leaves pushed up

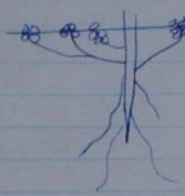
Lab - sketch ♀ strobilus of Zamia.
2. Draw a ♀ sporophyll of Zamia + of Dioon.
3. " " long section of an unfertilized ovule of Zamia.
4. Cut an ovule of Dioon. Observe. Note nucellar canals in X-section of sporophyll.

1/12/49-

Anatomy of the Cycads-

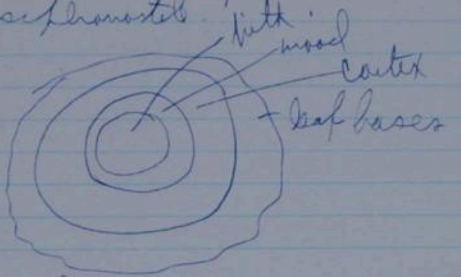
A Root-

1. Primary - unusually large - in seedling, bigger than stem, & even in mature plant very longer.
2. Branch - same at least 40.
3. Tetrarch - secondary thickening (cinc.) not uniform.
4. Nearly all Cycads produce roots which are negatively geotrophic, at ground surface, root tips affected w/ algae Anabaena.



B. Stem -

1. Tree like & erect or subterranean & tuberous -
2. " stems have leaf base scars.
3. Tuberous st. have no leaf-scale-scars
4. Stem is siphonostele.



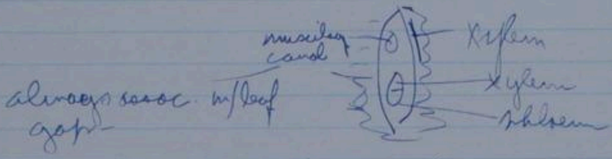
5. Xylem small in comparison
   a stem 21 cm in diameter has
   5 cm phloem
   5 cm xylem

6. In some, more than 1 cycle of xylem (polycyclic)
7. Cambium arising from cortex has been observed, usually from pericycle, however. This may be related to long periods of dormancy (i.e. after first of cones)

8. 2ndary xylem has tracheids w/ bordered pits.
Zamia + Stangeria have scalariform pitted tracheids.

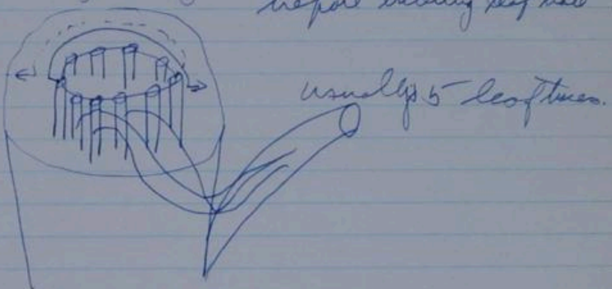
9. Rays 1 cell wide, 40-50 cells long, w/great deal of starch and Ca oxalate - Those cells w/Ca oxalate have no starch, + vice-versa - these cells evenly distributed

10. Leaf gap



Tangential section

11. Leaf traces - show "girdling" - going all the way around before entering leaf trace.



12. Exact conditions of normal types - 1st cone is truly terminal + all others considered lateral.
Every time plant cones, a new meristem is produced at base of cone.

C. Leaf

1. Two types circination:
   a. Circinate - genus Cycas
   b. Erect or straight (usual condition)
2. Juvenile leaf + mature leaves. Differences in spiny, or entire or both the young leaves one, the mature leaves another condition.
3. Both mature + juvenile leaves found.

4. Leaves very xeromorphic:
   1. Heavy cutin, epidermis, hypodermis (looks just like another layer of epidermis)
   2. Palisade,
   3. Mesophyll
   4. epidermis (sunken stomata)

Lab:
1. Draw a ♂ strobilus of Ceratozamia
2. " " sporophyll of " "
3. " " " " " " showing x-sec. thru. sporangia.
4. Draw a portion of ♂ sporophyll of Encephalartos showing mature sporangia.
5. x-sec of cycas leaf.
6. Cut tubercle of cycas root.

1. Bowenia - 1 sp. N. Australia.

♂ Sporophyll broadly obovate-cuneate, slightly stalked, apex transverse hexagono-peltate.
♀ sporophylls in spirals of 6, transversally hexagonal peltate.

2. Cycas - ♀ ~~sporophylls~~ flattened, the megasporangia borne laterally, about 6 per ~~sporophyll~~ covered with a dense tomentum. The terminal portion generally flattened.
microsporophyll cuneiform, somewhat acuminate.
8 spp. in genus

Indian Ocean, SE Asia & austral Asia + Oceania.

3. Stangeria - cones smooth, megasporophylls imbricate, ♂ sporophyll ~~sessile, microsporangia completely covering on abaxial surface~~ shortly stipitate, broadly cuneiform, apex triangular to sub-rounded. Macrosporophylls - concave, ~~base~~ subcordate the ovules somewhat sunken in base of lobes.
S.E. Africa (Natal).
1 sp.

4. Macrozamia - 9 spp, Australia ♂ Strobilus elongate cylindrical. microsporophyll cuneate to obovate-lanceolate, apex rhomboid peltate, acuminate to rounded. ♀ Strobilus oblong to ovoid, macrosporophyll pedunculate, 1 ovule borne on each side, rhomboid peltate to peltate acuminate.

5. Microcycas - ♀ strobilus w/ sporophylls in spirals, the tips of which is blunt, sub-quadrangular, and sometimes furrowed, the entire outer portion of the sporophyll covered by a dense mass of closely appressed grayish hairs, long stalked, and perpendicular to axis of the cone, the outer portion [illegible], [illegible] 4-ridged.

3 Microcycas (cont.) ♂ sporophylls, basal 2/3 densely covered w/ sporangia, the apical third gray-tomentose & prominently ridged along the median long, obtusely pointed.
1 sp. in western Cuba.

6. Ceratozamia – the ♀ + ♂ sporophylls have 2 awn-like appendages at the tip of the sporophyll; the sporophylls cyclic arranged.

Mexico + ~~Cent. Amer.~~ 2 sp.

7. Encephalartos – ♀ sporophyll with a large rugose projection above insertion of ovules. Two lobes extending down beside ovules. ♂ sporophyll with a short stalk – somewhat acuminate, rhomboid.

Tropical + S. Africa – ~~usually~~ 14 spp.

8. Zamia – sporophylls compact, arranged in subquadrangular tight spiral cone. the tips of the ♀ sporophyll ~~truncate~~ rhomboid. lobes not projecting beyond the insertion of the ♀ sporangia.

microsporophylls pedicellate peltate to cuneiform peltate.

26 spp – S. Fla, W. Indies, Mexico, Cent. + S. Am. in open well-drained soils.

9. Dioon – sporophylls densely covered with a fine tomentum – ~~the tips~~ ♀ sporophylls mostly with a very long attenuation at the tip. Megasporangia borne at base of lobes which do not extend downward – ♂ sporophylls long triangular, the tip, in end view broadly triangular,

3 spp Mexican – 2 in open semi-arid region, one in trop. rainforest –

Jan. 14, 1949.

Zamia floridana
integrifolia
costaricensis
Van Houtei (a gardener at Ghent)
furfuracea
Loddigesii (a nurseryman in England)
Skinneri - collected in Cent. Am.
Cycas Rumphii - a Fl. of Amboyna (Malay Pen.)
circinalis
revoluta
Micholtzii collected in S.E. Asia
tonkinensis
siamensis

Encephalartos horridus
elongatus
Lehmanni author of Cycadacea
lanuginosus
Hildebrandtii a collector in Africa
Villosus
caffer
Dioon edule
spinulosum
Microcycas calocoma
Macrozamia spiralis
Stangeria paradoxa
Ceratozamia mexicana

[Bowenia spectabilis]
governor of Queensland & patron of bty.

1. Write a key to genera based on leaf & trunk characters only
2. Under each genus, a brief description of ♂ & ♀ cones, w/ esp. ref. to sporophylls (size & shape of cones not too important). Use herbarium material & photographs
3. Give ~~of~~ distribution, habitat data, and no. of spp. per genus. Cite reference for above data
4. Key to spp. of Zamia, Cycas, Encephalartos & Dioon.
5. No. of leaflets, size of leaflet & size of leaf for each sp. keyed out in key.

Characters of trunk
1. Subterranean
2. Short (crown right at surface
3. Tall

Leaves -
1. Base of leaf -
1. leaflets end abbruptly
2. ~~s~~ midrib
3. decurrent
4. Entire
5. spiny

Base of leaflet
1. Pronounced broading
2. Narrowing
3. swelling -

This treatment very good / Sol: drawings not as good.

Key to Genera of Cycads

1. Leaves twice pinnate. Bowenia

1. Leaves once pinnate--2.

2. Leaflets with a definite midrib--3.

3. Leaflets linear, entire, lateral veins not prominent.

Cycas

3. Leaflets elliptic, serrate, lateral veins prominent and dichotomously forked. Stangeria

2. Leaflets without a definite midrib--4.

4. Leaflets with white glands at their bases.

Macrozamia

4. Leaflets without any glands at their bases--5.

5. Leaflets constricted at the base--6.

6. Leaflets articulated at base, leaves falcate.

Microcycas

6. Leaflets not articulated at base, leaves not obviously falcate--7.

7. Rachises with definite ridge above insertion of leaflets. Ceratozamia.

7. Rachises without definite ridge above insertion of leaflets--8.

8. Leaflets arising at acute ventral angle, apical leaflets less than ½ the length of the central leaflets.

Encephalartos

8. Leaflets arising at wide ventral angle, apical leaflets nearly same length as central leaflets.

Zamia

5. Leaflets not constricted at the base.

Dioon

Key to Seven Species of Zamia

1. Leaflets light green to light yellow green--2.

   2. Veins prominent in leaflet; leaves 60-65 cm. long, petiole 30 cm. long, leaflets 6-7 cm. broad. Z. costaricensis

   2. Veins not prominent in leaflet; leaf 85 cm. long; petiole 35-40 cm. long, leaflet 3.5 cm. broad. Z. Skinneri

1. Leaflets dark green--3.

   3. Leaflets ferruginous-puberulent beneath--4.

      4. Leaflets oval, 3.5-4 cm. broad. Z. furfuracea

      4. Leaflets linear, 0.6-0.8 cm. broad. Z. floridana

   3. Leaflets glabrous beneath--5.

      5. Leaves 45 cm. long, petiole 15-18 cm. long, leaflet 10-13 cm. long, oblanceolate-obovate. Z. Van Houtei

      5. Leaves 85-90 cm. long, petiole 20-45 cm. long, leaflets 14-20 cm. long, linear, or lanceolate--6.

         6. Leaflets entire, lanceolate, 14-17 cm. long, petiole 30 cm. long. Z. integrifolia

         6. Leaflets irregularly spiny margined, linear, 18-20 cm. long, petiole 40-45 cm. long. Z. Loddigesii.

Key to Seven Species of Encephalartos

1. Leaves 85 cm. long, leaflets deeply lobe, 2-5 partite, margins revolute.

E. horridus

1. Leaves 90 cm. long or longer, leaflets entire to very shallowly lobed, margins entire, not revolute--2.

2. Leaves without reduced basal leaflets--3.

3. Leaflets entire--4.

4. Tip of leaflet a sharp spine, leaflet 12-14 cm. long, 1 cm. broad.

E. elongatus

4. Tip of leaflet rounded, leaflet 16-17 cm. long, 1.5 cm. broad.

E. Lehmanni

3. Leaflets with 1-3 lobes, the lobe about 5 mm. long.

E. lanuginosus

2. Leaves with reduced basal leaflets--5.

5. Petiole distinct, 16 cm. long; 2-3 pairs of reduced basal leaflets.

E. caffer

5. No distinct petiole, 8-16 pairs of reduced basal leaflets or spines--6.

6. Leaf 220 cm. long, central leaflet 25-28 cm. long.

E. villosus

6. Leaf 100 cm. long, central leaflet 18-20 cm. long.

E. Hildebrandtii.

Key to Six Species of Cycas

1. Leaves usually 200 cm. or more long--2

   2. Margin of leaflets undulate, terminal leaflet 8-10 cm. long, central leaflet 35 cm long; petiole 85 cm. long, with about 88 pairs of spines.

      C. tonkinensis

   2. Margin of leaflet smooth, terminal leaflet 13 cm. long, central leaflet 30 cm long,; petiole 50 cm. long, with 22-24 pairs of spines.

      C. siamensis

1. Leaves shorter, 160 cm. or less--3.

   3. Petiole and rachis without spines, or if spiny, not more than 2 pairs of spines on the petiole. C. Rhumphii

   3. Petiole and rachis spiny(5 pairs or more on petiole)--4.

      4. Leaflet with revolute margin, 15 cm. long or less.

         C. revoluta

      4. Leaflet with smooth margins, 18 cm. long or more--5.

         5. Leaf 70 cm. long, petiole 10-12 cm. long, with 8-9 pairs of spines; leaflet 18-20 cm. long, 0.3-0.5 cm. wide, terminal leaflet 9-10 cm. long; bark definite, undivided.

            C. Micholtzii

         5. Leaf 160 cm. long, petiole 35 cm. long, with 15-16 pairs of spines; leaflet 35 cm. long, 1.3-1.5 cm. wide, terminal leaflet 18-20 cm. long; no evident bark.

            C. circinalis

Key to Two Species of Dioon

1. Leaves 140-150 cm. long; the leaflets serrate, 15-20 cm. long.

D. spinulosa

1. Leaves 75-80 cm. long; leaflets entire, 10-12 cm. long.

D. edule

Description of Cones of Cycadales

1. Bowenia

Staminate strobilus: small, ovoid to oblong-cylindrical.

Microsporophyll: broadly obovate-cuneate, short-stalked, apex transversely hexagono-peltate.

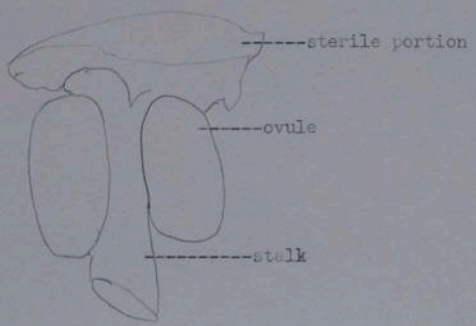
Ovulate strobilus: much larger than staminate, oblong-globose, with compact sporophylls, in spirals of 6.

Megasporophyll: broad at the apex, rather thick, truncate, with one ovule and seed on each side.

Distribution: Confined to northern Australia.

Habitat: In open forests or savannahs, rather xerophytic.

Number of species: one, with one variety, sp. B. spectabilis. and var. serrulata.



megasporophyll

2. Cycas.

Staminate strobilus: more come compact than female; oblong-ovoid.

Microsporophyll: cuneiform, somewhat acuminate.

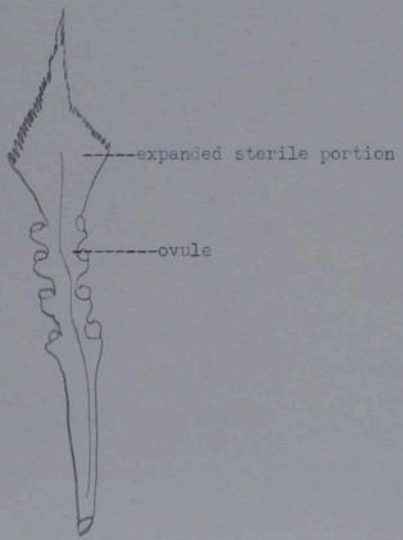
Ovulate strobilus: terminal, in center of the vegetative trunk.

Megasporophyll: Imbricated, stipe linear, sterile blade lanceolat-ovate to obovat-rhomboid, acuminate, crenate, denticulate, cristate to pinnatifid, bearing from 2-many ovules.

Distribution: Indian Ocean, Southeastern Asia, Austral Asia and Oceania.

Habitat: Tropical forests to temperate regions in India, mesophytic.

Number of species: Eight



megasporophyll

C. circinalis
microsporophyll

8. Stangeria

Staminate strobilus: oblong, smooth, compact, produced with only peduncle arising from soil a short distance

Microsporophyll: shortly stipitate, broadly cuneiform, apex triangular to sub-rhomboid.

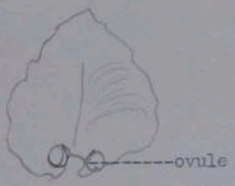
Ovulate strobilus: ovoid, smooth, the sporophylls imbricated.

Megasporophyll: concave, subcordate, the ovules somewhat sunken in base of lobes.

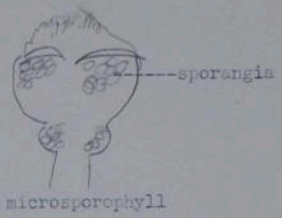
Distribution: Confined to southeastern Africa (Natal)

Habitat: open, savannah-like forest, xerophytic to mesophytic.

Number of species: One, S. paradoxa



megasporophyll



microsporophyll

4. Macrozamia

Staminate Strobilus: elongate, cylindrical

Microsporophyll: Cuneate to obovate-lanceolate, apex rhomboid-peltate to acuminate to rounded.

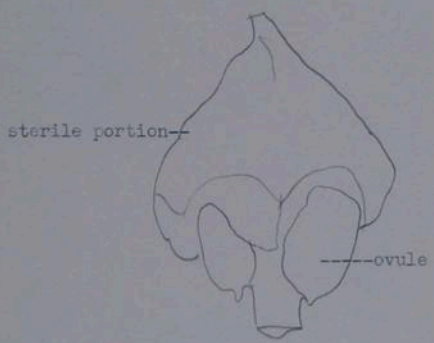
Ovulate strobilus: oblong to ovoid

Megasporophyll: pedunculate, 1 ovule borne on each side, rhomboid-peltate to peltate acominate.

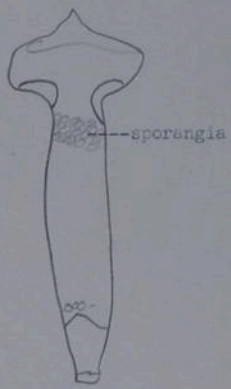
Distribution: Southeastern, central (near large lakes) and southwestern Australia.

Habitat: Usually in regions of moderate to plentiful rainfall.

Number of species: Nine.



megasporophyll



M. Denisonii
microsporophyll

5. Microcycas

Staminate strobilus: oblong-ovoid, about 1 foot long, compact.

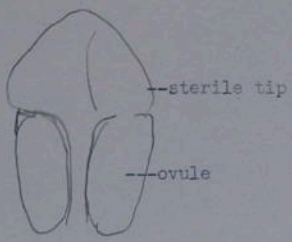
Mega
~~Xixxx~~sporophyll: In spirals, the tips blunt, sub-quadrangular, and sometimes furrowed, the entire outer portion of the sporophyll covered by a dense mass of closely appresse d grayish hairs, long stalked and perpendicular to the axis of the cone, the outer portion quite convex, u sually 4-ridged.

Microsporophylls: Basal 2/3 densely covered with sporangia, the apical third gray-tomentose and prominently ridged along the median line, obtusely pointed.

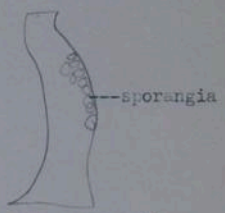
Distribution: Confined to the western end of Cuba.

Habitat: Tropical rainforest.

Number of species: One, M. calocoma.



megasporophyll



microsporophyll

6. Ceratozamia

Staminate strobilus: Cylindrical to narrowly elongate, not compact.

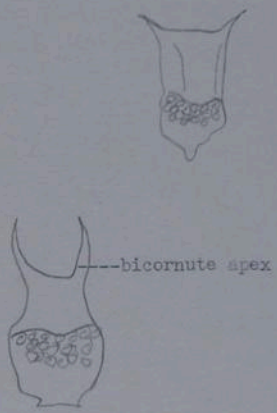
Microsporophylls: cuneiform, sterile part pyramidal-truncate to sub-flattened. Tips of sterial portion usually bicornute.

Ovulate strobilus: ellipsoid, compact.

Megasporophylls: short-pedicellate, one ovule on each side, the tips bicornute.

Distribution: Mexico and Central America

Habitat: Sub-tropical to tropical forests, from mesophytic to extremely wet conditions, but probably on very well-drained soils.



Two forms of microsporophylls

7. Encephalartos

Staminate strobilus: cylindrical to oblong-cylindrical.

Microsporophylls: microsporangia covering both sides EXXXXEER but with a prominent central nerve, cuneate, sterile part at the apex rhomboid-tetragonal to hexagonal peltate.

Ovulate strobilus: Ovoid to oblong ellipsoid.

Megasporophyll: pedunculate, peltate, biovulate, rhomboid, pyramidal truncate to apophysoid.

Distribution: southeastern and central Africa.

Habitat: Open savanah country, rather dry.

E. Lehmannii
microsporophyll

E. villosus
megasporophyll
x½

8. Zamia

Staminate strobilus: elongate-ellipsoid, rather compact, appearing above-ground on a short pedicel.

Microsporophyll: pedicellate-peltate to cuneiform peltate

Ovulate strobilus: ovoid to ellipsoid, short-stalked, very compact, from under-ground rhizomes.

Megasporophyll: tips rhomboid or subquadrangular, without any lobes covering the ovules.

Distribution: Southern Florida, West Indies, southern Mexico, Central America and ~~x~~xxx South America to Peru Venezuela, ~~x~~xxxx Columbia and North central Brazil.

Habitat: In xerophytic to mesophytic conditions, mostly in open forests.

Number of Species: 26, with variable numbers, up to four in southern Florida.

Zamia muricata
microsporophyll

9. Dioon

Sporophylls densely covered with a long tomentum.

The megasporophyll mostly with a very long attenuation at the tip.

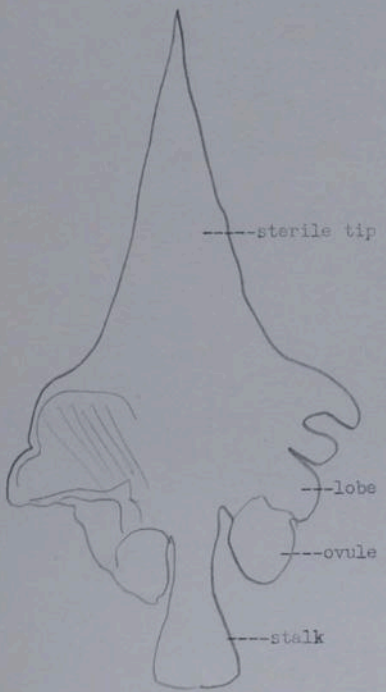
Megasporangia borne at base of lobes which do not extend downward.

Microsporophylls long triangular, the tip, in end view, broadly triangular.

Distribution: Found only in Mexico and Guatemala.

Habitat: D. edule and D. spinulosa prefer a rather dry climate, with well drained soils, but D. Pringleii is found only in tropical rain forests.

Number of species: Three, mentioned above.



WORLD (Mercator)—10 H

HALL'S OUTLINE MAPS AND GRAPHS

PUBLISHED BY JOHN WILEY & SONS, Inc., NEW YORK

Taken from J. Schuster in Engl. Pflanzenr. Heft 99, IV-I, 1932

WORLD (Mercator)—10 H

HALL'S OUTLINE MAPS AND GRAPHS

PUBLISHED BY JOHN WILEY & SONS, Inc., NEW YORK

Note:

The author wishes to thank his many friends for assistance in compiling this work. Especial mention must go to the following:

1. J. Schuster in Engl. Pflanzenr. Heft 99, IV.I, 1932

2. Bentham, Flora Australiensis, Vol. 4,248-254, 1873

3. Hemsley, Biol. Centr.-Amer. Bot. 3 & 5: 190-195, 1882-1886

4. Rudolf Marloth, Flora of South A frica 92-100. 1913

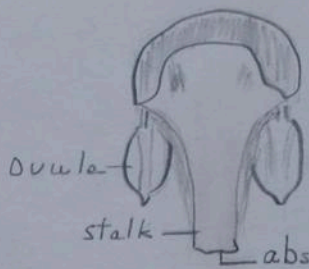
David J. Rogers

Missouri Botanical Garden

28th day of January, 1949

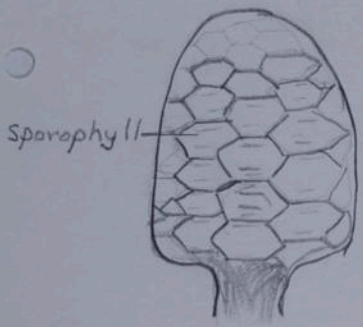
Cycadaceae

♀Sporophyll of Dioon

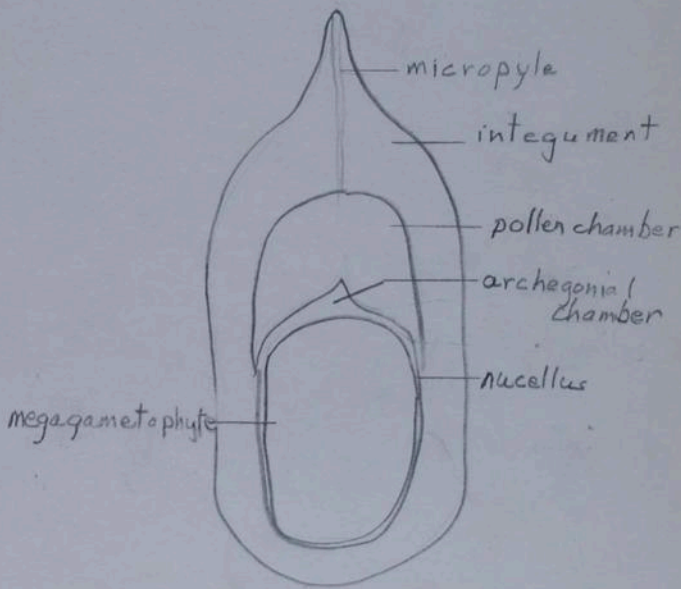


x15

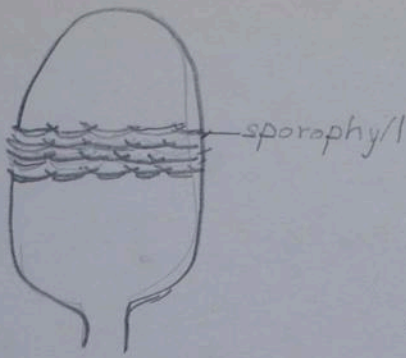
♀Sporophyll of Zamia



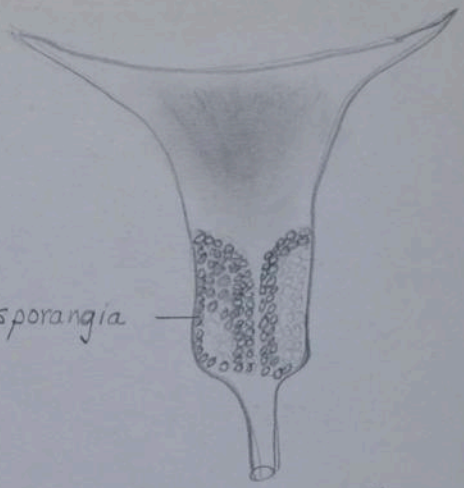
♀Strobilus of Zamia x1



Long. Sec of unfertilized Zamia ovule x10



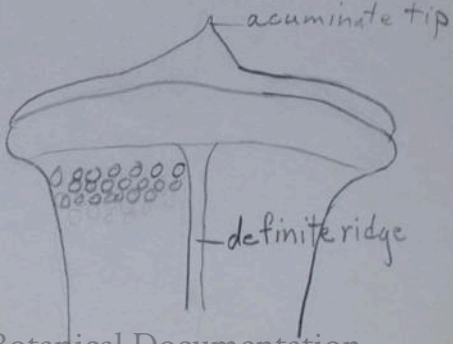
♀Strobilus of Ceratozamia X1

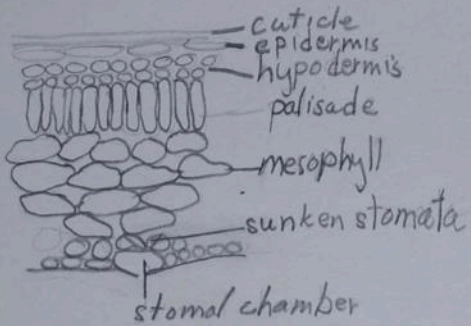


Microsporophyll of Ceratozamia X 10

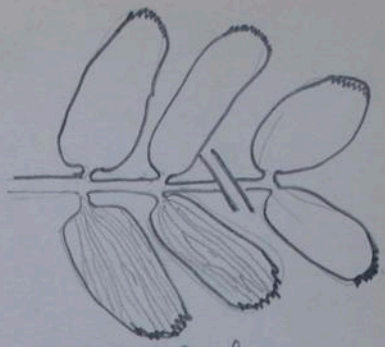
x-sec. of ♂ sporophyll of Ceratozamia.

Encephalartos ♂ Sporophyll

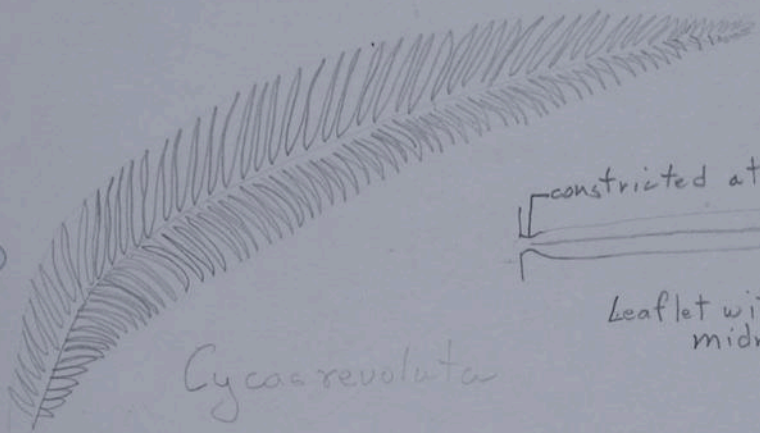




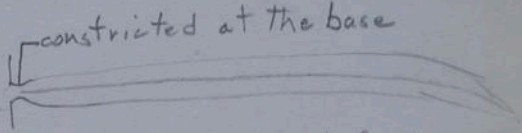
x-sec of Cycas revoluta



Zamia furfuracea

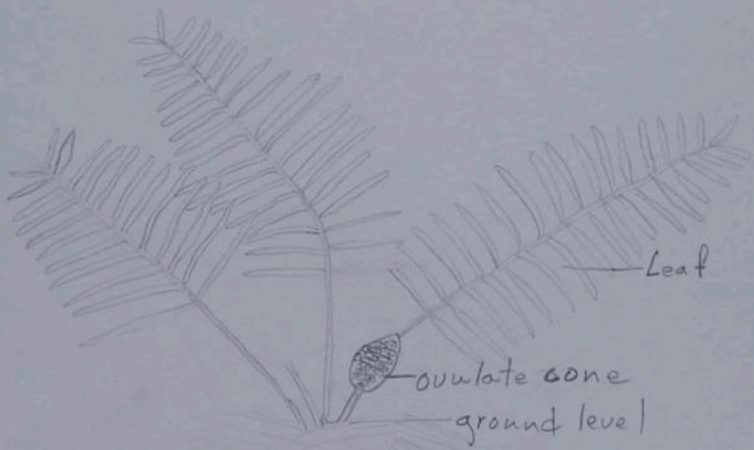


Cycas revoluta

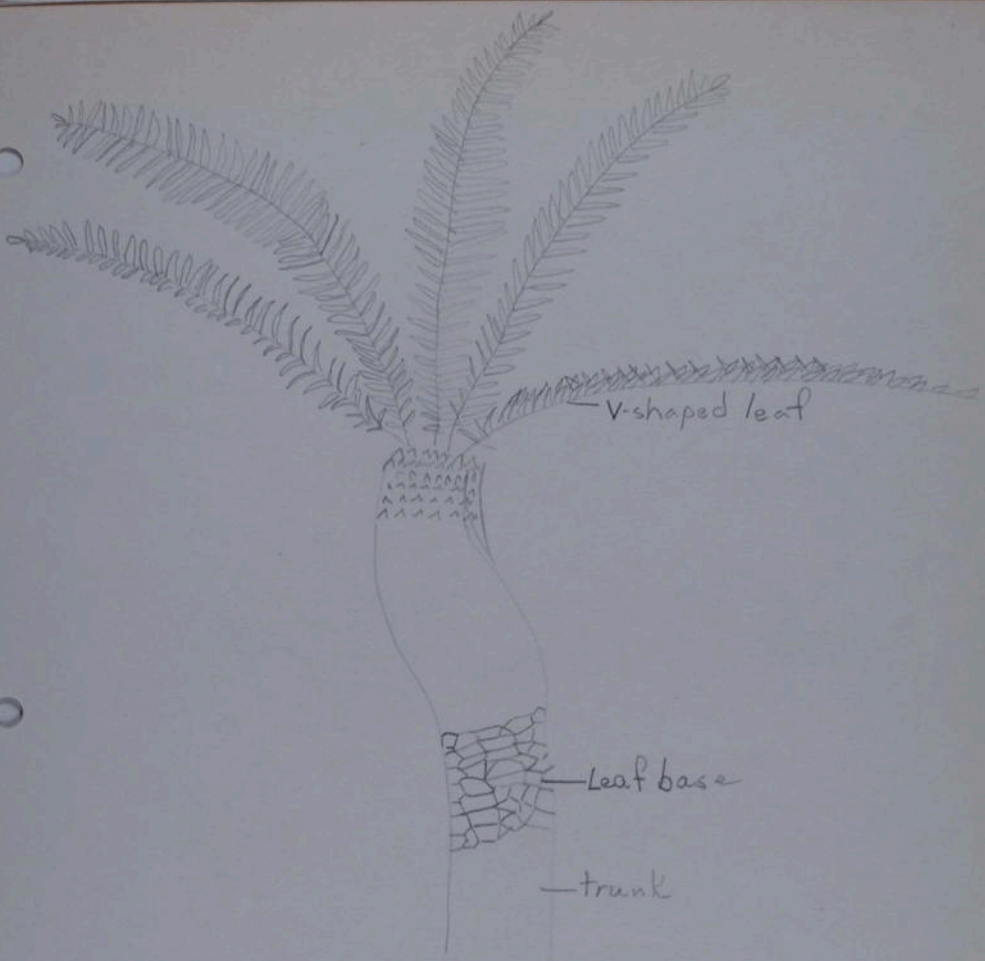


Leaflet with a definite midrib

Cycas revoluta.
Habit



Zamia floridana
Habit



Encephalartos caffer
Habit,

1949 Gymnosperm Exam

1. Construct and label a phyletic chart for the Gymnosperms, including Cycads and fossil groups. (10 points)

2. Some authors place Podocarpus as related to Taxus and Torreya. Why ? In what fundamental character is it unlike them ? (4 points)

3. One theory concerning the origin of the Angiosperms derives them from living Gymnosperms. What Gymnosperms are involved in this theory and why ? (4 points)

4. Of the leaves examined in class which was: the most xeromorphic ? the most mesomorphic ? the most unusual ? give three peculiarities of the unusual one. (8 points)

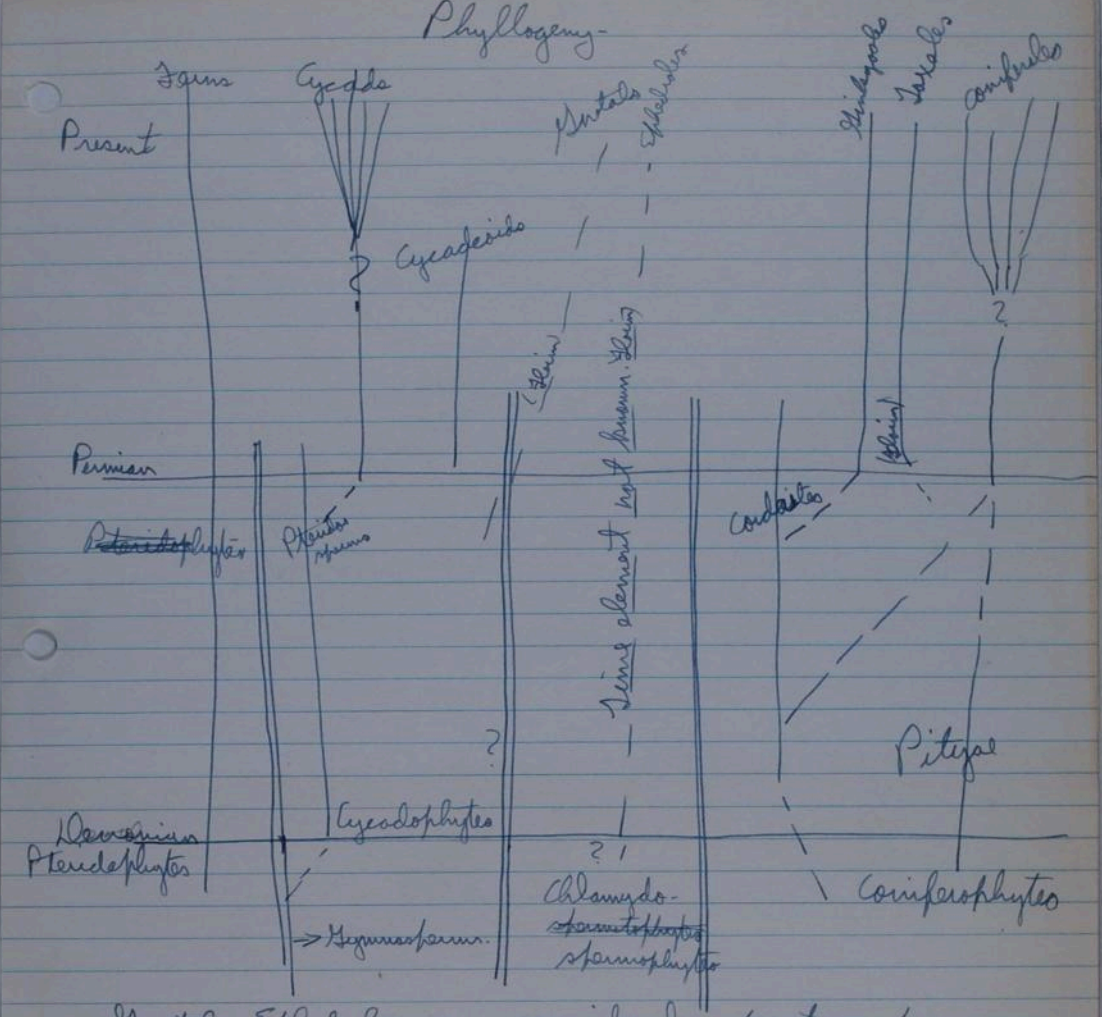
5. Identify to genus or to genus and species the 15 specimens given. Those to be identified to genus only are so marked. (15 points)

6. List six of the conifers given in class that grow in North Carolina. (6 points)

7. List four of the conifers given in class that grow in the state of Washington. (4 points)

8. Construct a checkerboard as given and fill in the squares, using an X to indicate the presence of a character. (49 Points)

Arnold's system (with Florin thrown in)



Gnetals + Ephedrales now considered separate group - Pteridosperms one way or another from Pteridophytes, and in turn, the Cycads from Pteridosperms

Florin found some evidences that Gnetales + Ephedrales might be derived from the Cycadeoids, - may however be completed separate.

Good evidence that Ginkgo derived from Cordaites.

Florin considers taxodiaceae as very distinct from Coniferales, but may connect may be.

Evolution within the Coniferales has been distinct as far back as Triassic.

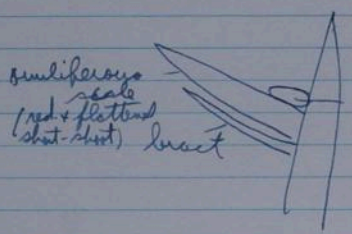
Conifers -

1. Two types of stem.
   a. Long shoot
   b. Short "

example Pinus - leaves borne on short shoots, not the long, except the young plant.

Pinus - leaves on short shoot only, leaves on short stalk within the fascicle.

Taxales + Coniferales all have a staminate strobilus.
Taxales have no pistillate strobilus, the ovule borne on the end of a peduncle.
Coniferales have pistillate strobili -
Most gymnosperms monoecious - at least in Pinaceae + Taxodiaceae; Araucariaceae, however, is dioecious.
Cupressaceae either mono, or dioecious (evidence in the group of tendency towards dioecism -
Taxales all dioecious.



Bract may be variously fused w/ ovuliferous scale.
Interpretation of ovuliferous scale doubtful - what is this thing in the axil of a bract.
Florin's most enlightening — ovuliferous scale was a reduced and flattened short shoot, so all right to have bract beneath - apparently the short shoot bore sporophylls.

Lab - Examine cones to see condition of ovuliferous scale - orientation, relation to bracts, etc.
Draw one ovuliferous scale with subtending bract of: Pinus
Pseudotsuga
Sequoia sempervirens
Picea
Tsuga.

A treatment of commoner genera of gymnosperms (excl. Cycads).
1. Draw up an outline of what is to be included -
2. Material consists of twigs w/ leaves, and except Podocarpus have staminate + pistillate cones.
3.

Feb. 4. 1949 - 2nd Semes. Gymnosperms -
Classification according to Buchholtz. Roman numerals = subfamilies.
Cycadales
○ Ginkgoales - Ginkgo*
○ Taxales - Taxus*, Torreya*
Coniferales
○ Pinaceae - Pinus*, Cedrus, Larix*, Picea*, Tsuga*, Pseudotsuga*
Abies*
○ Araucariaceae - Agathis*, Araucaria*
○ Taxodiaceae
I Sciadopitys*
II Sequoiadendron*, Sequoia*
III Cunninghamia*, Cryptomeria*, Taxodium*
○ Cupressaceae
I Cupressus*, Chamaecyparis*
II Callitris*, Widdringtonia
III Libocedrus*, Thuja*
IV Juniperus*
○ Podocarpaceae
I Pherosphaera
II Podocarpus*, Saxegothaea
○ Gnetales - Gnetum*, Welwitschia
○ Ephedrales - Ephedra*

Exclusive of Cycadales, 50 genera, about 550 spp.
Generic lines open to question, particularly those of Australia
S W Pacific into China + Japan.

1. Ginkgo - not native in any place - perhaps in China. preserved by mass cultivation - cult. in gardens of temples in China & Japan.

Theory that species have definite life span, & when first started, are vigorous. After 2-3 million years, viability reduced thru reduction in genetic capacity. Species senescence.

Ginkgo, however, is quite vigorous in cultivation. Whether it could compete successfully in a natural situation is not known.

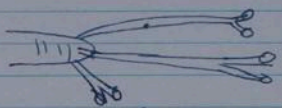
Ginkgo has marked development of long & short shoots. Long shoot developed from terminal buds, the short from laterals, the year after the long shoot. Short shoots grow very slowly.

Leaves variable, the bilobed usually on long shoots, the short shoot w/ rounded or slightly wavy.

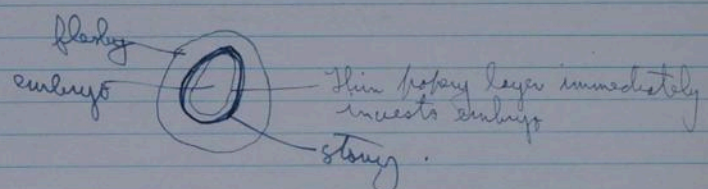
~~Cones borne on short shoots~~.

Dioecious.

Pistillate borne on short shoots



Usually 2 naked ovules borne at top of peduncle. Seed much like Cycad seeds -



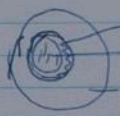
W/ except. of Cycads, only plants with swimming sperms.

Abundant mucilage canals, tannin cells + calcium oxalate crystals.

Feb. 16, 1945.

Taxaceae -

1. Resinous, but scattered; wood not strikingly resinous.
2. Dioecious, rarely monoecious
3. Staam. flrs. in cones + consist of sporangia borne on peltate scales
3. Ovulate plants have ovules borne solitary ily- no ovulate or pistillate cone.
4. "Fruit" consists of embryo, bony integument, surrounded by a fleshy aril. Aril is out growth + expansion of the stalk of the ovule.



5. Family (Taxus) w/ peculiar tracheids w/ tertiary thickening (spirally arranged) Makes good bows - great elasticity. Ovules solitary - not in pairs.
Taxus Torreya - female flrs (ovules) in pairs, but only 1 develops, so mature seed is solitary.
Unusual distribution - 6 spp - 1 in Fla. (T. taxifolia), 1 in Cal., the remaining in China + Japan.
Evidence that genus once existed widely (seeds from Bering straits)

Pinaceae -

1. Wholly monoecious
2. Staminate strobilus - simple no bracts.
3. Sporangia - borne on abaxial surface of staminate sporophyll
3. " " " adaxial " " pistillate "

Feb. 18, 1949 -
Mar. 9-16 talks on gymnosperms.

Feb. 23 -
Araucariaceae
1. Buds not scaly (pines have scaly buds)
2. Bracts + scale quite united
3. No of seeds per scale 1 (?) one per scale.
4. Monoecious + dioecious.

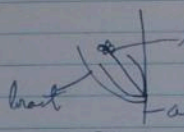
Taxodiaceae - very similar, buds not scaly, 2-6 seeds per scale, bract partly free, exclusively monoecious.

Cupressaceae - differ in leaves - appressed + whorled (cyclic), small and scale-like. Buds not scaly.
Bracts + ovuliferous scale fused.
in Juniper tribe - tendency towards berry-like fruit - when young, cone-like - maturing to a berry.

Podocarpaceae (often w/ Taxaceae) fleshy aril like Taxus + Torreya
1. Seed (ovule) inverted, with micropylar end is close to stalk.
2. Leaves broad (in Taxales, mostly narrow).
3.

Ephedra, Welwitschia + Gnetum.
1. Share many charac. w/ other Gymnosperms
2. Naked seeds.
3. Dicotyledons
4. Lack resin canals
5. Opposite leaves.
6. Long micropylar tube - the inner integument elongates into long neck.
7. Pistillate strobilus compound.
8. Unique in
   1. Vessels in 2nd ary wood.
   2. Compound staminate strobilus.

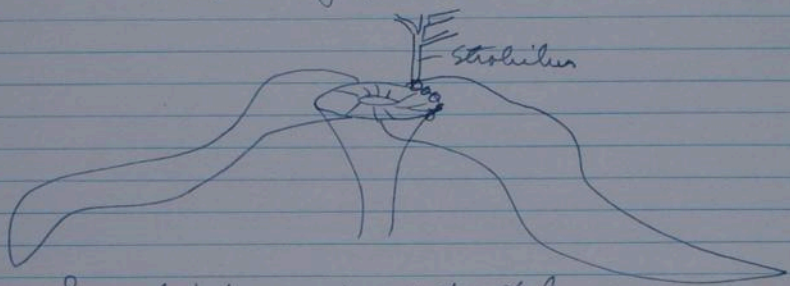
Ephedra - ♀ + ♂ Strobili borne in whorls at the nodes on the stem. St. strobilus of bracts, the lower sterile, the upper fertile, in the axil of each bract has 1 fl. consisting of a ... [illegible]



♂ Strobiles of Ephedra

♀ Strobiles similar, except ovule enclosed by 2 sets of bracts, somewhat united at base (frequently called "perianth").

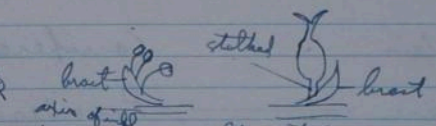
Welwitschia - dioecious.
Stem expanding upward, depressed in center



Leaves (2) permanent up to 2' long in
St. & Pistillate strobili borne branched axes -
St. fl w/ 6 stamens & rudimentary ovule in center. Stamens inclosed by 2 pairs of bracts.
Ovulate strobiles w/o stamens - only 2 bracts inclosing ovule.

Gnetum - consists mostly of lianas. Leaves large, net-veined.
♂ strobiles - catkin-like, long & drooping, bearing several groups of staminate fls. At base of each fl. cluster is a pair of bracts joined to form a cup-shaped structure. A single fl. of a stalk w/ 2 anthers and a sheathing perianth at the base.
♀ strobiles catkin-like, w/ 5-6 whorls of ovules, each whorl subtended by a pair of bracts (like staminate!)
Single fl. consists of ovule, its integuments plus perianth.

Gnetales -



Engler - origin of Angiosperms in Gnetales.
Not too good evidence for this.

Present

Feb. 25.
Classification

Gordon 1880 — Eichler 1887

Coniferous plants
1. Pinaceae
a. Abietineae ~~Vera (subtr.)~~
Abietineae
Pinus, Tsuga, etc.
Vera
Vera (true abies)
Tsuga
Araucarieae
Arac., Agathis

(over for full work)

~~Ends~~

Gordon 1880	Eichler 1887	Buchholz, 1948
Conifers	Coniferae	Ginkgoales
1. Pinaceae →	Pinoideae (S. fam.)	Taxales
a. Abietineae	Abietineae → Pinaceae	Coniferales
Abietineae = S. genus →		Pinaceae
Pinus, etc.	except Tsuga	
Abies		
{Vera / Tsuga} s. genus →		
Araucariae →	Araucarineae → Araucariaceae	Araucariaceae
Ara., Agathis		Taxod.
Cunninghamiae → Cunn., Sciad.		
Cunn. + Sciadop.	Taxodineae → Taxod.	Cupress:
	Cunn., Sciad.	
b. Cupresseae → Cupressineae	Seq. Taxodium	
Cupressineae (Cup., Thuja, etc.) → Cupressineae	Cupressineae	
Taxodiae → Seq. Taxodium		
Tax., Seq., Wellingt.	Taxoideae → Taxales	
	Taxeae	
c. Juniperae		
Juniperus →		
2. Taxaceae		
Taxineae →		
Tax., Torr., (Ginkgo) →		
Podocarpeae →	Podocarpeae →	Podocarpaceae
Podocarpus.		
	Gnetaceae	Gnetales
	Gn. Wel., Eph.	
		Ephedrales

Eichler - united all into 2 tribes, merely a shift of categories of Gordon -

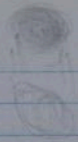
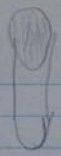
Reasons for shifting of categories, from lumping to splitting.
1. Additional knowledge of cytology, anatomy, morphology, etc.
2. Interpretation of fossil record (more coming to light)
3. Because of "harmony with the times."

G. Engelm. – borne in Frankfurt 1809 – MD in 1859 – came to St. Louis shortly thereafter – Bty a hobby – friend of Henry Shaw – instrumental in getting many gymnosperms to Garden. Outstanding monographer in America of his time – Cuscuta, Cactus, Quercus, Isoetes + others in add. to Gymnosperms. His 40,000 sheets + those of Bernhardi form nucleus of herb.
Collected many cult. gymnosperms from Eur. gardens.
Studied under Alex. Braun in Paris in 1857.
Collected in SE states (Appalachian region) Lake Sup, in Col. + Cal.

Pub.

Conif. of Rocky Mt Region.
Revisions of Pinus Juniperus, Abies + Picea.



Phyllotaxy

Descr. 1st by Bonnet in 1833 -
Est. 1st Factor 2/5 noted

Schimper - Braun most important

A. W Church - Bot. Memoirs 129. Complete summary.

Kerr + Lawrence - Elementary text for general
Gray - Structural Botany -

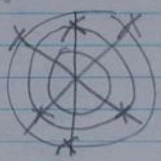
Opposite:
1. Distichous -
2. Decussate.

Quantities circles. all leaves fall on four lines, th.

lines called orthostiches

Story - consists of anything on the internodes between 2 nodes - in opposit, decussate, nothing. ∠ of divergence 90°.
No ratio -

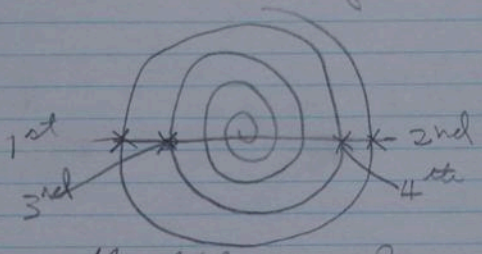
Nerium - instead of 2 leaves, 3 at a node - 60° ∠ of divergence. No story between :. no ratio.



6 orthostiches.

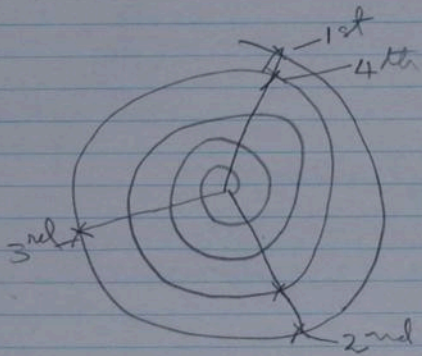
Schimper-Braun theory.

Tilia americana - alt. arranged - 3rd leaf on top of 1st leaf (Elm arch).
A spiral, called the genetic spiral.



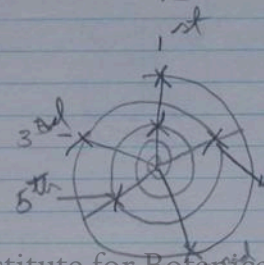
2 orthostiches ∴ 2 leaves in a story ⇒

∴ ratio 1/2 = 2 leaves in a story
one spiral in each story, 2 orthostiches.



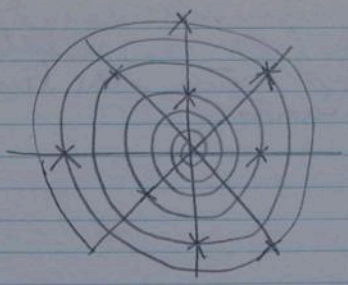
3 orthostiches, each story 3, leaves.
1 spiral, ratio 1/3

Quincuntial described by Brunet



Magnolia
in a story 5 leaves,
2 spirals needed
for 1 story
∴ ratio 2/5

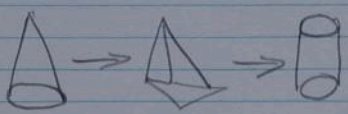
The story



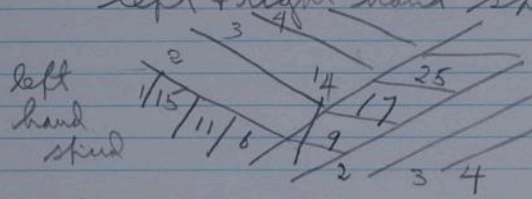
3/8 -
the 9th leaf starts
next story
3 spirals, 8 leaves per story

1/3, 1/3, 2/5, 3/8, 5/13 = fundamental ratios
may have multiples of these.

For conifer cones, orthosticles impossible
use parastiches - apparent spirals, more
apparent to the eye than actual spiral.



left + right hand spirals



the 9th leaf is the beginning of the 2nd spiral (right hand) ∴ 9th

13 cones in a spiral.
5/13 - the same as the Schimper-Braun

For the sake of phyllotaxy, put smaller number on top, add that to the other (larger) and put the sum on the bottom

5 - smaller, on top, 8 on other ∴
5/13 (5+8)

From phylogenetic standpoint, plants with high ratios (over 100) all belong to the algae & bryophytes, the lower ratios in the higher plants.

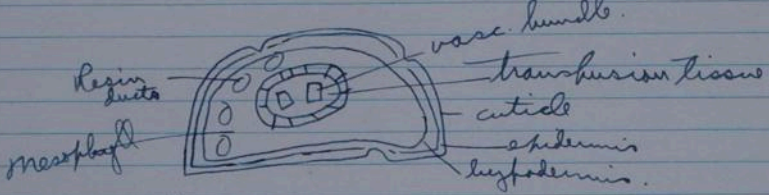
March 18

Leaf anatomy of gymnosperms.

1. Nearly all xeromorphic - leaves adapted to xeric condition
2. Thick cutin
3. Small, thick walled epidermis.
4. Thick walled hypodermis 1-3 cells thick.
5. Sunken stomata.

Trans-sec - tho cells packed, in longi sec. more intercellular space.

6. usually a well developed endodermis sheath, 1 cell wide. Casparian strands well developed.



Main features

1. No + point of resin ducts
2. Presence or absence of especially thickened areas (hypodermis

Sec + diagram, showing no of resin ducts, size of bundles etc.

Sciadopitys
Cunninghamia
Agathis
Pinus strobus
" saliana

Abies
Picea

Include cutin, epidermis, hypodermis, vasc. bundle, mesophyll, resin canals.

Conifers Identity & Distribution

Taxus canadensis
Pinus rigida
caribaea
virginiana
Banksiana
resinosa
strobus
monticola
edulis
palustris
Taxodium distichum
Sequoia sempervirens
Thuja occidentalis - appalachians, NE US + Canada, w. to Minnesota.
Libocedrus decurrens
Chamaecyparis thyoides
Picea mariana
glauca (canadensis)
Engelmannii
Larix laricina E. Canada, US w. into arctic circle, + NW Canada.
Tsuga canadensis
Abies concolor
nobilis - Washington - N. Cal. (Coast Ranges); Wash-Oreg. (Cascades)
balsamea NEUS, Appalachians, w. to Canadian Rockies.
Pseudotsuga taxifolia
Juniperus horizontalis
communis var depressa
virginiana Maine - N. Dak., Fla - Tex.

Tsuga canadensis – Distr. – Newfoundland to Virginia, Iowa and Manitoba.

"Pitch pine"
Pinus rigida – Eastern US. – Maine – Ga. Needles in 3's scales of the broad-based cones have thick ends, each armed with a short recurved prickle. Cones about 2-3" long.

Slash pine
Pinus caribaea – extreme SE. US – SC – Fla + E. Texas
Needles mostly in 2's, sometimes 3's. 10-12" long.
Mature cones glossy, leathery brown, egg-shaped, 3-6" long

P. virginiana – NJ – Ga – w. to S. Indiana; Ark + Miss.
Needles in 2's – 1-3" long, sheaths deciduous. Cones linear to narrowly ellipsoid, scales quadrangular tipped with a long recurved spine. Cones larger. ⓥ Stems somewhat crowded.

P. Banksiana – Nova Scotia to James Bay + Great Bear Lake, s. to Mass., N. Illinois, Minnesota and Rocky Mts.
Leaves in 2's, 1" long. Cones small with large tipped scales, spines absent. Cones smaller. ◇ Stems not crowded.

P. resinosa – NE US – to Pa, w – Minn.
Needles in 2's – stout scaly – leaves 4-6". Cones 1½" long, without spines or prickles.

P. strobus – NE US – Appalachians to Ga., w. to Minnesota.
needls in 5's, slender, bluish green. leaf bases small.

P. Monticola – extreem Western U.S. – Wash. to Calif. E. to Montana. Needles in 5's – leaf bases large.

P. edulis – SW US – N. Mex, Ariz., Col. + Utah.
Needes in 2's, seeds v. large in egg shaped cones at ends of branches.

P. palustris – SE US – Va – Fla – Texas.
Needles in 3's, 10-12" long, Cones 5-10" long – mostly longer than P. caribaea

~~Taxodium distichum~~

Abies concolor - north slopes, mod alts., Oregon, Cal., Nev., Utah, Colorado, Ariz + New Mex. Leaves long, mostly pointing upward on stems. Branches crowded.

Abies nobilis - Coast ranges - Wash - Cal.
Cascades - Wash - Oreg.
Many leaves all around, medium length. Branches crowded.

Abies balsamea - E. Canada, NE US, Appalachians w. to Manitoba?. Smallest leaves of the 3, all around, branches not crowded. The stem axils enlarged.

Thuja occidentalis - SE. Canad + NE US, Appalachian west to Minnesota. Leaves elliptic around. Cones coarsely ellipsoid.

Libocedrus decurrens - Northern Cal. + Oregon. leaves linear, with an acute out-pointing tip. St. cones at tip of branches, small + globular.

Chamaecyparis thyoides - local on coastal plains: S. Maine to Fla. w. to Miss. - very small cones. On secondary branches the leaf bases remain after fall of leaves

Taxodium distichum - E + SE US, coastal plain - NJ. - Fla. ~~Upp~~ Up Miss. valley to S. Mo, + Ind. - w. to middle Tex. Leaves linear

Sequoia sempervirens - sea level to about 4000' - extreme Cal - + S. Oregon. Cones small, leaves long

Picea mariana - NE Canada, US w into NW Canada and SE Alaska. Twigs medium sized, cones small, angle of branching acute. Sterigmata medium sized leaves fall off specimen.

P. Engelmannii - western U.S. - N. Mex, + Arizona — Mont + Wash. Twigs large + heavy, sterigmata large, cones large, angle of branching acute. Leaves fall off specimen.

Picea glauca - NE Canada + U.S - w in Canada to NW Alaska. Stems small, sterigmata small, angle of branching wide.

Pseudotsuga taxifolia = generally distrib - most. US - Ne Mex. - Col. - Wash + Montana. Three pointed bracts on cones slightly raised sterigmata.

Larix laricina - N.E. Canada, US, w. into Arctic Circle + NW Canada. Leaves on prominent short shoots male fls densely clustered.

Tsuga canadensis. Maine S on Appalachians to Ga. w. to Wisconsin - ? ? ? generally very fine terminal twigs, much more branched than Picea glauca.

leaves serrulate

Juniperus horizontalis - Newfoundland to N. Y, northern Minnesota + Northward. All branches on one side of stem. Very densely covered.

Juniperus communis var depressa - Newfoundland to New England, Great Lakes region + NW. Leaves long, not compressed.

Juniperus virginiana - eastern US w. to S. Dakota + S. to Tex. more slender than J. chinensis

KEY TO ORDERS OR FAMILIES OF GYMNOSPERMS

1. Broad leaved trees, shrubs or lianas with ovules borne in whorls or spirals of 2-many, each ovule on a separate peduncle, not in cones----2

2. Ovules born on long pedicels, usually 2, sometime 3 on a single pedicel and sessile; leaves flabelliform, sometime bi-lobed, the venation oviously dichotomous. Ginkgoales

2. Ovules borne individually on short peduncles, on a pedicel with 2-many ovules, leaves ovate or elliptic, acute or acuminate, the venation pinnate. Gnetales

1. Leaves linear, acicular, narrowly elliptic to rudimentary scales, compressed or loosely arranged; ovules solitary and arillate, many in woody cones, or few in succulent cones.----------3

3. Ovules 1-2 not in cones, usually only one developing into a mature seed with either a dry or eventually fleshy coat, more or less surrounded by a fleshy cup like aril, or by a succulent scale.-----4

4. Ovules at maturity covered by the fleshy peduncle; leaves linear, spirally arranged, pectinate; staminate flowers in stalked globose heads or borned singly. Taxales

4. Ovules at maturity surrounded by the inclosing fleshy ovuliferous scale, leaves linear to narrowly elliptic, spirally arranged, not pectinate; staminate flowers in catkin like strobili.

Podocarpaceae

3. Ovules in a cone, on under surface of an ovuliferous scale, usually few-many, several developing into mature, dry seeds.----------5.

5. Plants with rush-like stems, leaves reduced to rudimentary scales.

Ephedrales

5. Plants woody, stems more or less erect, leaves acicular, linear to narrowly elliptic.----------6.

6. Plants strictly dioecious, leaves spirally arranged and crowded, usually spiny-tipped; cones loose, the ovuliferous scale with a long (about 3 cm.) recurved, attenuated, fused bract.

Araucariaceae

6. Plants mostly monoecious (except in Juniperus, with some dioecious species); leaves various, in fascicles or free, whorled or spiral arrangement, compact or loose; cones woody or fleshy, the ovuliferous scale with bracts variously fused or free, but not so long nor so strongly recurved.----------7.

7. Leaves acicular, linear, (in Pinus, fascicled) spirally arranged.----------8.

8. Cone scales linear, scales and bracts separating at maturity; seeds terminally winged or wingless, buds scaly. Pinaceae

8. Cone scales peltate, scales and bracts partially fused at maturity; seeds laterally winged, buds not scaly.

Taxodiaceae

7. Leaves scale-like or awl-shaped, decussate.

Cupressaceae

GINKGOALES

1. Ginkgo Kaempfer why not h.?

Dioecious.

Ovules 2 -3 together on long peduncles, the mature ovule surrounded by a fleshy outer integument, the inner integument stony, the ovule yellow when ripe.

Microspores borne in a sporangium with longitudinal dehiscence; 2 sporangia borne terminally on a short pedicel, several pedicels together forming a loose, catkin-like strobilus.

Leaves borne on long petioles, flabelliform, margins wavy, sometimes deeply bilobed, with a symmetrical dichotomous venation, coriaceous, on either long or short shoots.

Twigs of long shoots with smooth bark, or short shoots with roughened surfaces.

Distribution ahd Habitat: one species and several varieties of large trees of uncertain origin, but probably native to China.

Drawing, plate 1.

GNETALES

1. Gnetum L.

Dioecious

Ovules borne in whorls on axillary peduncles. The mature ovule 1.5-3.0 cm. long, ellipsoid, borne on a short stalk, the outer coat succulent, the inner stony.

Staminate strobili axillary in small catkin-like inflorescences, the whorled flowers in compact bunches, leaving definite spaces on the stalk.

Leaves in decussate pairs borne on short stalks or long shoots, ovate or elliptic, about 15 cm. long, 8-12 cm. broad, acuminate, venation pinnate.

Distribution: approximately 33 species of small trees, shrubs or lianas from tropical regions of both hemispheres.

Drawing, plate 12

KEY TO TAXALES

1. Mature ovules up to 1.3 cm. long, the fleshy integument forming a cup over the basal portion of the ovule, Male flowers in stalked, globose heads. Taxus

1. Mature ovules 2-3.5 cm. long, the fleshy integument completely covering the ovule; male flowers single, not in heads.

Torreya

TAXALES

1. Taxus L.

Ovules borne separately and sometimes terminally, the mature ovule partially surrounded by the outer fleshy integument, the inner integument forming a bony shell surround the seed.

Male flowers in stalked globose heads, arising from leaf axils.

Leaves spirally arranged, spreading all around, but pectinate, linear, acuminate, a single vein prominent on both surfaces, decurrent.

Distribution and habitat: Seven species of evergreen trees and shrubs in North America, eastern Asia and Asia Minor.

Drawing, plate 2

2. Torreya Arnott.

Ovules 2 or 3 together, axillary, the mature ovule drupaceous, the fleshy outer integument completely surrounding the embryo, the inner integument stony.

Male flowers borne singly, not in heads.

Leaves linear, acuminate, alternate or opposite, decurrent, persistent.

Distribution and habitat: 3-4 species of evergreen trees of California, west Florida, China and Japan.

Drawing, plate 2

PODOCARPACEAE

1. Podocarpus L'Heritier

Dioecious

Male flowers axillary, forming dense, narrow, cylindrical catkins.

Leaves variable, densely crowded or distant on the branches, spirally arranged, linear, membranous, tip rounded or acut.

Distribution: about 65 species of the southern hemisphere and extending into Japan, China, India, the Malay States and the Philippine Islands.

Drawing, plate 12

EPHEDRALES

1. Ephedra Tournefort

Cones fleshy, red when fresh, borne in loose strobili on a branched axis which hangs downward, or individually on separate stalks.

Male spikes borne on shoots which arise in the leaf axils or branches of the current year or of a previous season.

Leaves reduced to scale-like projections, whorled athe nodes.

Stems of a reed-like nature.

Distribution: on all continents except Australia, in various habitats.

Drawing, plate 13

KEY TO ARAUCARIACEAE

1. Leaves alternate or opposite, relatively widely separated on stem; cones compact, 2.5-7.0 cm. long, the bracts not obvious.

Agathis

1. Leaves spirally arranged, inserted on stem so as to appear imbricated; cones loose, up to 20 cm. long, the bracts 3 cm. long, attenuated, recurved.

Araucaria

ARAUCARIACEAE

1. Agathis Salisbury

Cones almost spherical, from one to three inches in diameter, solitary, erect, and produced near the top of the branches on stout peduncles. Scales broad, spreading, wedge-shaped, thick, leathery, closely imbricated, smooth, and becoming smaller towards the base of the cone, thicker externally towards the apex.

Seeds solitary, wedge-shaped and brown, with a thin, transparent wing.

Leaves alternate or opposite, relatively widely separated on stem, linear, lanceolate or elliptic, acute to acuminate, coriaceous, 8-10 cm. long, 2-3 cm. wide.

Distribution: tall, evergreen resinous trees with massive, columnar trunks, natives of New Zealand, Australia, New Caledonia, Fiji, Philippine Islands, and the Malay Peninsula.

Drawing, plate 6

2. Araucaria Jussieu

Dioecious

Cones globular, up to 20 cm. in diameter, made up of numerous loose scales. Scales fused to the adaxial surface of the recurved, long attenuated bracts. Bract ending in a very sharp spine.

Leaves scale-like and spirally arranged, persistent for 10-15 years. Broadest toward the base, lanceolate, acuminate, ending in a sharp spine, arranged in a close, tight spiral.

Distribution: evergreen trees confined to the southern hemisphere and occurring in South America, Australia, New Guinea, New Caledonia and the New Hebrides, and Norfolk Island.

Drawing, plate 6

KEY TO PINACEAE

1. Leaves acicular, 1-5 born in fascicles.

Pinus

1. Leaves linear, on short shoots or main stem, not fascicled----------2

2. Leaves deciduous, on the growth of the season borne singly in remote spirals, on older growth recurring only in clusters on short spur shoots. Larix

2. Leaves persistent, consistently arranged in same method on young and old stems.----------3

3. Cones pendent---------- ----------4

4. Bracts shorter than the ovuliferou scales.----------5.

5. Leaves sessile. Picea

5. Leaves petiolate. Tsuga

4. Bracts longer than the ovuliferous scales.

Pseudotsuga

3. Cones erect. Abies

PINACEAE

1. Pinus L.

Monoecious

Cones borne in leaf-axils, scales woody, the ovules (2 per scale) borne in slight depressions on the adaxial surface. Usually the integuments become long and wing-like, membranous or coriaceous. The bract fused to abaxial surface of ovuliferous scale, evident only as a short terminal protruberance, sometimes taking the shape of a recurved spine.

Staminate strobilus compact, catkin-like, terminal.

Leaves borne in fascicles on short stalks, one to five leaves in each fascicle; needle like. The short stalks spirally arranged. Twigs usually stout. Leaf sheaths are essentially bud scales. The leaves if extended, would be alt.

Distribution: from near the limits of tree growth in the northern hemispheres to the subtropical forests of India, Burma, Sumatra, Philippines, British Honduras, the Bahamas and Canary Islands.

Drawing, plate 3

2. Larix Link.

Monoecious

Cones small.5-1.5 inches long, ovate, axillary, usually with only a few leathery, persistent scales which ar much thinner toward the margins. Bracts longer or shorter than the scales, unevenly notched on the edges, ovate, or lanceolate.

Male cones very small, appearing as buds.

Seeds small, with leathery covering and wings.

Leaves deciduous, linear, fasciculate or in loose, remote spirals.

Distribution: colder parts of Europe, Asia and North America.

Drawing, plate 3

3. Picea Diet.

Monoecious

Ovulate strobili terminal, erect or nearly so, growing on upper side of branches. Scales deciduous, bracts dorsal, and either enclosed by or projecting beyond the scales.

Staminate strobili erect or pendent, consisting of numerous spirally arranged stamens, axillary on shoots of the previous season.

Leaves spirally arranged, more or less pectinate, or extending from all sides of the twigs, linear or nearly acicular, flattened, laterally compressed, or more commonly 4-angled, persistent.

Distribution: 40 species of trees restricted to the cooler regions of the Northern Hemisphere, preponderence in China.

Drawing, plate 4

4. Tsuga Carriere

Monoecious.

Ovulate flowers erect, terminal on lateral branchlets, consisting of a number of membranous bracts, each subtended by a nearly orbicular scale with 2 basal ovules. Bracts and scales of nearly the same length.

Cones pendent, globose to ovoid, subsessile, maturing in 1 season. Bracts inconspicuous rarely exserted.

Staminate strobili axillary, globose, consisting of a number of short stamens.

Leaves spirally arranged, but 2-ranked, linear, flattened groved above, margin frequently serrulate above the middle, apex blunt.

Distribution: 10-14 species of evergreens, usually pyramidal shaped trees confined to forests of eastern and western North America, Japan, Formosa, China and the Himalayas.

Drawing, plate 4

5. Psuedotsuga Carr.

Monoecious

Ovulate strobili conical, terminal or axillary, composed of several spirally arranged, imbricate, 3-lobed bracts each subtended by a small ovate scale with 2 basal ovules.

Cone ovoid-cylindrical pendent, maturing at the end of the 1st season, the conspicuous 3-lobed bracts longer than the rounded scales.

Staminate strobiliaxillary consisting of a number of spirally arranged, short-stalked, subglobose anthers.

Leaves spirally arranged, linear, grooved on upper surface and with a broad band of stomata on each side of the midrib below, apex blunt to rather sharply pointed, persistent.

Distribution: four or five species of trees widely scattered throughout the forests of western North America, southwestern China, Japan and Formosa.

Drawing, plate 5

6. Abies L.

Monoecious

Ovulate flowers consi ting of erect strobili compo ed of many bracts each subtended by a large scale with 2 inverted basal ovules.

Cones erect, maturing at the end of the first season; scales thin, broadly fan-shaped, particularly near the center of the cone, longer or shorter than the bracts; bracts apiculate, often shouldered, both scales and bracts together deciduous at maturity leaving a mostly bare spinelike axis which frequently persists throughit the winter.

Staminate strobili appearing from buds of the previous season, and borne on the underside of the lower crown branches in the axils of the leaves.

Leaves spirally arra ged, often more or less pectinate, sessile, linear, flattened in cross section, or rarely 4-angled and then grooved above, with numerous lines of stomata on the lower, apex usually notched. Bruised leaves emit an odor of turpentine. Persistent, and on falling leave a characteristic disc-like scar on the shoot.

Distribution: evergreen trees confined to the temperate regions of the northern hemisphere, but widely distributed in Europe, N. Africa, Asia, from the Himalayas northwards and North America.

Drawing, plate 5

KEY TO TAXODIACEAE

1. Leaves double, whorled, 10-15 cm. long, with a small scale-like leaf at the base of the long leaf. Sciadopitys

1. Leaves single, spirally arranged or opposite and decussate, 0.3-1.5 cm. long, all alike, or of 2 or 3 different sizes and positions.----------2

2. Lateral branchlets and attached leaves deciduous (exceptx T. mucronatum, which is partially evergreen). Moist habitats, southeastern US and Mexico. Taxodium

2. Lateral branchlets and leaves persistent.----------3

3. Leaves up to 4 cm. long, branchlets growing from the apex of previous season's cones,* Japan. Cunninghamia

3. Leaves smaller, not longer than 1.5 cm.; branchlets from axillary buds, not produced from apex of cone axis.----------4

4. Leaves opposite and decussate, somewhat acicular; Japan and China. Cryptomeria

4. Leaves spirally arranged, linear, or scale-like.----------5

5. Cones about 4-5 cm. long, very woody and tough, leaves of 3 kinds, those of the main branches longest, somewhat boat-shaped; California, 5000-8000 ft. Sequoiadendron

5. Cones about 1.0-1.5 cm. long, woody, but not tough; leaves of two kinds, both linear, flattened. Sequoia

* Cones (♂) are actually lateral, and the new growth comes from the terminal bud in the middle of the cone axis.

TAXODIACEAE

1. Sciadopitys Siebold.

Cones elliptic or cylindrical, obtuse at the ends, 2-4 cm. long. 1.5-3.0 cm. in diameter; scales regularly imbricated, wedge-shaped, irregularly reflexed along the outer edges; bracts small and adhering to the scales.

Seeds seven under each scale, with a coriaceous covering, tapering into membranous wings, attenuating to the base and apex.

Leaves of two kinds (1) small, scale-like, triangular0.3-0.5 cm. long, (2) leaf-like shoots or cladodes, often called a double leaf in whorls, linear, 10-15 cm. long.

Distribution: found only in Japan.

2. Sequoiadendron Buchholz.

Cones ovoid to ellipsoid, 5-6 cm. long, 3-4 cm. in diameter; scales spirally arranged, wedge shaped, bracts competely fused with the scales, forming a terminal depression.

Seeds 5 under each scale, wingless.

Leaves spirally arranged, of three sizes. Those of the older twigs broadest at the base, about .5 cm. long, those at the nodes cuneat, about .3 cm. long, those on the younger twigs linear, boatshaped, the depression toward the axis.

Distribution: large trees up to 300 ft., in a xstrip about 250 miles long through the south central Sierra Nevada Mountains from Tulare to Placer counties, California. Altitudinal distribution: 5000-8000 ft.

Drawing, plate 7

3. Sequoia Endlicher

Cones ovoid, terminal, 1-2 cm. long, about 1 cm. in diameter, with few scales. Scales and bacts completely fused, as in Sequoiadendron, but much smaller.

Seeds five per scale, with a narrow wing.

Leaves spirally arranged, of 2 sorts; those on lateral branches 1-2.5 cm. long, linear or lanceolate, pectinate, apex acut, decurrent; those on leaders and fertile branches up to 2.5 cm. long, oblong to acicular, in several ranks; apex incurved, sharp-pointed.

Distribution: trees up to 364 ft. in height, from southern Curry County, Oregon south along the coast to the Santa Lucia Mountains, Monterrey County, California. Altitudinal distribution: sea level to 3000 ft.

Drawing, plate 8

4. Cunninghamia R. Brown.

Cones glovose, 0.5-1.0 cm. long, terminal, the next year's growth continuing thru the axis of the old cone; scales 0.2-0.4 cm. long, not woody, somewhat obovate, tips spiny acuminate, the margins serrulate; bracts not obvious.

Male flowers in terminal clusters or catkins. Each cluster about 0.8 cm. long.

Seeds 3 to each scale, thin, surrounded by a thin membranous wing.

Leaves spirally arranged, those on the main axis standing out from all sides of the stem, those on the under-side of the branches turning upwards by a basal twist so that all appear to spring from the sides of the shoot., persistent, lanceolate, 2.0-4.5 cm. long, acute, usually spiny.

Distribution: trees up to 150 ft. high, in China and Japan.

Drawing, plate 8

5. Cryptomeria Don.

Cones orbicular, 1.0-1.5 cm. in diameter, terminal; scales 20-30, attached to a more or less compressed axis, stalked, two spine-like processes at the apex.; bracts fused with the scale for the greater part of its length and showing as a recurved point on its outer surface.

Seeds 3-5 under each scale, irregularly triangular, with a very small wing.

Leaves spirally arranged, decurrent, 0.3-1.0 cm. in length, showing great variability on the twigs, those of the larger twigs usually much smaller than those of the ultimate branches.

Distribution: trees up to 150 ft. high, occuring in Japan

Drawing, plate 9

6. Taxodium Richard

Cones globular, resinous, 1-2 cm. in diameter, pruple-brown when mature, scales somewhat fleshy, fused completely with the subtending bracts, Seeds two per scale.

Staminate flowers borne in large terminal inflorescence, the inflorescence about 18 cm. across.

Leaves mostly deciduous, but in one variety , semi-evergreen. Spirally arranged, but appearing distichous on the deciduous shoots, mostly acicular, 0.2-1.0 cm. long, acut.

Distribution: three species, natives of North America: two in the southeastern US and one from Mexico.

Drawing, plate 9

KEY TO CUPRESSACEAE

1. Cones not opening at maturity, the bracts forming a fleshy covering over scale, having a glaucous, waxy coating.

Juniperus

1. Cones opening at maturity, woody, without glaucous, waxy coat.--------2

2. Cones narrowly ellipsoid, 2-3 pairs of opposite, recurved bracts at base of cone. Libocedrus

2. Cones ovoid, without opposite, recurved basal bracts.----------3

3. Leaves and branchlets flattened laterally so as to give a vertical orientation. Chamaecyparis

3. Leaves and branchlets variously arranged, but without vertical or lateral orientation.----------4

4. Cone scales alternately larger and smaller, obovate; leaves mostly fused to branchlets, the free portion cuneate, tip cuspidate. Callitris

4. Cone scales more or less the same size, elliptic or peltate; leaves awl-shaped.----------5.

5. Cone scales peltate, 5 in a cone.

Cupressus

5. Cone scales elliptic, 6 or more in a cone.

Thuja

CUPRESSACEAE

1. Cupressus L.

Cones globose, 2-5 cm. in diameter, woody, maturing in the second year; scales 6-20 per cone, peltate, with a central boss or mucro.

Seeds 6-20 on each scale, compressed with narrow lateral wings.

Leaves persistent, scale-like (often awl-shaped on juvenile or vigorous growth), decussate in 4 uniform ranks, or the lateral pairs boat-shaped and the facial pairs flattened; finely serrate on the margin and commonly glandular on the back.

Distribution: about 12 species of trees and shrubs found in western North America, Mexico, the Mediterranean basin, the Himalayan Mountains and western China.

Drawing, plate 10

2. Chamaecyparis Spach.

Cones globose, 0.5-1.0 cm. in diameter, leathery, or somewhat fleshy; scales usually 6 on each cone, peltate, each with a central boss.

Seeds usually 2, but sometimes 5 on each scale.

Staminate strobili cylindrical composed of numerous decussate stamens, each with 2 to 6 subglobose anthers.

Leaves persistent, scalelike, decussate, ovate, acuminate, entire on the margin, the lateral pairs boat-shaped, the facial pairs flattened, on terminal shoots linear-lanceolate or needlelike, spreading.

Distribution: about six species, three native in North America, and the others natives in Japan and Formosa.

Drawing, plate 10

3. Callitris Ventenat

Cones obovoid to ovoid, 1.0-1.5 cm. in diameter, terminal; scales 6-8, woody, attached in one whorl, xxxx obovate, tips acute, the alternate scales smaller; bracts absent.

Staminate strobili small, 2-3 mm. long, 2-3 flowers in each strobilus.

Seeds oblong, 2-9 on each scale.

Leaves scale-like, whorled, clasping and decurrent, the free portions cuneat, tip acute.

Distribution: evergr en trees and shrubs of Australia and Tasmania.

Drawing, plate 10

4. Libocedrus Endlicher

Cones erect or pendulous, ellipsoid, pointed, with 4-6 basal bracts; scales 4-6, oblong, woody, with a partly fused, recurved bract. Tip of bract acute.

Male flowers terminal, oblong, with 6-20 stamens.

Seeds 1-2 on each scale, 2-winged.

Leaves scale-like, small, of 2 sizes, those of the main stem longer than those of the secondary and tertiary branches, clasping, whorled, the tips cuspidate.

Distribution: nine species of evergreen trees widely distributed in western North America, South America, China, Formosa, New Guinea, New Zealand and New Caledonia.

Drawing, plate 11

Thuja L.

Cones before opening ellipsoid to ovoid, terminal erect; scales 3-10, more or less membranous woody, ovate; bracts and scales completely fused.

Male cones very small, terminal.

Seeds 2-3 or 5 on each fertile scale.

Leaves and upper stems flattened, the leaves decussate, flattened laterally or dorsi-ventrally, depending upon its position.

Distribution: Seven species of evergreen trees or shrubs native to China, Japan, Formosa and North America.

Drawing, plate 11.

6. Juniperus L.

Monoecious or dioecious.

Cone ~~x~~ fleshy, ovoid. The fleshy part being the enlarged and eveloping bract of the ovuliferous scales; scales 6-12.

Male strobili composed of numerous stamens on a central axis, each stamen with 2-6 globose pollen chambers.

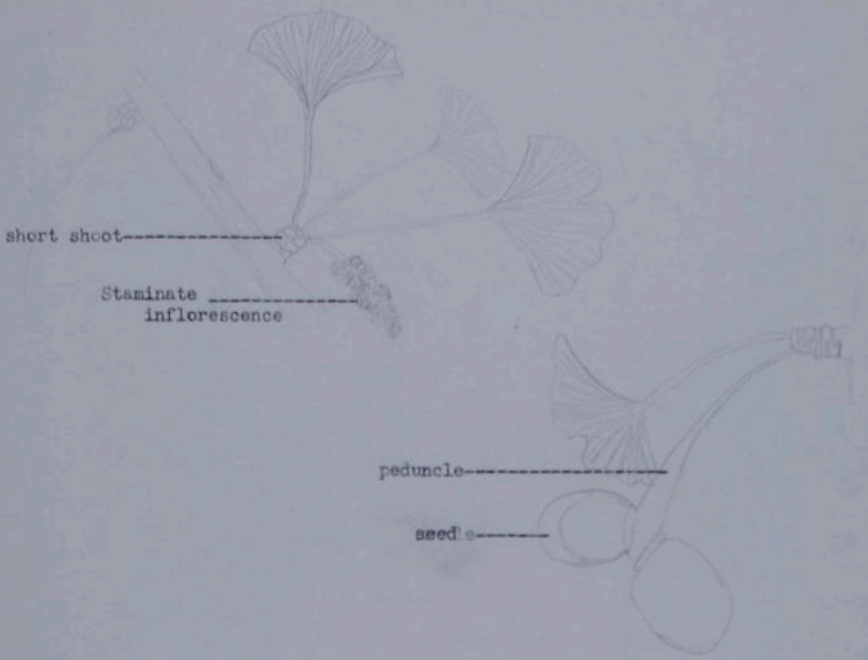
Seeds 2 or more, rarely 1.

Leaves on young plants spreading and awl-shaped, on adult plants either awl-shaped and spreading or closely pressed and scale-like, or evenly acicular.

Distribution: about 45 species of northern hemisphere from the Arctic circle to Mexico, West Indies, Azores, Canary Islands, North Africa, Abyssinia, the mountains of E. Tropical Africa, Himalayas, China and Formosa.

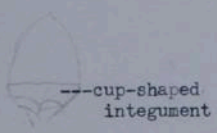
Drawing, plate 11.

PLATE 1



Ginkgo biloba

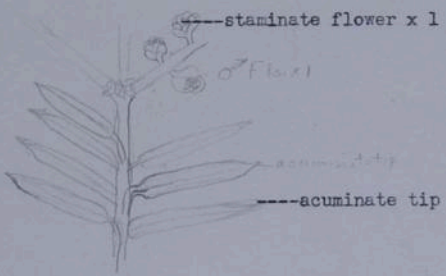
PLATE 2



Mature seede x 1

Taxus

x 1.5



Torreya xl

Ovule x 1

PLATE 3

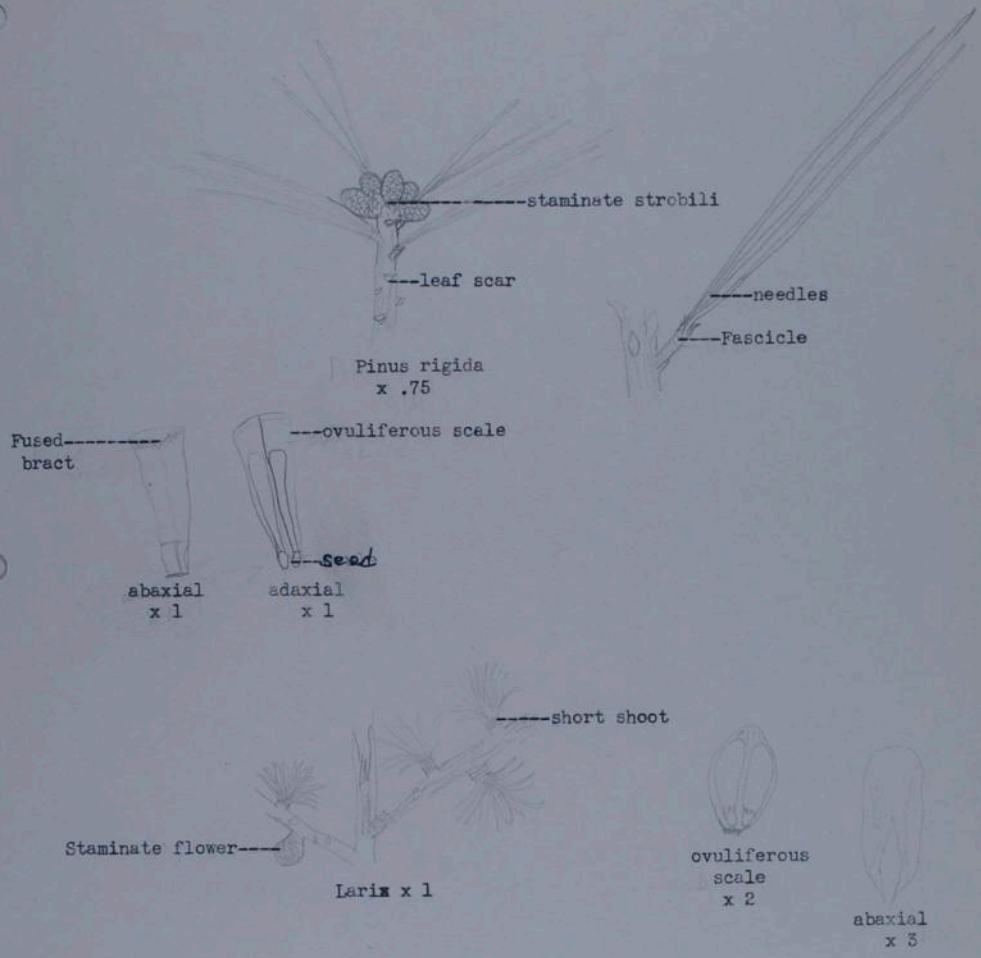


PLATE 4

Picea

scale without bract
abaxial
x 2

Tsuga

x 2

ovuliferous scale

x 1.3

PLATE 5

ovuliferous scale
x 1.5

Psuedotsuga

staminate strobilus

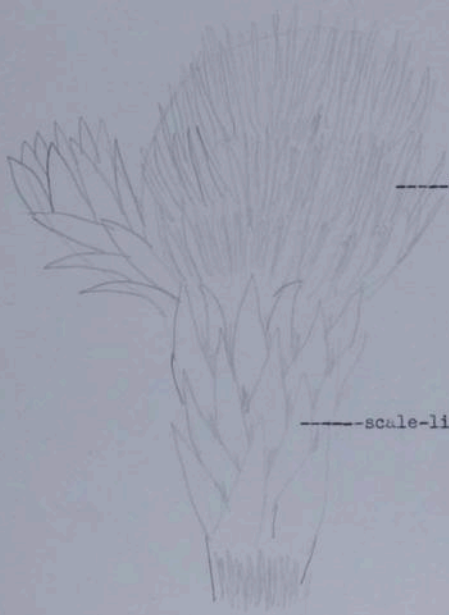
Abies

PLATE 6

ovuliferous scale

Pistillate strobilus

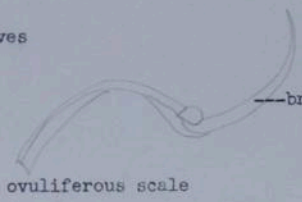
Agathis x 1



-----Pistillate strobilus

-----scale-like leaves

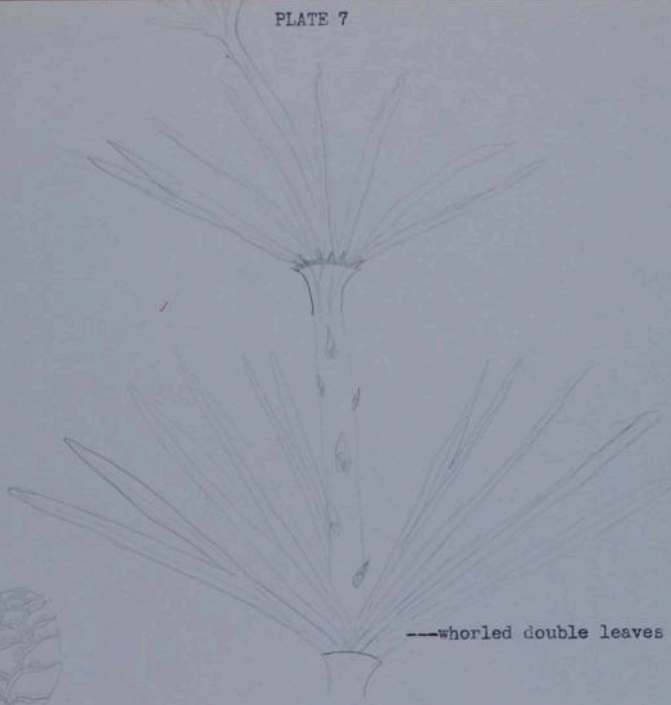
---bract



ovuliferous scale

Araucaria

PLATE 7



Sciadopitys

pistillate strobilus
x 1.5

Sequoiadendron

ovuliferous scale

PLATE 8

Sequoia

Cunninghamia

x .75

Staminate "flower"
x 2

PLATE 9

Staminate strobili

Cryptomeria

Taxodium with pistillate cones

PLATE 10

Cupressus

Chamaecyparis

Callitris

PLATE 11

Libocedrus

Thuja

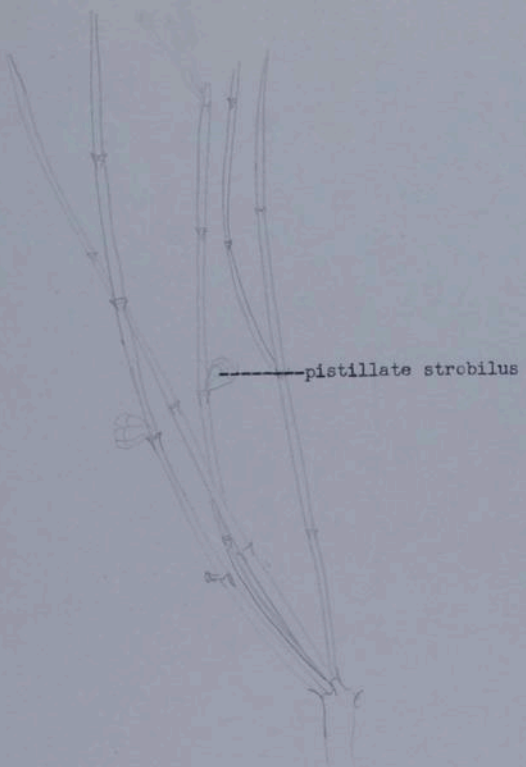
Juniperus

PLATE 12

Podocarpus

Gnetum

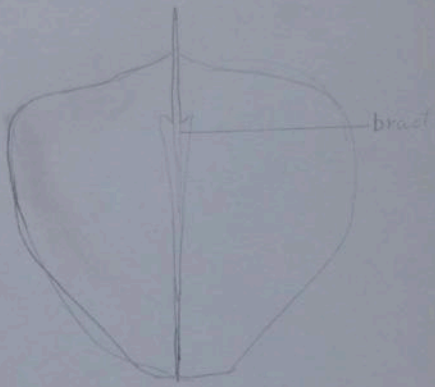
PLATE 13



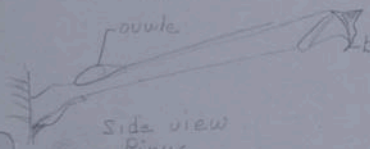
Ephedra

Pinaceae

Ovuliferous scale of
Pinus
abaxial view
X1



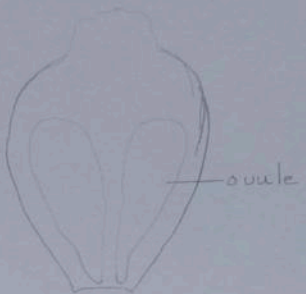
abaxial view
x2
Pseudotsuga



Side view
Pinus

Ovuliferous scale of
Pseudotsuga
X 1.5

Ovuliferous scale of
Picea
abaxial view
X 1.5



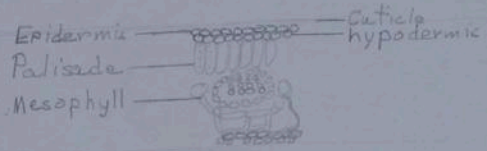
Picea X 2
adaxial view

P

Sequoiadendron
X 1.5
End view

ovuliferous scale of Larix
abaxial view
X 3

Pseudotsuga



Araucaria

Sciadopitys

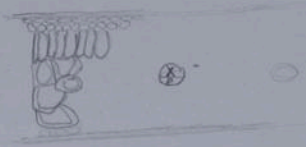
Pinus strobus

Pinus sabiniana

Abies

Cunninghamia

Picea



Agathis

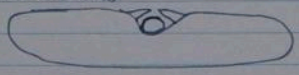
Florin - Morphology of & fructification in Cordaites + Conifers - Botaniska Notiser 547-565 1939.

3/30/49

Bryophytes

Marchantia - dioecious

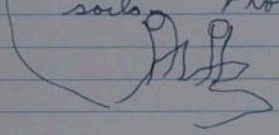
Ricciaceae - esp Ricciocarpus, Sphaerocarpus
In Ricciocarpus ventral scales highly developed (aquatic) + vent scales act as rhizoids, leaves, etc.
Archegonia borne in median furrow, almost covered, + spore ~~Dioecious~~ Monoecious. escape thru slit in median furrow.



Reproduces vegetatively very well, the older parts splitting, producing new plants, then die.

Also grows stranded in mud + assumes more elongate form. This genus one of a group preferring very high N conc. and for that reason grows in stagnant + sewage filled water.
Sphaerocarpus

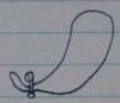
Sphaerocarpus - dioecious - unique feature in "envelopes" which looks like "peristome" of Marchantia, but envelope contains only one archegonium or antheridium.
Grown in fields of disturbed soils, in loamy + wet clay soils. Probably an annual.

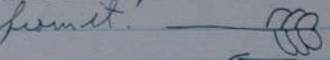


Habit - in large clumps on bare ground.

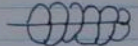
Musci
Jungermanniales -
Pellia epiphylla - mass. spores.

Jung: Acrogyne
Scapania nemorosa - succubous.
Underleaves present or absent.
Muscilage hairs present.
Leaves alternately 2-lobed.



1. Succubous - leaf towards apex overlaps one behind or down the stem from it. 

2. Incubous - basal leaf overlaps leaf above it



These seen from dorsal surface. →

Madotheca platyphylla (syn: Porella). (incubous)
perianth
calyptra
capsule.

Sporogoniums are terminal, frequently on a branch as compared with anacrogyne with lateral sporogonium.

Mosses -
Physiology
Most Bryophytes have parasitic or symbiotic relationships with Fungi or Algae. -
Ulicomycetes usually the genus Nostoc.
Basidiomycetes
Ascomycetes
+ others
The Fungi found in thallose liverworts, particularly the ventral part of the thallus
In leafy liverworts & mosses, occur in leaves & stem.
Example - Pellia epiphylla has been studied
In some cases fungus parasitic & destructive, causing deterioration. In other cases, the moss or liverwort benefits from the fungus, causing more luxuriant growth. More study & evidence required.

W/ Nostoc - occurs in Anthoceros - Nostoc fixes atmospheric N.

The gametophyte is most generally studied, but w/ diploid gametophytes - found that same physiology as the sporophyte - no chromosomal difference in this respect.

Spores germinate readily anywhere - only a small amt of H_2O required - this accounts for widespread distribution.

Protonema don't grow anywhere + requires constant water supply.
Have no effective means to prevent desiccation, so needs constant water supply. Can keep going in dormant state when dry - this true only for mosses, not liverworts.

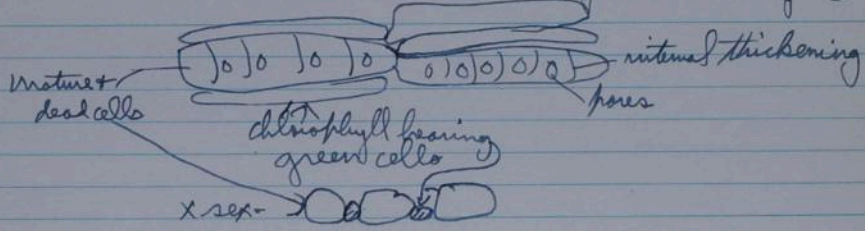
Water + nutrients absorbed by leaves + thallus as much as rhizoids

Bryophytes can regenerate as new plant from any part of an old plant.

Sporophyte always + parasitic, but occasionally (anthoceros) it has been found independent.

Two unusual + common substances in Bryophyta.
1. Dicranum - tannic acid.
2. Sphagnol - some antiseptic qualities - keeps fungal growth in check in upper portions - occurs frequently in Marchantia, with some use as a poltice.

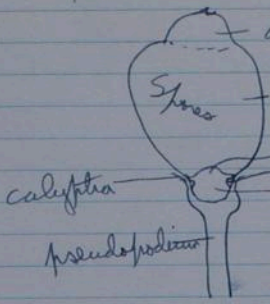
Sphagnum + Andrea -
Peculiarities - unusual in cell arrangement (Sphagnum).



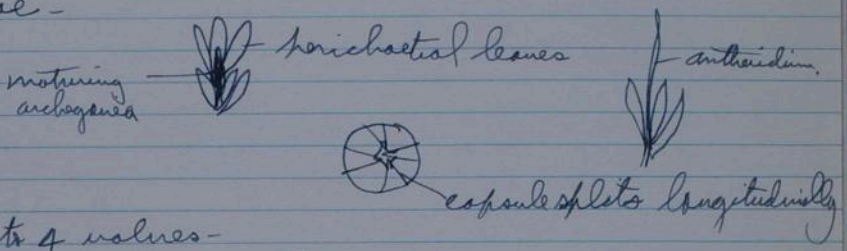
Very good absorbent - 15-20 x its own wt of H.O.

(Two types of branches)

Structure of capsule of Sphagnum.

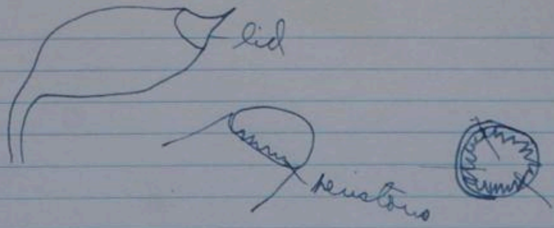


Andreae -



Andreae is xeric plant at high alts. leaves are papillose.

Two types of leaves.

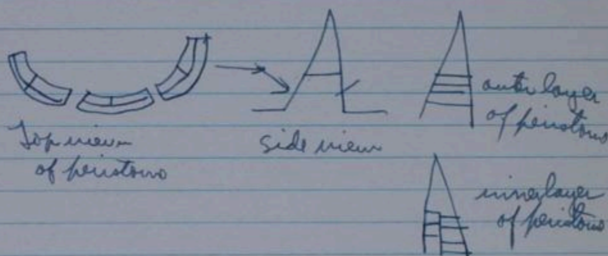


Additions to key
Subclass Bryales — teeth solid, thick
Clan Nematodonteae - peristome from several layers of cells.
Orders 1-5
Clan Arthrodonteae: Orders 6-17 - peristome from 1 layer of cells
Subclan Haplolepideae " 6-10 — teeth barred (cross partitions). (thin, membranous).
" Heterolepideae " 11
" Diplolepideae " 12-17

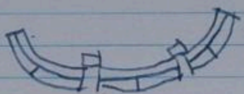
In Heterolepideae - amorphous - peristome like either 1st or last, or absent.

In Haplolepideae - peristome single
" Diplolepideae - " double.

Haplolepideae -



Diplolepideae



outer layer has cells ½ width of the tooth
inner layer has cells the full width of the peristome tooth.

(perichaetium)
Acrocarpus - sporophyte antheridia + archegonia terminal on gametophyte, but growth may continue laterally.

Pleurocarpus - lateral growth of perichaetium.

Much more variations in orders + families of Bryophytes than is common in the Angiosperms

10 See MacVicker "The Student's Handbook of British Hepatics

BRYOPHYTA

Keys adapted from Verdoorn and from Dixon in Verdoorn, Manual of Bryology; from R.I.Evans (MS); and from Bartram, Philippene Mosses.

a. Prostrate, usually with dorsiventral symmetry; capsule splits longitudinally; rhizoids without transverse walls; leaves (if present) without a midvein; cells isodiametric or not greatly elongated. b. HEPATICAE

a. Usually erect and with radial symmetry; capsule with a lid; rhizoids septate; leaves often with a midvein (costa); cells usually elongated. h. MUSCI

b. Cells with many chloroplasts; sporophyte usually setate; columella absent. c.

c. Gametophyte leafy or thalloid but lacking distinction between green and ventral tissue and lacking air-chambers; rhizoids with smooth walls. d.

d. Perianth present; (anacrogynes only - acrogyne have short setae setae long); thallose or foliose. e.

e. Bilateral, generally foliose; sporogonium terminal. I. JUNGERMANIALES ACROGYNAE

e. Dorsiventral, generally thallose; sporogonium dorsal. II. JUNGERMANIANIALES ANACROGYNAE

d. Perianth absent; setae short; thallose. III. SPHAEROCARPALES

c. Gametophyte talloid with sharp distinction between green and ventral tissue, with air-chambers and usually pores; rhizoid walls often with peg-like inner thickenings. IV. MARCHANTIALES

b. Cells with one or two chloroplasts; sporophyte lacking a seta; columella usually present. V. ANTHOCEROTALES

Hepaticae: additional keys

I. Jungermaniales acrogynae

Leaves complicate-bilobed, keeled, succubous; underleaves usually absent. Scapaniaceae

Leaves incubous; underleaves large. Porellaceae

IV. Marchantiales

Sporogonium on stalked receptacle; pores usually present. Marchantiaceae

Sporogonium immersed; pores usually absent. Ricciaceae

SYNOPSIS

From Verdoorn, Manual of Bryology

Bryophyta:

Archegoniatae containing chlorophyll, having two distinct, but closely continuous phases of growth or alternating generations. Terrestrail epiphytic or rare aquatic plants. Gametophyte (sexual haploid generation) at some time dependent upon liquid water for its development. Spore-protonema-plant, generally differentiated into caulidium (stem) and phyllidia (leaves); occasionally the caulidium may be broadened or otherwise modified and the phyllidia reduced etc. Growth by segmentation of an apical cell. No vascular system, a simple conduction strand often differentiated. Vegetative reproduction by various methods. Achegonia and antheridia (with various kinds of protective envelopes) , paraphyses. Egg cell and motile spermatozoids (wuth 2 cilia). Sporophyte (asexual, diploid generation). Seta. Capsule.

Hepaticae:

Protonema much reduced, often forming only one plant. Apical cell 2,3 or 4 sided. Vegetative body generally dorsiventral and bilateral, either with two lateral rows of leaves and a ventral row of under-leaves or the vegetative body is more developed and thalloid (often with ventral scales). Oilbodies of special and constant form. Archegonia borne apically or laterally on the stem. Cover cell of the archegonium maintains its power of division only for a short time. Seta soft, not developing more quickly than the capsule. Calyptra persistent or evanescent, not forming a cap carried up by the young capsule. Generally no columella. Elaters.

Musci:

Protonema usually strongly developed, filamentous or plate-like, seldom persistent, generally forming many plants. Apical cell 2 or 3 sided. Gametophyte gonrally radially symmetrical. Conducting strand simple, histologically differentiated. Archegonia always borne apically, generally in special buds. Cover cell of the archegonium maintains its power of division for a relatively long time. Seta firm and wiry, completing its development before the capsule. Archegonium wall forming vaginula and calyptra. Apophysis. Annulus, Peristome. Columella.

CLASS HEPATICAE

Subclass: HEPATICALES

Vegetative body foliose or thallose. Cells with many chloroplasts. No pyrenoids. Stomata of variable form in the thallus. Sporophyte without stomata. Seta usually distinguishable. Columella absent. Vegetative reproduction by various means.

Hepaticeae

ORDER I. JUNGERMANIALES ACROGYNAE

Bilateral, generally foliose, in any case the shoots which bear the sexual organs are differentiated into stem and leaves (dorasl leaves and underleaves(. Inner covering of the embryo (perianth) formed by leaves. Sporogonium terminal.

HAPLOMITRIEAE

Fam. Haplomitraceae

Stem upright with 3 rows of leaves, basal part rhizome like, without rhizoids. Archegonia terminal, in groups. No involucre. Calyptra large. Capsule incompletely 4 valved. Capsule wall unistratose. Each cell with annular thickenings. Antheridia crowded on broadened apex of the shoot or irregularly arranged on the stem.

Calobryum
Haplomitrium

MACVICARIEAE

Fam. Macvicariaceae

Foliose, irregularly branched. Leaves large, transversely attached. Amphigastria small, undivided. Archegonia terminal, on short lateral shoots. Calyptra and perianth (?) fused. Seta very short. Capsule split to 1/3 . 16 valved. Capsule wall 2 layered. No annular thickenings. Elaters unispiral.

Macvicaria

JUNGERMANIEAE

Leaves succubous or incubous. Perianth generally present. Capsule spherical to oval, 4 valved to the base. Elaters with two or more spiral~~x~~ thickenings, not firmly attached to the valves of the capsule.

Fam. Scapaniaceae

Leaves complicate-bilobed, keeled, succubous. Postical lobe (lobulus) larger than the antical lobe (lobus). Keel well developed. Underleaves usually absent. Rhizoids one celled. Leaves usually 2- or multistratose at the base. Multicellular mucilage hairs in the axils of the leaves. perianth oval or flattened, with open or contracted mouth.

Scapania
5 other genera

Fam. Porellaceae

Leaves incubous, divided into a lobus (antical lobe) and a smaller lobulus (postical lobe). Large underleaves; rhizoids forming a tuft at the base of

Fam. Porellaceae (cont)
Lateral branches replace postical lobes. Perianth large, inflated, with compressed mouth, bilabiate, valves of the capsule splitting to only half way down. Madotheca

Eight other families.

JUBULEAE

Leaves always incubous. Postical lobe (lobule) always distinct. Stylus present. Capsule 4 valved, only splitting to 2/3 of its length. Elaters trumpet-shaped, ± unispiral, attached to the tips of the valves in a regular and constant arrangement.

Fam. Lejeuneaceae
Fam. Frullaniaceae

ORDER II. JUNGERMANIALES ANACROGYNAE

Dorsiventral, generally thallose. Vegetative body differentiated into sten and leaves or into more indefinite leaf-like lobes. Inner involucre not formed from leaves. Sporogonium dorsal. Seta long. Capsule wall multistratose. Capsule 4 valved. Elaters with spiral thickenings. Pellia.

7 families.

ORDER III. SPHAERocarpALES

Thallose, delicate. Midrib multistratose, not always well defined. Air-chambers and pores absent. Each antheridium and archegonium is surrounded by a special envelope. Perianth absent. Seta short. Foot well developed. Capsule wall unistratose, subsequently decaying. No true elaters.

Fam. Sphaerocarpaceae
Fam. Riellaceae

ORDER IV. MARCHANTIALES

Frondose. Vegetative body consisting of epidermis and chlorenchyma, enclosing air-chambers (with pores). Rhizoids smooth or with thickenings on the walls. Ventral scales (sometimes reduced to rows of cells) present. Capsule wall unistratose. Elaters present or abortive.

Fam. Marchantiaceae
Air-chambers not made spongy by secondary walls; with branched cell structures (assimilating filaments). Pores simple or barrel-shaped, occasionally reduced or absent. Sporogonia on stalked receptacles, representing branches or brach systems of the thallus. Perichaetium often containing several archegonia. (continued next page).

Fam. Marchantiaceae (cont).
Pseudoperianth frequently present. Sporogonia of each ray surrounded by a common involucre. capsule dehiscing by valves. Cells of capsule wall with annular thickenings. Antheridiophore generally stalked. Marchantia, Lunularia, Conocephalum and 8 other genera.

Fam. Ricciaceae
Assimilatory region of the thallus having air-spaces or narrow air-canals enclosed by columns of cells. Generally no distinct pores. Ventral scales irregularly arranged. Antheridia and archegonia in open cavaties on dorsal side of the thallus. No seta. Sporogonium remains immersed in the archegonial cavaty. No elaters. Riccia, Ricciella, Ricciocarpus and Oxymitra.

4 other families.

Subclass: EXTENSUM ANTHOCEROTALES

ORDER V. ANTHOCEROTALES

in wall of capsule → Vegetative body lobed, leafless. Cells generally with only one chloroplast (with pyrenoid). Stomata and mucilage cavities. No ventral scales. Archegonia and antheridia not confined to one position. Archegonia dorsal, in open cavities. Antheridia (with dehiscing cap) endogenous, grouped, in cavities, differing from those of the Hepaticales in their mode of development. Sporogonium with a bulbous foot, with involucre but without seta, dehiscing downwards by two long valves; wall often rich in chlorophyll and often with stomata. Columella generally distinct. Archesporium dome-shaped over the columella. Spores mixed with sterile filamentous cells. Vegetative reproduction by means of gemmae or ventral tubers.

Fam. Anthocerotaceae

Anthoceros and 4 other genera.

Split open capsules to see stomata + chloroplasts + columella. Show preparation to see sterile filamentous hairs (not quite elaters). Meas. width + length of cells in capsule.

END OF HEPATICAE

Musci

h. Leaves with colorless cells alternating with green cells; rhizoids absent.

SPHAGNALES *

h. Leaves with adjacent cells essentially uniform; rhizoids present. i.

i. Capsule on pseudopodium; dehiscence by 4 longitudinal slits.

ANDREALES *

i. Capsule setate; dehiscence irregular or by a lid (operculum). j.

BRYALES *

j. Peristome teeth solid, not transversly barred (very faintly so in Buxbaumia). k.

k. Peristome 0. 2. CALOMNIALES

k. Peristome of 4 to many teeth. l.

l. Capsule regular, symmetrical. m.

m. Capsule erect. n.

n. Peristome of 4 teeth. 1. TETRAPHIDALES

n. Peristome of many teeth. 5. POLYTRICHALES

m. Capsule suberect, subglobose. 3.SCHISTOSTEGALES

l. Capsule irregular, dorsiventrally symmetrical.

4. BUXBAUMINALES

j. Peristome teeth (if present) thin, membranous, transversly barred and articulate. o.

o. Acrocarpous; peristome single, of two layers at the base, the outer layer (plate) the width of the tooth, the inner of two plates each ½ the width of the tooth. p.

p. Leaves distichous. 6. FISSIDENTALES

p. Leaves not distichous. q.

q. Inner basal cells large and empty, upper cells minute, opaque. 9. SYRRHOPODONTALES

* SUBCLASS

q. Inner basal cells not conspicuously differentiated. r.

r. Leaves often hyaline-pointed, cells usually minute, opaque. 7. GRIMMIALES

r. Not as above, if cells minyte and opaque, then ~~xx~~ pappilose. s.

s. Peristome teeth broad at base, entire or cleft above. t. 8. DICRANALES

t. Leaf blade nearly all costa, with 3 or more layers, with small green cells and larger hyaline ones. Leucobryaceae

t. Broader, 1-2 layers of similar cells. Dicraniaceae

s. Peristome teeth divided, forming 32 filiform, pappilose branches. 10. POTTIALES

(Order 11. ENCOLYPTALES has been omitted)

~~xx~~

o. Often pleurocapous; peristome double, the outer teeth of two layers at the base, the outer plate with two verticle series, the inner of a single plate. u..

u. Leaves single nerved or nerve absent. v.

v. Calyptra large, often plicate, often hairy. 12. ORTHOTRICHALES

v. Calyptra smaller, not plicate nor hairy. w.

w. Cells thin walled, smooth; calyptra inflated, often fringed below. 13. FUNARIALES

W. Cells sometimes thick walled, or pappilose; calyptra not inflated, may be hairy but not fringed. x.

x. Pleurocarpous. y.

y. Primary rhizomatous stems present. z.

z. Calyptra not hairy. 14. EUBRYALES (Pleurocarpi)

z. Calyptra hairy. 15. ISOBRYALES

y. Primary rhizomatous stems absent. Alar cells often present. 17. HYPNOBRYALES

x. Acrocarpous. 14. EUBRYALES (Acrocarpi)

u. Leaves double nerved. 16. HOOKERIALES

SYNOPSIS MUSCORUM

CLASS MUSCI

SUBCALSS I. SPHAGNALES

Spores developed from a distinct layer of cells, the amphithecium. Columella developed from the endothecium, not penetrating the spore layer. Capsule opening by a lid. Peristome 0. Capsule dvevated at maturity on a pseudopodium.

Sphagnaceae

SUBCLASS II. ~~ANDREALES~~ ANDREAEALES

Spores and columella developed from the endothecium, the columella not penetrating the spore bearing layer. Spore sac not separated from the wall of the capsule, capsule opening by verticle slits.

Andreaeaceae

SUBCLASS III. BRYALES

Spores and columella developed from the endothecium. Columella penetrating the spore bearing layer. Spore sac separated from the capsule wall by an air cavity. Capsule dehiscing irregularly or opening by a lid.

Order 1. TETRAPHIDALES

Protonema foliose, persistent; capsule erect; calyptra conical, plicate; peristome of four solid conical teeth.

Georgiaceae

Order 2. CALOMNIALES

Stems erect, leaves in three series, two lateral and one ventral;capsule erect; calyptra cucullate; peristome 0.

Calomniaceae

Order 2. CALOMNIALES

Stems erect, leaves in three series, two lateral and one ventral; capsule erect; calyptra cucullate; peristome O.

Calomniaceae

Order 3. SCHISTOSTEGALES

Protonema persistent, highly refractive. Leaves vertically set, decurrent, forming a polypodioid frond. Cells very large. Capsule small, suberect, subglobose.

Schistostegiaceae

Order 4. Buxbauminales

Capsule irregular, dorsiventeally symmetrical. Calyptra small, conical. Peristome single or double, outer teeth when present arising from several concentric layers of cells, linear. endostome a conical plicate membrane open above.

Annual: Buxbaumiaceae
Perennial: Diphysciaceae

Order 5. POLYTRICHALES

Mostly tall , perennial mosses; leaves narrow, often with longitudinal lamellae on the back, or on the ventral surface of the nerve. Cells parenchymatous. Capsule erect to horizontal. Calyptra cucullate, smooth, spinulose or covered with a felt of deflexed hairs.

Dawsoniaceae
Polytrichaceae

Order 6. FISSIDENTALES

Leaves distichous, vertically placed, equitant, complanate; fruit lateral or terminal, small; peristome dicranoid.

id
Archefissentaceae
Fissidentaceae

Order 7. GRIMMIALES

Mostly rupestral mosses, forming dense cushions; leaves often hyaline-pointed; cells usually minute, opaque; seta often cygneous; peristome resembling Dicranium, often irregularly branched.

Grimmiaceae

Order 8. DICRANALES

Plants variable in size, mostly terrestrail or rupestral Leaves narrow from subulate to broadly lanceolate; cells small mostly quadrate to rectangular, alar often differentiated; capsule often elongate; peristome of 16 teeth, usually cleft above, sometimes to the base, into two lanceolate or filiform divisions; typical peristome is Dicranoid: divisions broad at base and transversly barred, often vertically striolate. Calyptra cucullate.

Dicranaceae, Leucobryaceae and 3 other families.

Order 9. SYRRHOPODONTALES
Small, corticolous, tropical and subtropical mosses. Leaves narrowx, more or less subulate; inner basal cells very lax and hyaline, upper cells minute and opaque. Capsule erect on a short seta; calyptra large, plicate, persistent.

Syrrhopoxxxdontaceae
Peristome teeth short

Order 10. POTTIALES
Mostly small, terrestrial mosses. Leaves variable. Cells nearly always isodiametric, usually small and opaque. Capsule usually exserted on a long thin seta, mostly elliptic or cylindric and erect; calyptra narrow and cucullate. Peristome of 16 straight or spirally twisted teeth, entire or divided into 32 filiform branches, often papillose.

Pottiaceae

Order 11. ENCALYPTALES
Terrestrial or rupestral, tufted mosses. Leaves broad, more or less spathulate. Calyptra large, campanulate, covering the capsule. Capsule erect, cylindric. Peristome single, double or 0.

Encalyptaceae

Order 12. ORTHOTRICHALES
Plants of varying habit, leaves variable, often papillose. Calyptra usually large, campanulate or mitriform, rarely cucullate, often plicate, frequently hairy. Outer teeth of peristome usually broad and short, often united into 8 pairs.

Erpodiaceae
Ptychomitriaceae
Orthotrichaceae - Ulota Drummondii

Order 13. FUNARIALES
Plants usually terrestrial, small, often annual or biennial. Leaves often forming a terminal rosette, broad, ovate or spathulate; cells very lax, thin walled, smooth. Acrocarpous mosses. Capsule usually wide, lid never rostrate. Calyptra often inflated, sometimes fringed below. Peristome normally double; endostome processes opposite to the outer teeth; endostome without basal membrane, cilia 0.

Funariaceae
Splachnaceae
3 other families

Order 14. EUBRYALES
Perennial, often strongly developed plants. Leaves variable Calyptra cuculate. Peristome double, normally Bryoid, ie. with endostome consisting of a basal membrane, processes lanceolate, keeled, more or less slit or perforate, cilia present or rudimentary. Dorsal layer of outer teeth frequently finely striolate, transversely or obliquely.

Eubryales Acrocarpi:
Bryaceae, Mniaceae, Timmiaceae, Bartramiaceae and 7 other families.
Eubryales Pleurocarpi:
Hypodontiaceae, Spiridentaceae

Eubryales Pleurocarpi:
Hypnodendracea, Spiridentaceae

Order 15. ISOBRYALES
Pleurocarpous mosses, mostly with creeping, rhizomatous primary stem. Leaves uninerved or nerveless. Capsule immersed or exserted, erect and symmetric, rarely slightly asymmetric. Endostome wanting or imperfect, rarely normally developed. Calyptra small, usually cucullate, often hairy.
Fontinalaceae, Climaciaceae, Neckeraceae and 16 other families.
Neckera

Order 16. H OOKERIALES
Mosses mostly of warm moist regions. Stems usually of soft texture, extenral layer of cells mostly lax. Leaves often double nerved. Cells variable. Calyptra conical or mitriform, frequently hairy, often fringed a t base. Peristome usually double, outer teeth mostly with a longitudinal median furrow; cilia mostly wanting.

Hookeriaceae and 3 other families.
Hookeriopsis - best characters in leaves of gametophyte.

Order 17. HYPNOBRYALES
Mostly terrestrial or corticolous mosses, without primary rhizomatous stems. Leaves usually symmetric, not distichous. Capsule never immersed, erect, or more commonly curved. Peristome mostly well developed, Bryoid.

Thuidiaceae, Amblystegiaceae, Entodontaceae, Hypnaceae and 9 other families.
Stereodon (Hypnaceae)
Amblystegium

End of Musci

Sphagnales: sphagnum - large empty cells, with annular thickenings of the wall.
In fruit, the pseudopodium is characteristic

Andreales: Andreaceae - character - capsule doesn't split open all the way to the top, but has 4 lateral slits.

Bryales - lack a pseudopodium.
1. Nematodonteae - many cells thick, solid.
2. Arthrodonteae - single cell layer of peristome - with transverse bars.
Haplolepideae - single peristome - with one cell wide on outside of peristome + 2 cell width inside.
Diplolepideae - double peristome, with two cell width on outside, one on inside of tooth.

Nematodoneae
Haplolepideae -
Tetraphidales - Georgia - 4 large peristome teeth.
Calomniales - Calomnia - no teeth, epiphytic.
Schistostegales - Schistostegia - has leafy branch similar to miniature fern leaf.
Buxbaumiales - Buxbaumia - dorsally symetrical, looks like a bug on a stick. No leaves - an annual - (the gametophyte is annual).
Polytrichales - Polytrichum - unusual columella - which joins on to the peristome.

Arthrodonteae
Haplolepideae - acrocarpus
archegonia + antheridia terminal, but sporophyte may appear terminal

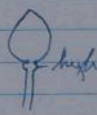
Fissidentales - Fissidens - leaves distichous
Grimmiales - Grimmia - hyaline - tipped leaves.
peristome teeth are perforated.
Dicranales - Dicranum - not easily differentiated.
Leucobryum - large empty cells (as Sphagnum) but not with annular thickening of empty cells.
The "pin-cushion" moss - forms round humps.

Symphodontales - Symphodon - bottom (basal) part of leaves have large cells, the cells above much smaller.
Pottiales - Pottia - 16 peristome teeth, each split in two, each tooth papillate. No peristome.
Tortula + Tortella

Encalyptales - Encalypta -

Funariaceae
Physcomitrium - lacks peristome.

Splachnaceae
Splachnum - dioecious, nitrophilous - specialized habitat - mostly on decaying animal matter.
Hypophysis - a swelling of the seta immediately below the capsule.



May 20, 1949 -

Remaining orders of Mosses -

1. Orthotrichales - Ulota - large calyptra, usually plicate; outer teeth united into pairs, making 8 teeth, rather than 16.

2. Funariales - Splachnum - enlarged, or expanded portion of the seta just below the capsule, called hypophysis.
Ordinal characters - Leaves have large thin cells, large in terminal rosettes. Calyptra inflated + fringed.

3. Eubryales - Bartramia + Bryum - acrocarpus. Heterogenous collection, calyptra not inflated or fringed, as in Funariales.

4. Isobryales - Neckera - long, creeping, rhizome-like main stem, [illegible] Pleurocarpus.

Hookeriales - leaves w/ 2 nerves -

Hypnobryales - Pleurocarpus, calyptra generally hairy.
Stereodon, Amblystegium, Entodon.

Genetics -
Chromosome nos. - counts differ in same spp. from 1-3 variants.
Funaria has had counts of 14 + 20.
Polytrichum " " " " 6 + 7 (3 diff. spp.).
Catharinia " " " " 14-17 + 21 in another

Apparently 7 is a basic no. of chromosomes in mosses.
This is the haploid no.

Sporophytes a bit different - basic no. 8, or 8+1.
Sphagnum + Marchantia 8
Riccia 14
Pellia 9
Cephaloziа 32.

9 in both, chromosome no. quite low, w/ considerable evidence for ploidy.
Native + experimental hybrids occur. At least 25 putative (native) hybrids at least 10 of which are intergeneric, involving 11 different genera.
Experimental hybrids show intermediate characters between the 2 parents.

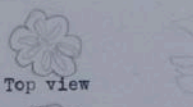
Funaria hygrometrica.
Leaf cells (mature)
n —— 50 μ length
2n —— 75 " "
3n —— 100 " "
4n —— 125 " "
A regular

Geographic distribution – generally show same distribution as flowering plants.
See Sh Hertog
1. General type I colder part of N. Hemis.
Dicranum
Encalypta
Weberd (Diphiscium)
Georgia
Fissidens
Saxifraga
Pellia
2. Typical tropical (pan-tropical) only rarely into N or S temperate regions.
Leucobryaceae.
Hookeriaceae
Neckeriaceae

3. Same patterns of disjunct + endemic distribution as fl. plants.
Heliophyllum – trop. America + ~~Eth~~ Micronesia (disjunct).

MARCHANTIALES
MARCHANTIACEAE
Marchantia

Rhizoid x50



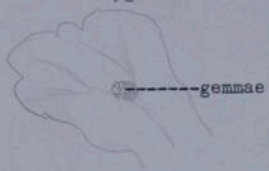
Pore structure
x 40

♀ sporogonium
x 1

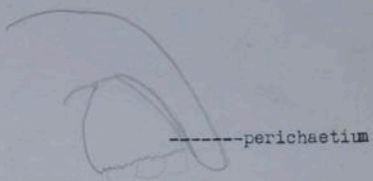
♂ sporogonium
x 1

Polygonal air chambers x 30

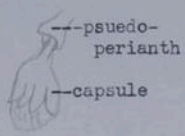
undersurface of sporogonium (♀)
showing fimbriate perianth.

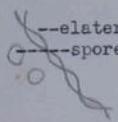


Thallus with gemmae

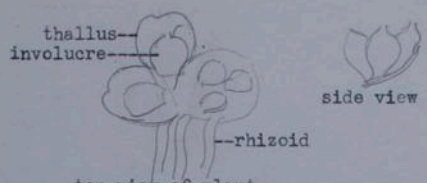


section of sporogonium
showing perichaetium

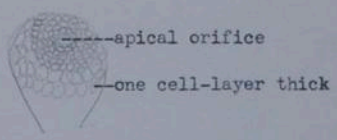




SPHAEROCARPALES
SPHAEROCARPACEAE
Sphaerocarpos



top view of plant
X 36

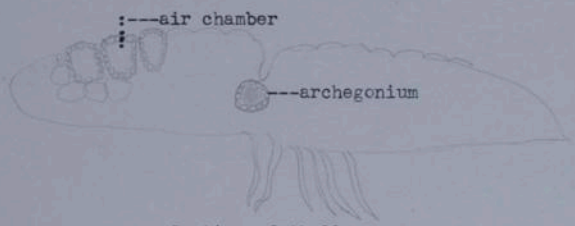


female involucre
X 40

MARCHANTIALES
RICCIACEAE
Ricciocarpus natans

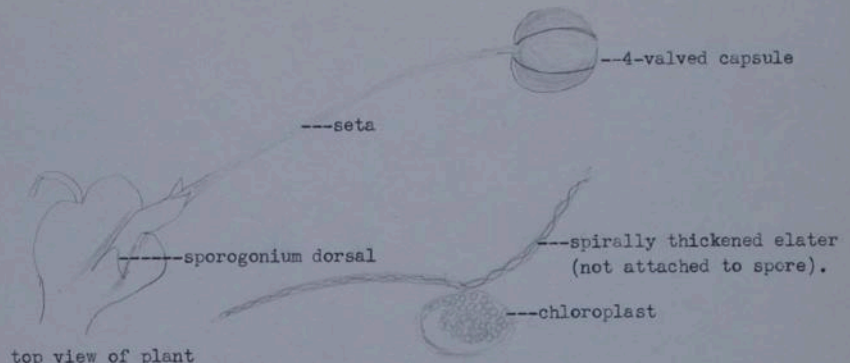
top view of plant
X 3

section of ventral scale
X 15



Section of thallus

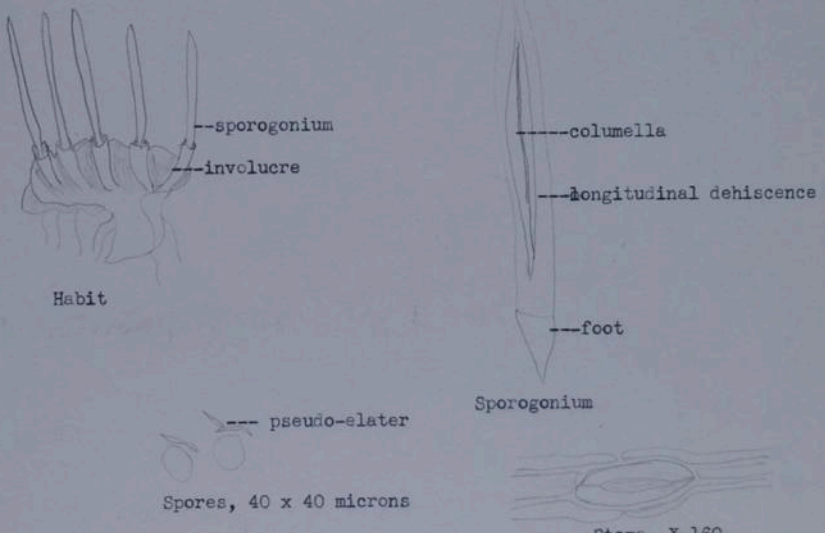
JUNGERMANIALES ANACROGYNAE
Pellia epiphylla



top view of plant
X 36

99.8 x 80.27 microns.

ANTHOCEROTALES
ANTHOCERATACEAE
Anthocerus



Habit

Sporogonium

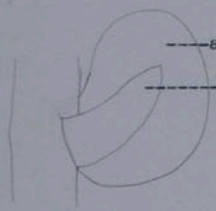
Spores, 40 x 40 microns

Stoma X 160
Stoma 59.8 x 18.2 microns
Guard cell 143 microns long

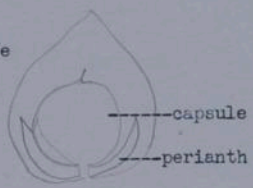
JUNGERMANIALES ACROGYNAE
PORELLACEAE
Madotheca porella

dorsal surface

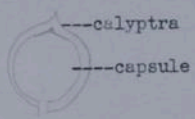
ventral surface



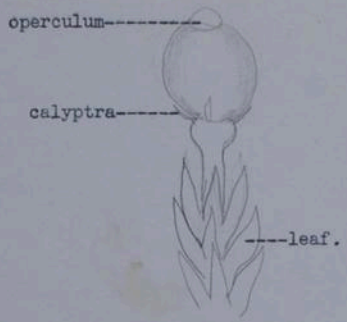
ventral side of
incubous leaf

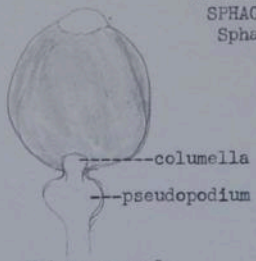


mature capsule



MUSCI
SPHAGNALES
SPHAGNACEAE
Sphagnum





Mature capsule
X 40

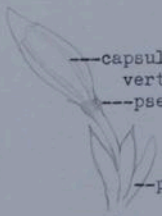
section of leaf
X 180

types of stem

spore X 400

ANDREALES
ANDREACEAE
Andrea

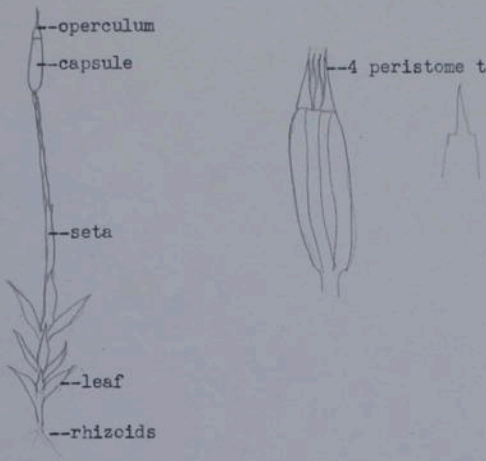
habit



capsule

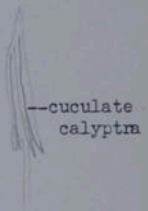
leaf section

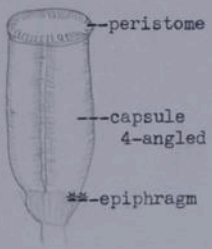
TETRAPHIDALES
GEORGIACEAE
Georgia



habit

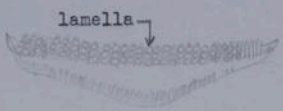
POLYTRICHALES
POLYTRICHACEAE





Leaf, w/serrate
margin

Habit X 1



section of leaf

BUXBAUMIACEAE
Buxbaumia

peristome teeth

X 150

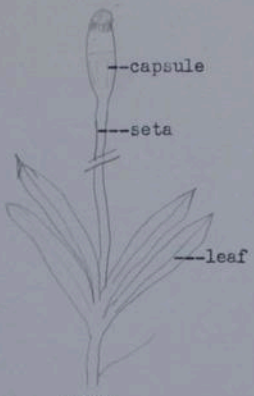
--operculum.

asymetrical capsule
X 10

--annulus w/o peristome.

CALOMNIACEAE
Calomnia X 2.5
Leaves in 2 series, 2
lateral, 1 ventral

SCHISTOSTEGALES
SCHISTOSTEGIACEAE
Schistostegia



habit

leaf margin

peristome tooth

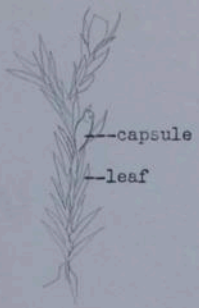
DICRANALES
DICRANACEAE
Dicranum

Habit

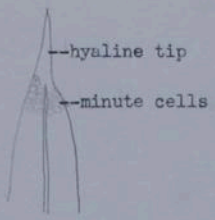
inner layer of
peristome tooth
X 180
(two rows of cells)

outer layer of
peristome tooth
X 180
(single layer)

GRIMMIALES
GRIMMIACEAE
Grimmia

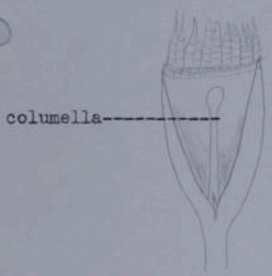


habit



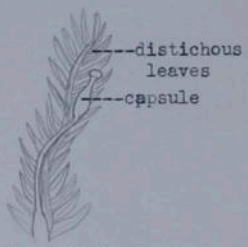
irregular peristome teeth

FISSIDENTALES
FISSIDENTACEAE
Fissidens

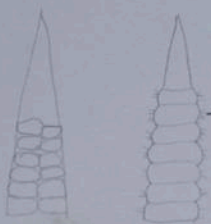


capsule cut open

exterior of capsule.



habit X 10



Peristome teeth
left, inside; right outside

SYRRHOPODONTALES
SYRRHOPODONTACEAE
Syrrhopodon

leaf X 20

habit

short peristome teeth

DICRANALES
LEUCOBRYACEAE
Leucobryum

habit

double layer
peristome
interior

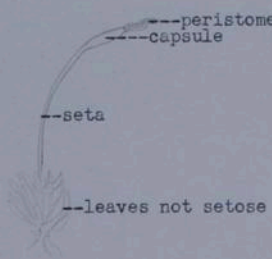
exterior
peristome

POTTIALES
POTTIACEAE
Pottia

habit

capsule

POTTIACEAE
Tortella

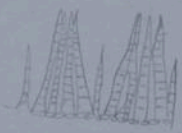


Peristome teeth (16)

ORTHOTRICHALES
Ulota

habit

capsule



peristome teeth (8)
slightly split into 16

ENCALYPTALES
ENCALYPTACEAE
Encalypta

habit

capsule

peristom teeth (8)
slightly split

inner layer
single row of cells.

outer layer
(2 rows of cells)

duct lined from a double layer of cells