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Standards for botanical nomenclature -

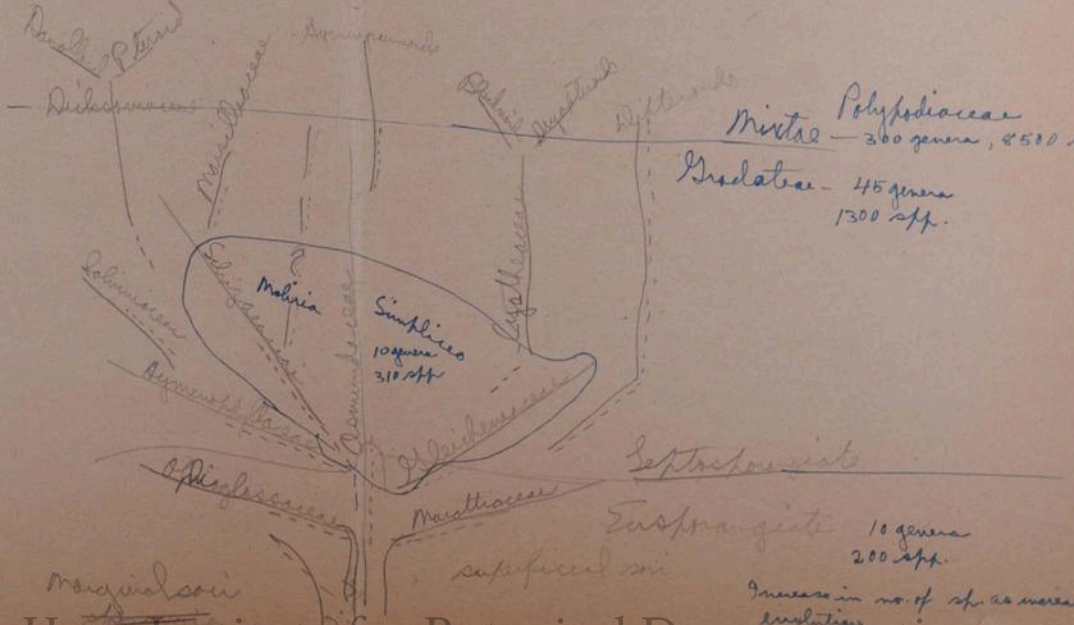
Christensen
Index Filicum

+ Copeland
Genera Filicum

Saccardo
Sylloge Fungorum

Detoni
Index algarum

Stephani
Index hepaticum.



Fern Course, 1948-49 Dr. R.M. Tryon, Jr.

Thallophyta	Thallophyta
Bryophyta	Bryophyta
	Hepaticae
Hepaticae--Prostrate, dorsiventral, capsule dehiscing longitudinally.	
	Musci
Musci--Erect, radial, capsule with lide	
Pteridophyta	Tracheophyta
PPsilotinea--alternate or no leaves, terminal sporangia	Psilopsida
Lycopodineae--alternate leaves, strobili	Lycopsida
Equisitinea--Whorled leaves, strobili	Sphenopsidae
Filicinae--alternate leaves, spores single or in a sorus.	

old	new
Spermatophyta	Pteropsida
	Filicae
Gymnosperms	
Cycads--pinnate, motile sperms	Cycadae
Conifers--scales or needles, non-motile sperm	Coniferae
Angiosperms	Angiospermae
Monocots	Monocots.
Dicots.	Dicots.

Morphology of Ferns (Cyrtomium, Polypodiaceae).

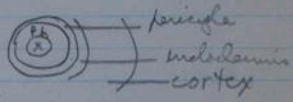
Cyrtomium,

Erect stem (rhizome), large leaves, roots all adventitious

In ferns, all roots adventitious except first root of sporophyte.

Fern stems usually a rhizome.

Roots--always protostelic.



Botrychium has underground, erect stem (geophyllous).

Tree fern--erect stem, leaves at top, stem covered with leaf basees and adventitious roots. (Angiopteris leaf 15' x 6'.

Trichomanes has long rhizome, alternate leaves.

Fern steles

1. Protostele. (Rhizome of Trichomanes, Gleichinia, etc.).

2. Siphonostele--protostele with pith
   a. Evolution of central xylem into pith (fossil Osmundas show this, also traumatic reversion of pith in Osmunda).
   b. Invasion of cortex.
   Sometimes an internal endodermis
   a. Ectophloic
   b. amphiphloic.

3. Dictyostele--siphonostele with overlapping gaps. Parts of dictyostele called "meristele".

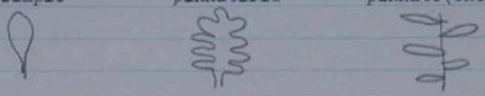
Sometimes accessory strands, stelar perforations, extra cycles (polycycly). Complicated types usually in tree ferns.

Meristem usually protected by scales.

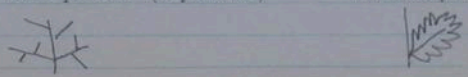
Leaves typically circinate when young.

Parts of frond
1. Stipe (petiole).
2. Blade (lamina).
3. Rachis (main axis of frond).
4. Pinnae--primary divisions.
5. Pinnule--secondary division.
6. Pinnula--third division.

Blade may be simple pinnatifid pinnate(once divided.



twice pinnate (bipinnate) Pinnate-pinnatifid.



V

Veins a. usually open, not reticulated.
b. Areolate--joined to form a network of closed loops.

Appendages

1. Scales, hairs most abundant
2. Glands

simplest type a hair with glandular tip 

from this is derived sessile glands 

all probably derived from hairs.

Sporophylls (types).

1. Same as sterile leaf (as Adiantum),

Intergradations from this type to separation of sterile from fertile.

Life cycle (see any text)

1. Spores usually 48 or 96 in number, but primitive up to 15,000.
2. Archegonia imbedded, several celled neck, egg at bottom.
3. Antheridia simple, with a lid.
4. Sperms motile, flagellated, attracted by malic acid from archegonia
5. Only on sporophyte develops per prothallus.
6. Gametophytes sometimes filamentous, tuberous, subterranean,

green cordate type is most common.

First classification of ferns into families are based on sporangia.

later, some other characters have been added on.

1. Ophioglossaceae
2. Marattiaceae
3. Osmundaceae
4. Schizaeaceae
5. Marsiliaceae
6. Gleicheniaceae.
7. Hymenophyllaceae.
8. Dicksoniaceae
9. Cyatheaceae
10. Polypodiaceae
11. Salviniaceae.

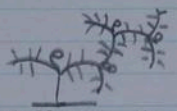
1. Ophioglossaceae--frond divided into a sterile and a fertile part. two separate parts to the leaf. Sporangia are borne naked. Sporangia, large, massive, sessile, and no annulus. Generally world-wide, occurring occasionally in sub-arctic regions.

2. Marattiaceae--sporangia in sori, on the under surface of the leaf. Sporangia are in separate groups. Sporangia large, massive and sessile, either no annulus or a rudimentary on (in Angiopteris). In the tropics of both hemispheres.

3. Osmundaceae--some or all the pinnae of the blade completely fertile. In some cases the whole leaf. There is no separate part--part of the leaf proper. Sporangia naked--no sori--sporangia are large, short-stalked and have rudimentary annulus. World wide and gets into boreal regions.

4. Schizaeaceae--has the fertile pinnae much reduced except in single genus Mohria, in which sporangia are under surface of the leaf. Sporangia are large with an annulus xxxxxxx at apex. No sori. Sporangium has a stomium. Tropical, very few temperate spp. (Lygodium, Anemia).
5.
5. Marsiliaceae--heterosporous, At the base of leaves are sporophylls, which contain sori. Each sorus has megasporangia and microsporangia. The sporocarp is a modified leaf. Aquatic or semi-aquatic, world-wide. most of the spp. Australian.

6. Gleicheniaceae--generally climbing fern. Sporangia borne in a sorus on the undersurface of the leaf. Sporangium lacks indusium. Has complete transverse annulus. The leaf has indeterminate growth, and peculiar type of leaf. The growing point (terminal bud) is arrested and side buds carry on the growth of the blade. Tropical and extra-tropical in the southern hemisphere.



7. Hymenophyllaceae--the filmy ferns. The blade is usually one cell thick. The sporangia in sori, and one terminal on the vein ends(on the margin of the blade). There is an indusium present which is 2-valved or campanulate (bell-shaped). Receptacle is long and cylindrical. Tropical, with few temperate representatives. Of exceedingly moist and shady regions.

8. Dicksoniaceae--family of tree ferns. Sorus terminal on the vein ends. Indusium 2-valved or cup shaped. Receptacle rather short. Tropical and extra-tropical in southern hemisphere.

9. Cyatheaceae--mostly tree ferns. Sorus on the underside of the blade. No indusium or a cup shaped indusium. Sporangia has complete oblique annulus and stomium. In tropical mountains.

10. Polypodiaceae--Sporangia in sori or not, indusium or not; usually long-stalked, may be short. Incomplete annulus and has a stomium. World-wide, well developed even in artic regions.

11. Salviniaceae--hetero-perous--aquatic, plants free floating in water. In Salvineae no roots present. Sporocarps, and sori in the sporocarp of either mega- or microsporangia. World wide in distribution. Some occur in boreal regions.

Types of annulus

1. complete

2. oblique

3. apical

4 vertical

5. transverse.

Phyllogeny

Most primitive

Ophioglossaceae & Marattiaceae--these have massive, large and simple sporangia.

Intermediate

Osmundaceae & Schizaeaceae--sporangia are smaller than above, annulus present, the not well developed. (No sorus; sporangia marginal--a primitive character).

Advanced

Gleicheniaceae, Hymenophyllaceae, Dicksoniaceae, & Cyatheaceae--sporangia in sori. The annulus is well developed, complete.

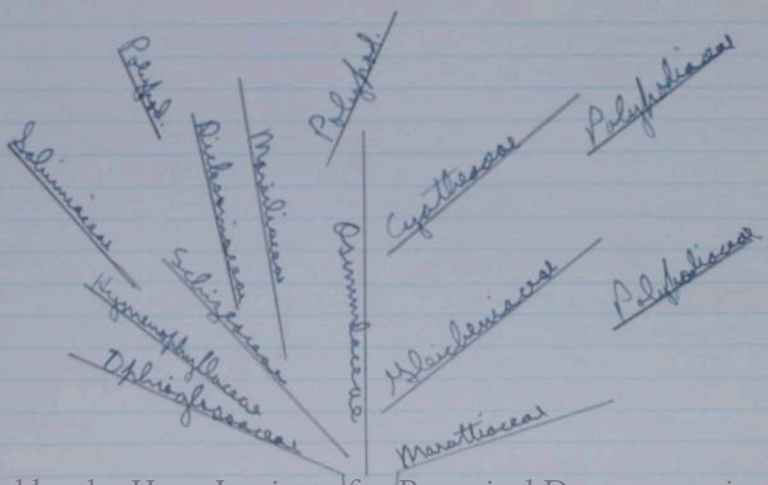
~~Most~~ advanced

Polypodiaceae--incomplete annulus.

Most advanced

Marsiliaceae & Salviniaceae--heterospory--~~xxxx~~

F.O. Bowers "The Ferns", vol. I-III.



Filicinae

I. Eusporangiatae---sporangium is developed or arises from several cells and the walls are several cells thick.

Ophioglossales
Ophioglossaceae
Marattiales
Marattiaceae

II. Leptosporangiate--sporangium arising from single initial cell and the wall is 1 cell thick.

Filicales
Osmundaceae, etc.

1. Ophioglossaceae--3 genera. (R.T. Clausen--Monograph of the Ophio.
   1. Helminthostachys--species 1. Mem. Torr. Bot. Cl. 19^2: 1938.)
   2. Botrychium--23 spp.
   3. Ophioglossum--27 spp.

Fertile spike or panicle is inserted on the leaf. The leaves have stipules. The stem is short, upright, except in Helminthostachys which has a creeping rhizome.

The roots are fleshy. The sporangia are large; the spore output per sporangium is from 1000 to 15,000.

The gametophyte is fleshy, subterranean, rather irregularly cylindrical. The antheridia and archegonia are sunken in the prothallic tissue. The prothallus is strongly mycorrhizic.

There are no fossils of the family and hence no evidence of more primitive members. Considered to be most primitive of the ferns. The spikes in fossil Zygopterids (genus Stauropteris) are very similar to Helminthostachys. No living ferns have been derived from Ophioglossaceae.

Helminthostachys--believed to be most primitive because of analegues in fossils.
Botrychium & Helminthostachys have open venation

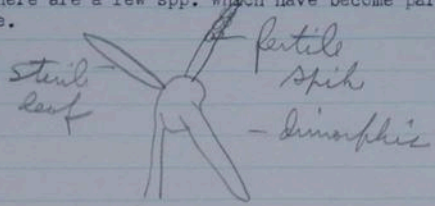
Ophioglossum--areolate (reticulate), believed to be derived form.

Helminthostachys & Botrychium--siphonostele.

Ophioglossum--dictyostele.

Only in spke characters is Ophioglossum more primitive, having a very simple spike and very large sporangia and spore output, but it is believed that this is due to mycorrhizic development and not primitive character.

There are a few spp. which have become parasitic, and much reduced in size.



2. Marattiaceae.

1.	1. Angiopteris	62 spp.	
	2. Macroglossum	1 sp.	separate sporangia
	3. Archangiopteris	1 sp.	
	4. Marattia	28 sp	
	5. Protomarattia	1 sp	united or fused sporangia
	66 Danaea	26	
	7. Christencenia (Kaulfussia)	26	sori subdivided

Characters

1. Massive root-stalks, erect in some Christencenia, creeping in Danaea.
2. Stipules present.
3. Pinnae are jointed to the rachis.
4. Spore output 1500 to 8000 per sporangium.
5. Sporangia borne on the undersurface of the leaf.
6. Muscilage canals.
7. Tannin cells.
8. Prothallus green and flat, mycorrhizic.

Phyllogeny

Family represents survivors of ancient stalk, with no living derivatives.

Fossils from late Paleozoic:

1. Danaeopsis--Rhaetic
2. Ptychocarpus--upper coal measures.

Those with separate sporangia primitive, united advanced; those united and again subdivided most advanced.

II. Leptosporangiate

Filicales

1. Osmundaceae

1. Osmunda	9 spp.	sporangia marginal
2. Todea	1 spp.	sporangia superficial
3. Leptopteris	7 spp.	(undersurface of leaf)

Leptopteris is filmy and Todea ordinary type, otherwise both the same.

There are specimens of Osmunda which have transitional placentation of sporangia--from marginal to superficial:

O. Cinnamomea	dimorphic leaf.
O. claytoniana	fertile pinnae middle of the blade.
O. regalis	fertile pinnae on tip.

Characters

1. Massive erect rhizomes. (adventitious roots used for growing orchids).
2. Family has stipules.
3. Osmunda hs muscilage canals.
4. Sporangia marginal or superficial.
5. Spore out put 128--512 per sporangium.
6. Prothallus green, cordate, fleshy and long-lived.

Phyllogeny

Osmundaceae ranks intermediate in characters other than sporangia between Eusporangiate and Leptosporangiate.

1. Apical meristem of root--1 to 4 initials (In Ophioglosaceae and Marattiaceae--several initials. Higher Leptosporangiate--1 initial).
2. Undivided leaf-trace (Primitive).
3. Annulus is rudimentary.
4. Spore out-put--

5. It shows the transition between marginal and superficial sporangia.

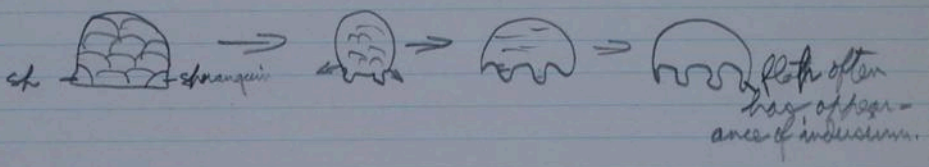
There are no living derivatives of the family, but there are fossils: Zaleskya, known from the upper Permian.

Distribution--wide and disrupted.
1. E. Asia
2. S. E. U.S.
3. Cent. Am. and N. S. Am.

2. Schizaeaceae

1. Lygodium	40 spp.	pan-tropic.
2. Schizaea	30	tropical and temp. in S. Hemis.
3. Anemia	90	Tropical Am., Afr. Madagas, & 1 sp. in India.
4. Mohria	3	S. Africa.

The family is diverse vegetatively. The best characters that hold family is in sporangia. The distal and complete ~~sporangia~~ Annulus, opening by a slit. The sporangia are marginal in their origin but become superficial.



Prothalli are cordate and green except in Schizaea, which is filamentous.

1. Lygodium--~~upright~~ climbing ferns. A long creeping rhizome often elongate; leaves of unlimited growth (up to 100 ft. in L. palmatium). Tropical ones pinnate.

2. Schizaea--upright rootstock; the frond erect, either simple or dichotomous. Native sp., S. pusilla with entire leaves; tropical with dichotomous leaves. Sporangia are borne in compact distal pinnae.

3. Anemia--short creeping rhizome, frond is pinnate in division and basal pinna ~~his~~ long-stalked and completely fertile.

The above genera have hairs, but no scales on the rhizomes.

4. Mohria--rhizome with scales, fronds also with scales intermixed with scales. Short rhizome. The fertile and sterile leaves are alike. No dimorphism as in others.

Phylogeny

In order from primitive to advanced
Lygodium protostele, spore output 256.
Schizaea modified protostele, spore output 128
Anemia siphonostele, sp. output 128
Mohria dictyostele.

Lygodium has larger sporanga and the annulus is not well developed or as constant as in the other genera. It has elaborate leaves, probably most highly advanced in leaf character, in some cases having areolate venation (others have open venation. As far as leaf is concerned,

Schizaea is very primitive because of dichotomous type. Scales of Mohria would rank it as a derived genus. Mohria is first genus taken up so far which has scales, and all other genera have hairs.

Fossil types

Sentfenbergia from upper carboniferous. Somewhat doubtful, and may have affinities with Osmundaceae.

Klukia--Jurassic, no doubt.

Tempskya--proposed, but not sure yet, from lower Cretaceous.

Marsiliaceae has very strong affinities with this family. Derivation of Marsiliaceae from Schizaeaceae.

3. Marsiliaceae

Marsilea 70 spp.
Regnellidium 1 sp.
Pilularia 6 sp.

The family is semi-aquatic either in water of mud. Frequently in places that dry out in midsummer. The rhizome is long creeping and hairy. The stem has a siphonostele.

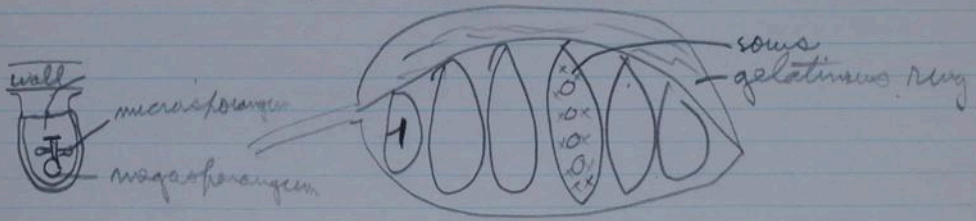
The fronds vary from simple with 2 pinnae up to 4 pinnae. Sedge-like simple blades in Pillularia. Regnelidium has 2-lobed rather fleshy leaf.

Marsilea--4 pinnae that is believed to be 2 pairs of opposite pinnae World-wide in its distribution with concentration in Australia and S. Afrida.

Regnellidium--known only from 3 localities in Brazil. Very distinct genus--discovered about 1900.

Pilularia--quite widely distributed in Europe, N & S. Am., and Australasia.

The family is heterosporous. Sporangia are borne in sporocarp.



Megasporangia are central on the receptacle and the microsporangia are along the border. The gelatinous mass expands upon maturity of spores and as it extrudes from sporocarp, carries sori along. The indusium breaks open and spore are liberated and germination can take place. (Abscission layer at the receptacle).

In the microsporangia 64 spores.
In megasporangia, 1 spore.

Upon germination, prothalli and these are borne upon the spore (actually attached).. They are very small.
Microprothallus has 2 antheridia.
Mega " " 1 archegonium.

Phyllogeny

Evidence good that sporocarp is a pinna. Its position, anatomical nature of origin and nature of its tissue. Considerable evidence of its Schizaeacecus affinit. Campbell, D.H., Mosses & Ferns, Ed. 3, 1918.

In some of the Marsiliaceae are abortive. Annulus is present, of the Schizaea type.

Primitive type will be Marsilia, especially when one finds 6 pinnae type--a reduction from pinnate.

In soral characters, Pilularia primitive and Marsilea advanced.

The 3 genera are rather remotely related.

4. Gleicheniaceae

Gleichenia	150 spp.	pantropic, pan austral.
Stromatopteris	1 sp.	New Caledonia.
Platyzoma	1 sp.	Queensland.

The whole family has a creeping rhizome which is generally scaly. The leaves have interupted apical growth. They are pinnate in plan. Arrested bud. Dichotomous type. In the sporelings fist leaf is entirely pinnate with no leaves developed. It is only later that arrested buds develop.

Sore are all superficial. Prothallus is normal type green and flat.

Gleichenia--very large leaves. Typical arrested buds. sp. output 256 or 512-10
Stromatopteris--long and narrow, either pinnate or pinnatifid leaves. 256 or 512
Platyzoma--------
Platyzoma not only dimorphic but shows incipient heterospory. Small spores, 24-32, large spores 16.

Fossil record--oldest from Carboniferous

1. Oligocarpa--affinity somewhat doubtful.

From Mesozoic onward good fossil records, with sporangia attached to the leaves.

Stromatopteris and Platyzoma are interpreted as specialized xerophytes. The genus Gleichenia has been divided into many other genera, but those have pretty much in common.

The families taken up so far are SIMPLICES of Bower. Includes Eusporangiate as well as Leptosporangiate ferns, including those somewhat intermediate in characters.

The characters which hold this group together are:

1. Sporangia of a sorus or group all mature at the same time.
2. Sporangia and the spore output per sporangia is relatively large.

The later families have sporangia maturing at diffirent times, relatively small sporangia and small spore output.

When sporangia mature together, there is considerable nutritive strain on the plant.

5. Hymenophyllaceae--600 spp.
Trichomanes and Hymenophyllum both tropical and austral.

Trichomanes--indusium rather tubular, receptacle exserted.
Hymenophyllum--indusium 2-lipped, the receptacle hardly or not at all exserted.

The family is characterized by marginal sori with an indusium. The receptacle is continuation of the vein end. It is surrounded by marginal tissue forming the indusium.
Leaves are one cell thick, no stomata on the leaves.
The prothallus is quite varied, but generally filamentous of flat and ribbonlike.
Spore output-- Trichomanes--32-64
Hymenophyllum--128-512.

	Sporangia per sorus	Spores per sporangia	Totalper sorus.
H. tunbridgense	20	420	8000
T. reniforme	40	256	10,000
H. dilatatum	90	128	11,000
T. radicans	140	64	9000.

Some of these filmy ferns are extreme epiphytes. Some species have no xylem in the roots. One species does not even have roots, it has rhizoids and the whole plant is 4-5 mm. tall.

Fossils--eviden questionable especially in the genus Hymenophyllatis.

The marginal sori and the generally protostelic nature relates it to the symplices.

Trichomanes is more speciallized, and spore output is lower.

6. Dicksoniaceae.

1. Thyrsopteris	1 sp.	Juan Fernandez
2. Dicksonia	17 spp.	S. Hemisphere.
3. Cibotium	13	E. Asia, Hawaii, Central Am.
4. Culcita	9	Trop. and sub-tropical
5. Dennstaedtia	70	Trop; 1 sp. in N. Am.

Family mostly one of tree-ferns. A few with creeping stems. Has hairs and no scales. The sori are marginal, being terminal on the vein end. An indusium either cup shaped or 2-lipped. The sorus is gradate--sporeoutput from 48-64.

Taxonomy

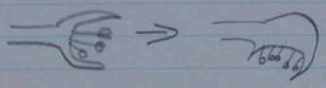
Bower adds Hypolepis to the family.
Christensen splits and puts Dennstaedtia and Hypolepis in Polypodiaceae.
Copeland puts them in Pteridaceae

Bower: Pteris, Pteridium, Paesia, Hypolepis — Dennstaedtia, Dicksonia.

Pteris is much different from basic primitive genera. What most people do will be to cut off the top end, putting the top 3 in Polypodiaceae.

Copland admits that Pteridaceae is undefinable, but if the series is cut in the middle, the family becomes definable but not natural.
Most of the family has large, several-times pinnate leaves.

There are fossils of Thyrsopteris type known from the Jurassic.
In the genera there are several evolutionary tendencies:
1. Tree fern vs. creeping habit. More primitive ones tree ferns, and the recent ones creeping.
2. Series from oblique to vertical annulus (in Dennstaedtia). This fits into the tendency of Polypodiaceous sporangial
3. The sorus is gradate except in some spp. of Dennstaedtia which has mixed sori, that is, different ages are mixed on the receptacle.
4. General tendency of the indusium--cup-shaped or 2-lipped indusium becomes modified.



Upper one becoming larger and lower one smaller. Upper one tends to be fused--get one long indusium over the whole margin.

Dicksoniaceae giving rise to a line of evolution in Polypodiacea, the Pteroid line. The origin of the line will be from a marginal one such as Schizaeaceae, although relationship not at all close.

7. Cyatheaceae

Hairs-	1. Lophosoria	1 sp.	Mex. and South America
	2. Metaxya	1 sp.	Br. Honduras and Brazil.
Scales-	3. Alsophila	300 spp.	Tropis & S. Hemisphere.
	4. Hemitelia	100 "	" "
	5. Cyathea	300 "	" "

These genera are variously splite and reorganized. Two of the genera are monotypic and the others very large. In the large ones, there are a great many endemics--very local species.

Characters
1. Mostly of tree ferns.
2. Large, several times compound leaves.
3. Either hairs or scales; genera 1. & 2. have hairs and the remaing 3 scales.
4. Sori are superficial, round and either with an inferior cup-shaped indusium or lacking one.
5. The prothallus is rather long-lived and has bristlyes and scales when it is about a year old. Generally cordate and flat.
6. Spore output--64 per sporangium.

Phyllogeny
1. Primitive group has hairs and siphonostele.
2. Sorus is simple, not gradate, i.e. all mature at the same time.

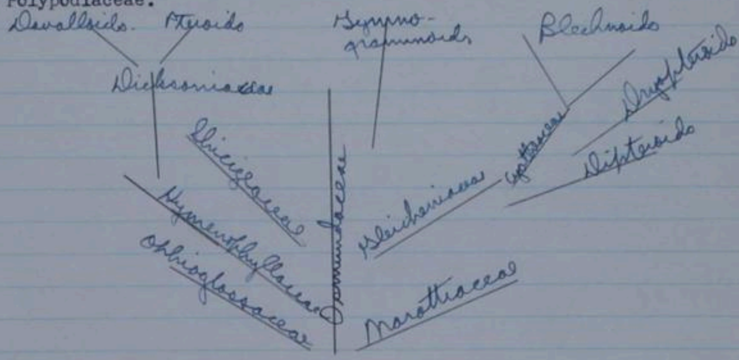
These 3 characters relate back to Gleicheniaceae. (Also superficial soruls). Caudex is short, i.e., very small tree ferns.
The second group has:
1. dictyostele.
2. gradate sorus
3. True tree ferns.

Development of the indusium.

- Alsophila lacks one
- Hemitelia has only scale
- Cytheaa has inferior cup-shaped indusium.

This line goes on into the Dryopteroid line of the Polypodiaceae, such as Woodsia.

The family occupies an intermediate position between Gleicheniaceae and Polypodiaceae.

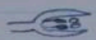


Copeland breaks down the family Polypodiaceae into many families.

1.x~~Fewxcharacterxxofxthexfamily~~
2. ~~Phyletixpositionxofxthexgroupx~~
3. ~~Fewxcharacters thatxplacexthexfamily inxitsxrelative positionx~~
4.x~~Generalxgroupxof typexfrom which the familyxcame.x~~

The Pteroid line of Polypodiaceae

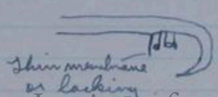
Dennstaedtia has essentially equal 2-valved indusium.



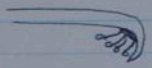
There are some spp. of Dennstaedtia in which upper one is enlarged and lower one reduced.

This is contiñued and becomes more prominent in Paesia. Upper indusium even larger and incurved and low er even smaller.

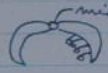
In Pteridium infrequently, the inner indusium is present. Here it is reduced to a thin membrane.



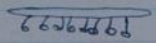
In Pteris the inner indusium is completely lost and the sporangia covered by outer marginal indusium.



In Acrostichum praestontissimum the whole leav is incurved, and the receptacle sprad on lower leaf margin.

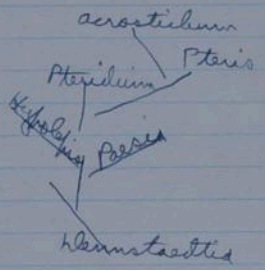


In Acrostichum aureum the entire surface bears sporangia, not only on veins but on the tissue between.



In Pteris there are segments with continuous marginal indusia. The same in Pteridium.

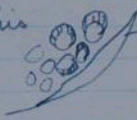
Phyllogeny of the group.



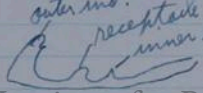
In Hypolepis the inner indusium is completely lost, but intermediate in position and number of sori.

1. Dennstaedtia punctilobula

2. Hypolepis

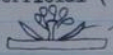


3. Paesia

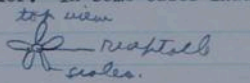


Dryopteroids

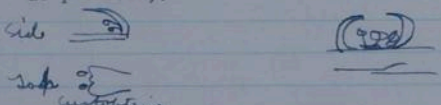
Primitive type in Cyatheaceae, with indusium like Hemitelia, which has an extended receptacle with 1 or more indusial scales. Sorus superficial (Pteroid line has marginal sori).



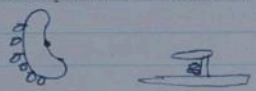
1. Woodsia--indusium inferior. In some cases indusial segments are hairs, others, scaless



2. Cystopteris (from Woodsia). Single scale, attached at the base and arches over the sporangia (if one side of Woodsia indusium is lost, the other side more developed, and tills over, the Cystopteris indusium is produced).



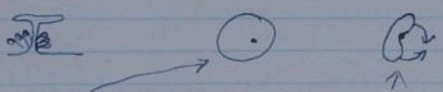
3. Dropteris has reniform indusium with attachment at the sinus, that is, lateral spread of indusium of Cystopteris.



From Dryopteris type, three tendencies develop:

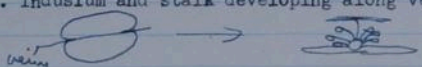
1. Loss of indusium--Dryopteris (w/o indusium) to Polybotrya in which the porangia are all over the surface, no sori, like Achrostichum.

2. To Polystichum (Xmas fern) and Tectaria, further development of the indusium



The peltate indusium developed from reniform type.

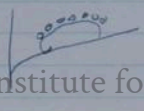
3. Indusium and stalk developing along vein, and attached to the veins.

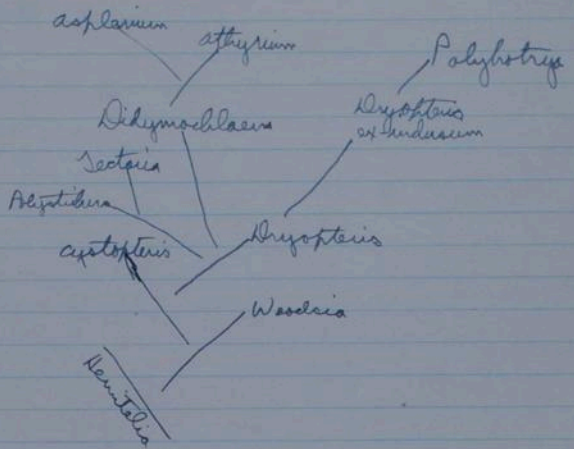


Spread of receptacle also along the vein., such as Didymochlaena.

In Athyrium, the line of the start of reduction--one one side of the vein, a complete indusium and receptacle, but on the other side, much smaller.

In Asplenium, the half-reduced in Athyrium is completely lost, the half towards the midrib remains. An elongation of the receptacle along the vein.





Start with an inferior indusium, the whole tendency being changes in indusium and sorus.

Salviniaceae

1. Salvinia 10 spp.
2. Azolla 6 "

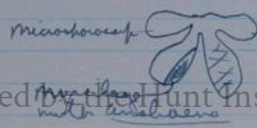
Some authors split these 2 genera into separate families.

Both are small floating aquatic. They have sporocarp of single sori. Sporocarps are either micro or megasporangia.

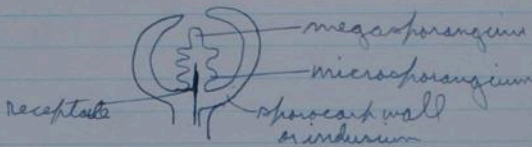
Some differences of opinion whether to call it a sporocarp or sorus with an indusium. Not homologous with Marsilea covering, which has indusium inside.

Salvinia--leaves in whorls of 3. Two of them floating, one leaf greatly dissected and pendent (called water leaf). Dissected members of this leaf function as roots since plant has no roots. There is one megaspore per megasporangium and 64 microspores in microsporangium. Floats by hairs on the leaves.

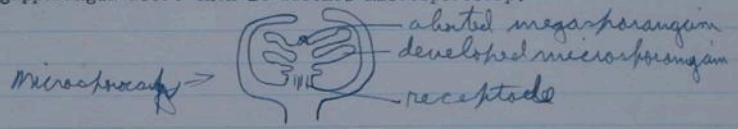
Azolla "mosquito fern" gives a characteristic velvety shen to water, frequently covers water completely. Characterized by roots, as opposed to Salvinia, leaves that are divided into two lobes. The lower lob is extremely thin. Upper has mucilaginous deposit; upper part of it photosynthetic. Colonies of Anabaena (BG alga) in the muscilage. Floats by means of papilae on leaves.



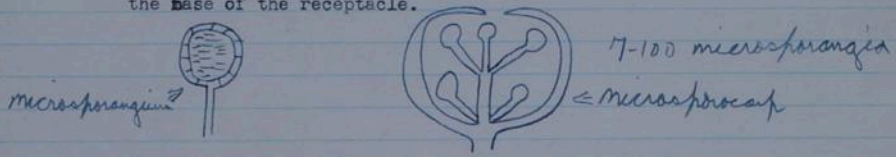
Megaspores small and frequently look like an acorn. Microsporocarps are large (about size of leaf) spherical with many sporangia.



If it develops into megasporocarp, then microsporangia abort, or if megapporangia abort then it becomes microsporocarp.

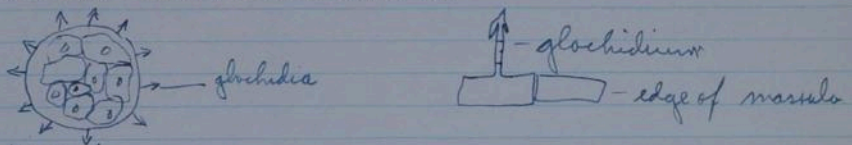


There is a basal meristem in the receptacle so that receptacle elongates and thus gets production of additional microsporangia towards the base of the receptacle.

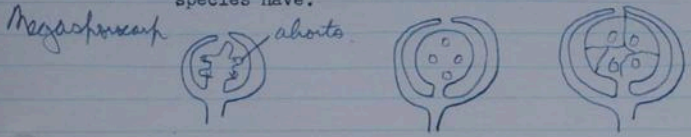


In some species a vestigial, complete and oblique annulus occurs.

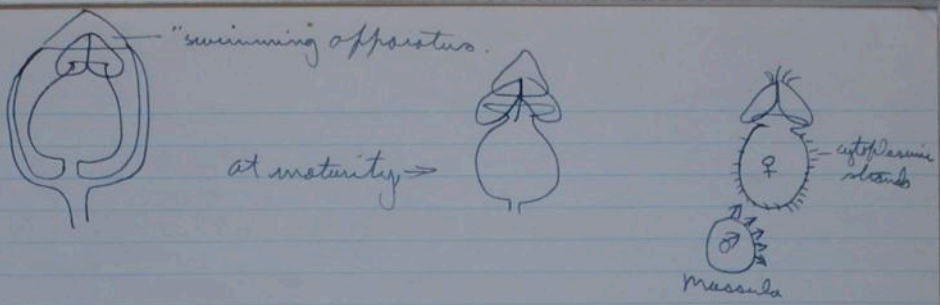
The material inside of the sporangium becomes vacuolated. 4-9 large vacuoles are formed. Periplasmodium formed in the plasmodium (many nuclei). The nuclei which are going to form spores come to lie in the periphery of the vacuoles. This happens in each vacuole. Potential microspores distributed in each vacuole. Threads, etc. formed and general drying up until a single large mass of "massula" is formed, from each vacuolate plasmodium.



The old world species do not have glochidia, only the New World species have.



Four megaspores formed, and 4 vacuoles, 1 basal and 3 on top. Megaspores (1 each) move into vacuoles. Only basal one matures. The 3 other degenerate. The vacuoles form a deeply trilobate cap, which fits on top. Frequently a cushion is also formed on top.



In fertilization, both sporocarps sink to the bottom and fertilization occurs under water. The sporocarp walls dissolve. (Massula gets entangled with megasporocarps). Germination of spores. Microprothallus consists of 4 or 5 cells, just one antheridium.

Megaspores produce a small prothallus and may have 2 archegonia, and have small green cushion.

Relationship of Salviniaceae

1. Sporangia typically leptosporangiate.
2. A gradate sorus (especially the Microsorus).
3. Sorus is marginal.
4. The annulus is oblique and complete.
5. Basal meristem in the receptacle. ~~The~~

These last three relate it to Hymenophyllaceae, which are in themselves modified to moist environments.

For good drawings, see Mart. Icones, Plant. Cryptogam. 1834).

Some other families of Filicales

1. Matoniaceae--related to the Gleicheniaceae.

2. Loxsomaceae--somewhat of Dicksoniaceae relationships.

3. Hymenophyllopsidaceae--related to Cyatheaceae (filmy tree ferns).

4. Plagiogyraceae--related rather distantly to the Osmundaceae.

Fern Allies

Psilotinae
  Psilotaceae
    1. Psilotum
    2. Tmesipteris

Lycopodinae
  Lycopodiaceae
    1. Lycopodium
    2. Phylloglossum
  Selaginelliaceae
    1. Selaginella
  Isoetaceae
    1. Isoetum

Equisetinae
  Equisetaceae
    1. Equesetum.

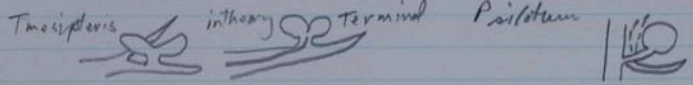
Psilotaceae

Psilotum	1-2 spp.	tropica & subtropics.
Tmesipteris	1 sp.	Tasmania, New Zealand, Eastern and southern Australia, and adjacent Oceania.

Quite a bit of local geographical variation--not enough for specific rank.

Family is characterized by green stem, apparently no leaves, no roots. Plants are strongly mycorrhizic. Sporangia are terminal, lobed and chambered.

Psilotum usually has 3-lobed and 3 chambered sporangia.
Tmesipteris usually has 2-lobed and 2 chambered sporangia.



These are branches rather than leaves. They apparently are reduced branches and in Tmesipteris ~~it~~ less so.

The spores are the same--homosporous. The prothallus looks superficially like that of Ophioglossum and rather elongate cylindrical. Small subterranean and brown. Antheridia and archegonia borne all over prothallia, with no specialized place for either.

Lycopodiaceae (Ref. Walton and Alston.).

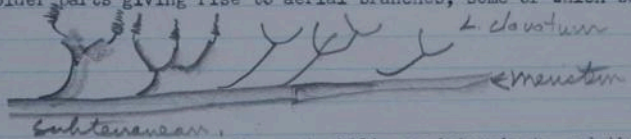
1. Lycopodium	180 spp.	cosmopolitan.
2. Phylloglossum	1 sp.	Australia and New Zealand.

The family has usually a long creeping stem and adventitious roots. The leaves are small and either in spirals or whorls. The sporangia are borne singly at the base of the leaf on the adaxial side of the base. Occasionally truely axilary and rarely on the stem. The spore bearing leaves are aggregated into cones or strobili. The genera are homosporous.

Lycopodium is divided into 6 sections, based upon the various types of strobili and branching of the stem.

Types of growth:

1. Apical growing point, with little short branches near the tip; in older parts giving rise to aerial branches, some of which bear the strobili.

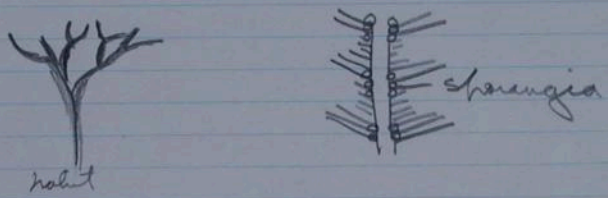


The branches that bear strobili are determinate and the vegetative branches continue their growth. If the subterranean branch were to die, the aerial branches (older) could give rise to new independent plants.

The number of strobili is effected by the age--more in older ones.

2. Branching strictly dichotomous, more or less erect. This type does not bear cones, but has sporophylls same as vegetative leaves. There are alternate sets of vegetative and fertile leaves, a set of long and a set of short in a year.

Sporangia are borne partly in short and partly in long leaves. At the base of each set of short leaves is a sterile region, and at the base of the set of long leaves, there is a fertile region.



Gemmae --are found in a number of spp. of Lycopodium and serve for vegetative reproduction. They fall off and take root. Find best in the fall. Believed to be modified stems.

Spores --contain a lot of oil. Used for flashy photography in the old days.

Gametophyte--two types, both mycorrhizic

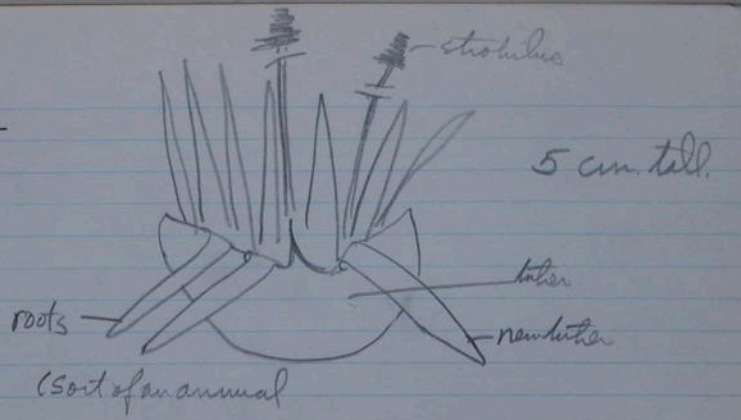
1. Small, about 2-3 mm. long. The germination of spores is rapid. The prothallus is short-lived, above the surface, epiphytic, green.

2. Larger, up to 2 cm. long ($\frac{1}{2}$-2 cm.). The spore germination takes 3-8 years. The prothallus takes from 6 -15 years to mature. Long-lived after fertilization. These types are subterranean, not green.

All north American spp. are of type 2. Most tropical spp. are of the first type.

The gametophytes are irregular in structure, more or less conduplicated. The antheridia and archegonia are borne on the crown toward the top. The archegonia are sunken.

Phylloglossum



Plant has a short strobilus, similar to Lycopodium, but shorter and ovoid. At the end of growing season, new tuber grow larger and the old tuber dies down. The new tuber again sends out leaves, strobili, and roots and a new tuber. Each tuber lasts only a year.

SELAGINELLACEAE

1 genus, Selaginella, with 700 spp, mostly tropical. To a lesser degree represents a tendency found in Hymenophyllaceae. The species are mesophytic. There are some, however, which are extreme xerophytes.

The leaves are in 4 ranks. They are borne on a usually creeping stem. Sometimes the stem is short and erect, and variations of different types of branching. Most commonly creeping with branches rather erect.

The plants have adventitious bodies--usually called rhizophores, and some call them roots. Anatomy of roots.

The sporangia are borne in the sporophyll's axil. It is heterosporous, with either micro- or megasporangia.

The megasporangia bear 4 megaspores and sometimes more or fewer.

Spores have definite markings. The markings in mega- and microspores are different.

Mega and microsporangia are borne either on same or different strobili--many different relationships.

Prothallus is very small, a half or 1/3 remaining within the spore.

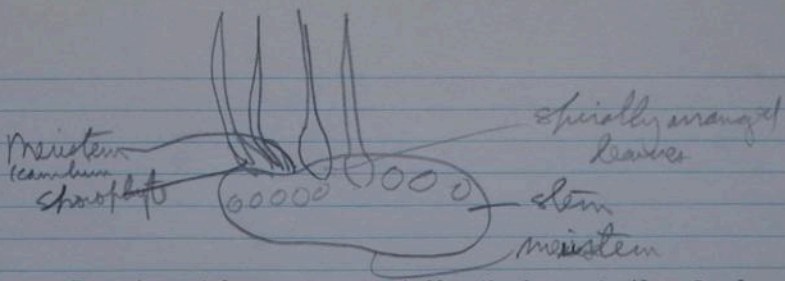
If the mega- and microspores are close together, dew or rain at night can effect fertilization, then the young sporophyte grows on the gametophyte. Sometimes the spores are not shed. Prothalli may develop on the plant. Fertilization may take place in the leaf axis. This sort of gives a seed habit. But this has no special significance.

Isoetaceae

1 genus--Isoetes, with 65 spp. of cosmopolitan distrib. mostly in N. Am. & Eur. Frequently aquatic. some amphibious and semi-terrestrial.

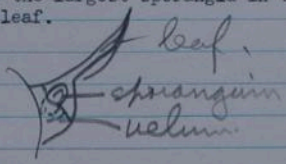
Genus has longest leaves of any of the fern-allies. Long, awl-shaped leaves.

Bi-lobed or tri-lobed "corm" . The upper part is stem, and on the stem are leaf bases, arranged in a close spiral. The depressed center is the meristem. There is a cambium. The side-lobes grow more than the center, and meristem usually sunken.



The outermost leaves are sporophylls, the inner sterile. Basal part of "corm" is called the rhizomorph and it bears roots. The meristem is also sunken.

The sporangia are produced on the adaxial side of the leaves. They are said to be the largest sporangia in the plant kingdom. Only one sporangium per leaf.



On the inner side of the basal portion of the leaf is the "vellum", a thin membrane, indefinite as to its extent.

Being heterosporous, either mega- or microsporangia. Usually outer sporophylls bear mega- and the inner ones microsporangia. In some cases the plants are dioecious.

The megasporangium produces 50-300 megaspores.

Microsporangium produces 200,000 to 1,000,000 microspores.

The two sporangia are about the same size. The spores are usually ~~mxkx~~ marked, and the markings are characteristic.

The spores are said to germinate in the spring, shortly after they have been shed. The microprothallus consists of a single antheridium and has few cells contained in in the ~~microsperang-~~. Megaprothallus is considerably larger, flattened and with several archegonia. The 2 kinds must be very close together before fertilization can occur.

No vegetative propagation is known--very rare exception. Mostly by spore-reproduction.

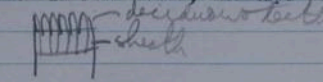
The plants are perennials and quite long-lived.

EQUISITACEAE

Equisetum, 25 spp. mostly in N. temp. regions.

Underground stem, variously branched, gives rise to green aerial stem which is photosynthetic. The stem is jointed, redged and hollow.

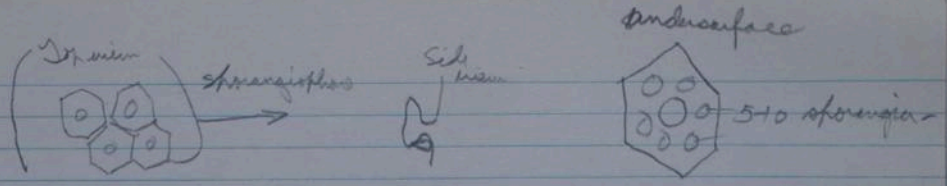
The leaves are greatly reduced and appear as teeth, which are borne in a whorl around the stem. The bases are fused and thips frequently are free. In some cases, the tips are deciduous.



If the stem branches, the branches a re also in whorls.

The stems are most notable for silica deposits.

The sporangia are borne in cones. The cones are terminal. Sometimes the branches might have terminal cones.



Equisetum is homosporous. The spores are all of one kind and contain chlorophyll, and probably due to this the spores are viable for very long time (2-3 days). The germinate very readily.

Each spore has 4 elaters, hygroscopic (Dig out dried spores, breath on the while examinging under mike.

The prothallus is a very irregularly lobed structure. The antheridia and archegonia are borne at the base (sunken).

Phyllogeny

Each family is mostly an end-line in evolution. The plants are extremely distinct.

There are abundent fossils of the types. The fossils do not connect any of these lines.

Selaginella with 700 spp. is a more or less successful in the tropics. Others are bearly getting by.

Bty 451 — 1st Lect. 9/24/48

Pterydophyta

Psilotinae - Alt. leaves, very small, or none, sporangia terminal. — Psilopsida

Lycopodinae - Alt. leaves, sporangia in strobili — Lycopsida

Equisetinae - Whorled leaves, sporangia in strobili — Sphenopsida

Filicinae - new classification places these in Spermatophyta rather than Pteridophyta, largely because of vegetative characters. No leaf gap, leaves small, in 1st 3 (Psilota, Lycops + Equis) but in Filicinae, large leaves and leaf gap. These characters not constant - many Filicae have protostele + no leaf gaps.

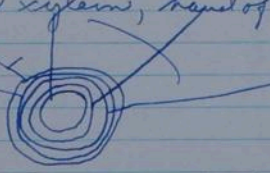
General classification

Old Classification		New Classification
Gametophyte dominant; Sporophyte parasitic (partially): Thallus; No archegonia	Thallophyta	Thallophyta
T. or stem + leaf + Archegonia	Bryophyta	Brophyta
	Hepaticae - Prostrate, dorsiventral symmetry, Capsule splits longit.	Hepaticae
	Musci - Radial symmetry, erect, capsule with lid	Musci
Gametophyte independent; Sporophyte ... ; Vascular tissue; root, stem + leaf; Spores	Pteridophyta	Tracheophyta
	Psilotinae (see above)	Small leaves; no leaf gap
	Lycopodinae	
	Equisetinae	
	Filicinae - alt. leaves, sporangia single or in sori (NEW SYS. →)	Pteropsida: Filicae (large leaves + leaf gap)
Sporophyte independent; Gametophyte parasitic; Seeds	Spermatophyta	
Naked	Gymnospermae	
	Cycadales - Pinnate leaves, swimming sperm	Cycadae
	Coniferales - Scale or needle leaves, non-motile sperm	Coniferae
Enclosed	Angiospermae -	
	Monocots	
	Dicots	

Tracheophyta: Vascular tissue, root, stem + leaves

2nd Lect. - Bty 451 - 9/25/48

General Morphology of Filicinae - Polypodiaceae in particular.
Cyrtomium - basket fern habit - stem erect, hidden by adventitious roots - all roots except primordium of primary root are adventitious.
Stems nearly always a rhizome - underground + creeping.
Roots - anatomy - solid xylem, band of phloem, pericycle, endodermis, cortex.



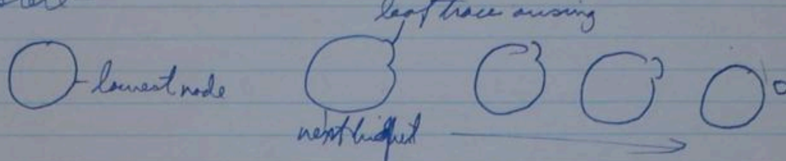
Botrychium - short, erect underground stem - fleshy roots.

In tree ferns - stem is covered with remains of leaf bases, in the axils of which are adventitious roots, making up largest portion of bulk.

Angiopteris - one of largest tree ferns -
Stem - consists of leaf bases, an outside.
3 Primary types of stele.
1. Protostele - simplest. solid core of xylem. no leaf gap. esp. in rhizomes of slender, creeping - mostly all Hymenophyllaceae.
2. Siphonostele - next in order of complication - has pith in center, otherwise same as protostele. Origin of pith uncertain - possibly from xylem cells, or pith has come in from cortex thru leaf gaps. In Osmunda evid. that pith is stelar in origin (an injury will cause production of tracheids in the pith)
Outside of pith, a repetition of endodermis.
Ectophloic - single band of phloem on outside.
Amphiphloic - inner + outer band of phloem (one on each side of xylem.
Siphonostele has leaf gap - sometimes endodermis covers gap.
3. Dictyostele - a siphonstele with overlapping leaf gaps. - in a x-sec at least 2 leaf gaps.
gap. Dictyostele has several strands of vascular tissue.
Monostele - a single group of the siphonostele - Each monostele is constructed in same way

These three steles arranged in order of evolution.

Leaf traces — arise several nodes below actual departure from stele—



Polycycly — several concentric steles. found particularly in the large tree ferns.

Growing stem covered by scales or hairs-

Leaves-

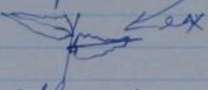
Young leaves are typically circinate (coiled in bud.
In growth merely unroll.

<u>Parts</u> — Whole leaf is frond.

Stipe = petiole
Blade — starts where lowest pinna is inserted.
Rachis — main axis of blade — a continuation of stipe.
Pinna~~x~~ — primary divisions of blade.
Pinnule — 2nd ary "
Pinnula — ~~tertiary~~

Degree of division — blade may be <u>simple</u> (undivided)
" <u>deeply lobed</u> <u>pinnatifid</u>
" <u>once divided</u> <u>pinnate</u>
" twice " <u>bipinnate</u>
"

If frond not quite twice pinnate — pinnate pinnatifid



Veins — most frequently <u>open</u> — not joined
or may be <u>areolate</u> — veins joined in one way or another.

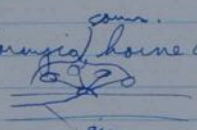
Appendages to leaves — <u>scales</u> or <u>hairs</u>. usually remaining on stipe ~~[illegible]~~ or rachis — glands — often found, are related to hairs (may be a multicellular hair with a round tip.  tip, or may consist of only round cell and base — or no more than round cell.

~~Glands may be~~

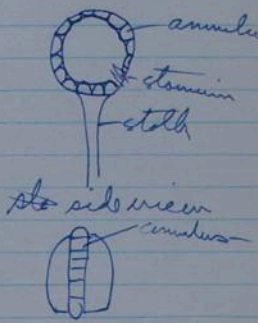
Sporophylls - spore bearing leaves.
Many modifications - Sterile + fertile alike, to where sterile + fertile fronds entirely different.

Morphology + life cycle -

1. Sporophyll - bears sporangia, borne commonly in sori



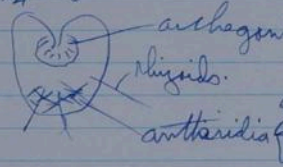
indusium - cover of sorus.
Sporangium -
Stalk
Head or sporangium proper.
Annulus - ring of bordered cells
Stomium - lip cells.

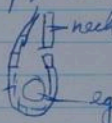


Not all ferns have sori or indusia.

Common no. of spores per sporangium = 48, 96.
Some sphaerosporum may contain 15,000 spores.

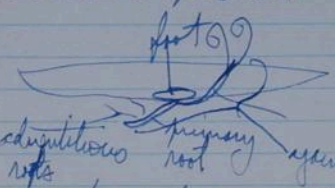
2. Spore germinates, producing the prothallus (gametophyte)
1/4" - 1/2"



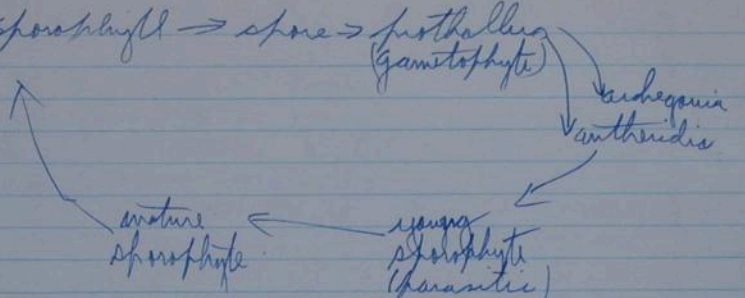


Sperm swim to archegonium, + young sporophyte produced in place. Only 1 sperm fertilizes 1 egg, and only 1 sporophyte per prothallus is produced.

X-sec of prothallus



Young sporophyte parasitic for short time on prothallus



Most prothallia are heart-shaped but some are quite filamentous in nature - others which are fleshy, cylindrical and subterranean.

Lab.- Draw longitudinal sec & x-sec of rhizome of Equisetum

3rd Lect. Oct. 6, 1916 - Bty 451

Characters of sporangia of Filicinae.
1. First classification according to sporangia types.
2. Families
   - Ophioglossaceae
   - Marattiaceae
   - Osmundaceae
   - Schizaeaceae
   - Marsiliaceae
   - Gleicheniaceae
   - Hymenophyllaceae
   - Dicksoniaceae
   - Cytheaceae
3. Characters of Ophioglossaceae
   1. Frond dimorphic into sterile & fertile parts (separate.
   2. Sporangia borne naked in a spike or panicle - massive, sessile, w/o annulus, large.
   3. World-wide distribution, occurring in boreal regions i.e., Iceland
4. Marattiaceae
   1. Sporangia in sori on under surface of pinnule.
   2. Sporangia large, massive, sessile, w/o annulus, except Genus Angiopteris, w/ rudimentary annulus.
   3. Tropical, both hemispheres.

5. Osmundaceae.
1. Some or all of the pinnae of the blade completely fertile - no separate part of blade fertile.
2. Sporangia borne naked - no sori; large, short-stalked, have rudimentary annulus.
3. World-wide, included in Tyg boreal regions.

6. Schizaeaceae
1. Fertile pinnae much reduced, (except in Mohria, in which sporangia borne on under surf. of blade).
2. Sporangia long, annulus, no sori, sporangia have stomium
3. Tropical, w/ very few temperate sp.
Anemia is typical.
Lygodium - occurs to New England.

7. Marsileaceae
1. Heterosporous
2. Sporocarp borne in axils of leaves - contains sori inside. The single sorus contains micro+ mega sporangia.
3. Sporocarp is modified leaf.
4. Aquatic or semi-aquatic. World-wide, mostly Australian.

8. Gleicheniaceae
1. Generally climbing ferns.
2. Sporangia in sori on under blade.
3. Sacks indusium, has complete transverse annulus.
4. Leaf has indeterminate growth.
5. Leaf division unique. After each division, apical growth ceases, and is taken up by new pinnae from side-buds.
6. Tropical + in in southern hemisphere extra-tropical.
6. Not a simple dichotomy

9. Hymenophyllaceae - filmy ferns.
1. Blade one cell thick in many members.
2. Sporangia in sori terminal on veins ends. Indusium present bell-shaped or two-valved. Receptacle long + cylindrical.
3. Family tropical w/ a few temp. representatives - in very humid

10. Dicksoniaceae - tree ferns.
1. Sori terminal on vein ends. Indusium 2-valved or cup-shaped. Receptacle rather short.
2. V. similar to Hymenophyllaceae.
3. Tropical + extra-tropical in southern hemisphere, same as Gleichneaceae.

11. Cyatheaceae tree ferns
1. Sori under blade - indusium none, or a cup-shaped or at base,
2. Sporangia have complete oblique* annulus + stomium.

*Oblique = slanting, or off-center

Incomplete annulus - one interrupted by stalk of sporangium.
3. Have a stomium present.
4. Tropical mountains.

12. Polypodiaceae.
1. Sporangia w/o or w/ sorus
2. Very diverse.
3. Sporangium has incomplete annulus and a stomium.
4. Annulus primarily vertical.
5. World-wide - well developed in boreal + artic regions.

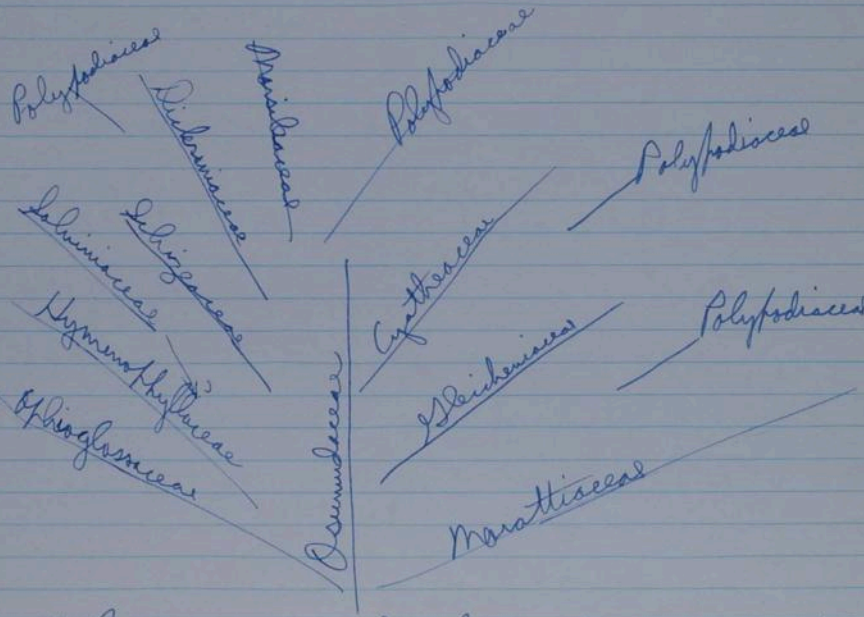
13. Salviniaceae
1. Heterosporous
2. Aquatic, extreme - floating.
3. In Salvinia no roots present.
4. Sporocarps present.
5. Sori in sporocarps of either mega or micro sporangia w/ 1 megaspore and several microspores formed.
6. World-wide, some in boreal regions.
7. Vegetative budding common

Phylogeny -
Primitive families
Ophioglossaceae - have massive sporangia, no annulus no stomium
Marattiaceae
Intermediate families
Osmundaceae } sporangia smaller, more highly org. than above,
Schizaeaceae } no sorus, sporangia marginal

Advanced families.
Gleicheniaceae – have sori, annulus complete
Hymenophyllaceae –
Dicksoniaceae
Cyatheaceae

Polypodiaceae – incomplete annulus.
Highest evolution.
Salviniaceae } heterosporous
Marsiliaceae }

F. O. Bower – The Ferns – 3 vols. for phylogeny



The Polypods not natural, but represent ends of phyletic lines.

451 Lab- 9/28/48

Sketch & label the following-

1. Long. sec Cystopteris rhizome showing: roots leaf buds, leaf bases, meristema.
2. Frond of Cystopteris showing: stipe, blade, rachis, pinna.
3. Part of a pinna showing: sorus sporangia, indusium, venation, relation of sorus to vein.
4. Cut x-sections of the rhizome & draw the stele semi-diagrammatically leaf-gap, leaf trace, cortex, meristel, pith.
5. Examine, if necessary, material of prothallus & young sporophyte.

10/6/48

1. Sketch sorus or grp of sporangia and indusium if present.
2. Sketch a single sporangium w/ details of annulus, stalk, stomium of the following families-
   1. Ophioglossaceae
   2. Marattiaceae
   3. Osmundaceae
   4. Schizaeaceae
   5. Gleicheniaceae
   6. Hymenophyllaceae
   7. Dicksoniaceae
   8. Polypodiaceae (sporangium only)

10/13/48-

1. Sketch sorus or groups of sporangia and relation to veins:
   1. Marattia
   2. Todea
2. Sketch habit of sporophylls in 3 spp. of Osmunda.
3. Observe superficial marginal sporangia in ".
4. Sketch a segment & ~~sporophyll~~ sporangia in
   1. Lygodium
   2. Schizaea

10/8/48 - 3rd Sect. Bty 451.

Filicinae

Eusporangiatae - sporangium developed on axises from several cells. The wall of sporangium is several cells thick.

Ophioglossales
Ophioglossaceae
Marattiales
Marattiaceae

Leptosporangiales - sporangium develops from a single cell. Wall 1 cell thick.

Filicales
Osmundaceae.

Details of Ophioglossaceae - 3 genera - monograph by R. T. Clausen. Mem. of Torrey Bot. Club. 19, 1938

1. Helminthostachys - 1 sp.
2. Botrychium - 23 spp.
3. Ophioglossum - 27 spp.

Characters of sporangia -.
Fertile spike inserted on leaf.
Leafe - stipules present
Stem - upright except in Helminostachys, which has rhizome.
Roots - fleshy
Sporangia - large and large spore output 1-15,000 spores.
Gametophyte - fleshy, subterranean, irregularly cylindrical. antheridia + archegonia sunken in prothallus. Prothallus strongly mycorhizae.

Family is most primitive of ferns - morphological features of Helminthostachys, esp. of stipe, is related to Devonian fern Zygopteridae, genus Stenopteris.
Primitive group w/o further advancement - no derived types.
Phylogeny within family: Helminostachys most primitive, since has analogs in fossil ferns, but no relation between 3 genera.
In Helminthostachys + Botrychium, have open venation, a primitive character, while Ophioglossum has areolate venation (or reticulate)

Helminthostachys + Botrychium - siphonostels
Ophioglossum has dictyostels.

Spike, large sporangia + large spore output thought to be derived from mycorrhizic habit. Almost all saprophytic parasitic.

Dimorphic form of Ophioglossum Bergianum Schlecht very rare form from S Africa

Marattiaceae -

Angiopteris	61	spp.	} Separate sporangia - primitive
Macroglossum	1	sp.	
Archangiopteris	1		} fused sporangia - advanced
Marattia	28		
Protomarattia	1		
Danaea	26		

Christensenia = Kaulfussia 26 - - soral groups subdivided. highest advanced.

Characters
1. Massive root stock, erect or creeping
2. Stipules present - primitive character.
3. Pinnae jointed to rachis.
4. Spore output 1500 - 8000 per sporangium -
5. Mucilage canals + tannin cells present.
6. Prothallus green + flat, mycorrhizic

Phylogeny
- Present members are survivors of ancient stock, with no derivatives - only the end-line of evolution.
Fossils from late paleozoic.
Danaeopsis - from Rhaetic
Ptychocarpus - upper coal measures.

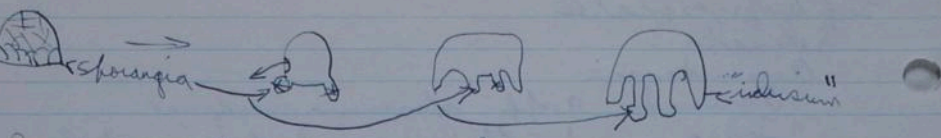
Leptosporangiatae
Filicales
Osmundaceae
Osmunda 9 spp. - sporangia marginal
Todea 1 - thick leaves - } sporangia superficial (under
Leptopteris 7 spp. - filmy } surface of blade)

3 sp. of Osmunda in US
1. cinnamomea - dimorphic - fertile & sterile fronds separate.
2. regalis - fertile pinnae at tip, sterile below
3. claytonia - fertile pinnae inserted between sterile pinnae.

Characters
1. Massive erect rhizomes.
2. Stipules present at base of leaf
3. In Osmunda, mucilage canals.
4. 128 - 512 is spore output per sporangium
5. Prothallus green, cordate, fleshy, long-lived.

Phylogeny - rather intermediate between Eusporangiatae & Leptosporangiatae of root
1. Apical meristem has 1-4 initials (several in Ophioglossace)
2. Undivided leaf trace (primitive)
3. Annulus is rudimentary (intermediate)
4. spore output intermediate
5. Indicates transition between marginal & superficial sporangia.
6. No living derivatives of family
7. Fossil representatives
Zalesskia - upper Permian

Oct. 13, 1946 - 4th Lect.
Schizaeaceae - charact. of sporangium - distal & complete annulus, opening by a longitudinal slit. holds family together.
Lygodium 40 spp. Pantropic
Schizaea 30 - Tropical & temperate in S. hemis.
Anemia 90 " Am., Africa & Madagascar
1 sp. in India
Mohria 3 South African
Sporangia marginal in origin but became superficial (ever)

pr. 

Prothallia commonly heart shaped, green except Schizaea, w/ a filamentous prothallium.

1. Lygodium - climbing fern - long & creeping rhizome, leaves have unlimited growth.
   Sk. palmatum is native.
2. Schizaea - upright exotrophic, fronds erect, simple or dichotomous. Sporangia borne in compact distal pinnae.
3. Anemia - short, creeping rhizome, frond pinnately lobed pinnae long stalked and completely fertile.

1, 2, 3 have hairs, no scales
4. ~~Molinia~~ has ~~no~~ scales as well as hairs. fertile & Mohria sterile segments practically alike.

Characters:
1. Lygodium has protostele
2. Schizaea has modified protostele (adult more advanced)
3. Anemia has siphonostele and a few dictyosteles
4. Mohria has all dictyosteles.

Lygodium 256 spore out. part large sporangium, poorly developed annulus
Other 3 genera have 128 spore out-put

Lygodium has elaborate leaves - most highly advanced leaves, with areolate venation.
Leaf of Schizaea is very primitive - dichotomous type
Scales of Mohria rank as devices - 1st time seen in any family.

Fossil types of Schizaeaceae:
Sentfestbergia - upper carboniferous doubtful affinity more like Osmundaceae.
Klukia Jurassic - certainly is member of family
Sentfestbergia - doubtful affinity - Linear relations.

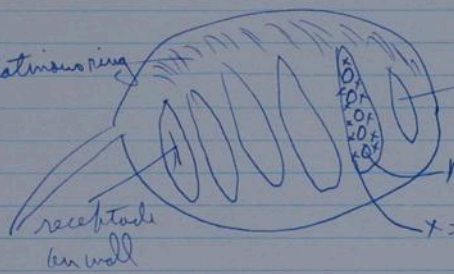
10/15/48 - Bly 451

Marsiliaceae - semi aquatic, in H₂O or mud - frequent in vernal pools, which dry up in summer.
Rhizome long-creeping + hair.
Stem has siphonostele.
Fronds from simple, 2-pinnae to + pinnae.
Marsilea 70 sp. - 4 leaf clover type of leaf - (2 pairs of opposite pinnae). Worldwide, esp in Australia + S. Africa

Regnellidium 1 sp. — Recently (1950) discovered — 3 locations in S. Brazil.

Pilularia 6 sp. - mid. distrib. - Europe, N + S Amer + Australia

Family is heterosporous - sporangia borne in sporocarps.



Dorsal suture acts as hinge, the two sides spreading apart. The gelatinous ring acts as a mechanism (by swelling up) to extrude the coil from sporocarp. On exposure, indusium breaks, permitting exposure of spores.

In microsporangium, 64 spores - 1 sporium megaspores.
Each of above produces microprothallus + megaprothallus.
On each microprothallium, 2 antheridia -
" " megaprothallium, 1 archegonium

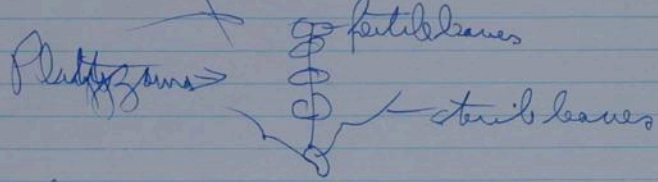
Phyllogeny of Marsileaceae

1. Sporocarp is a pinna, by position + details of origin + nature of vascular tissues.
2. Affinity with Schizaeaceous family - determined by Campbell, D.H.
   "Mosses & Ferns", Ed. 3, 1918
3. The 3 genera distantly related.
   In leaf architecture Marsilia is primitive, indicated especially when 6 pinnae are produced.
   Venation of leaflets indicates arrangement.
4. In soral characters, Pilularia seems oldest.

Gleicheniaceae -

Gleichenia — 130 spp. Pantropic + austral
Stromatopteris - 1 New Caledonia
Platyzoma - 1 Queensland

Family has creeping, scaly rhizomes.
Leaves have continued apical growth, pinnate in plan. By reason of arrested terminal bud, branching seems dichotomous.
Sori superficial.
Prothallus green + flat.
Gleichenias disting. by very large leaves + typically arrested buds. Other 2 genera no such branching.
Stromatopteris - dimorphic leaves.



Spore out put

Gleichenia - 256 to 512 - 1024.
Stromatopteris - 256 or 512
Platyzoma - incipient heterospory - in some sporangia small spores, 24 - 32 spores - others large spores 16 - 24.
dimorphic

Fossil record of Gleicheniaceae
Oligocarpia - doubtful - upper Carboniferous -
Others from Mesozoic - leaves with sporangia attached.
Stromatopteris is specialized xerophytes -
Genus Gleichenia subdivided sometimes into closely related

Families up to here are Bower's Simplices - including all Eusporangiate ferns, plus primitive Leptosporangiate ferns.
Sporangia of a sorus all mature at same time is character holding together this class.
Sporangia + spore output relatively large.
(Marsileaceae are exception, but usually 512 or above is normal).
Later families disting. by having sporangia maturing at diff. times, small spores + spore output.

~~Segment~~.

Hymenophyllaceae - 600 sp. tropical + austral.
"Trichomanes" } large + diverse type.
"Hymenophyllum" }
Copeland Monograph of Genera in Philippine Journ. of Sci. 67, 1938.
33 genera recognized.

Trichomanes - indusium tubular, + receptacle exserted -
Hymenophyllum indusium 2 lipped receptacle hardly or not at all exserted
Fam. charac. - marginal sori. indusium. Receptacle is continuation of vein end. Leaves 1-celled thick. No stomata.
Prothallus variable but generally filamentous or flat + ribbonlike.
Spore out put in Hymenophyllum - 128-512
Trichomanes - 32-64
In relation to spore out put Bower thinks the spore production at different times is advanced over simultaneous " .

	sporangia per sorus	spores per sporangium	total spores per sorus
H. tunbridgense	20	420	8000
T. reniforme	40	256	10,000
A. dilatatum	90	128	11,800
T. radicans	140	64	9,000

Some filmy ferns extreme epiphyte—
" have no xylem in roots.
1 sp. has no roots — has rhizoids — whole plant 4-5 mm tall.

No undisputed fossils in this group.
Marginal sori + degenerate steles relate this family to some of the Simplices.

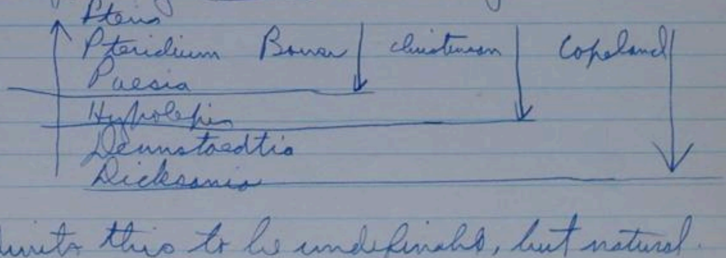
Oct. 20, 1948 –

Dicksoniaceae

Thyrsopteris	1 sp	Juan Fernandez
Dicksonia	17 spp	S. hemisphere
Cibotium	13 spp	E. Asia, Hawaii, Cent. Am.
Culcita (Culcita)	9	Tropical + sub-tropical
Dennstaedtia	70	Tropical. 1 sp N.A.

Characters — mostly tree ferns. Hairs, but no scales. Sori marginal, terminal on vein end. Indusium + cup-shaped or two-lipped. Sorus gradate (develop indefinite succession from inside out.) Spore out put 48-64.
Bower adds Hypolepis to family.
Christensen places Dennstaedtia + Hypolepis in Polypodiaceae.
Copland makes a family Pteridaceae including

This represents a good phylogenetic sequence—



Copeland admits this to be undefinable, but natural.

Lab - 10/15/96

Dissect a sporocarp of Marsilea

identify: gelatinous ring
sorus
indusium
micro + mega sporangia
Venation in sporocarp wall

Sketch a micro + mega sporangium

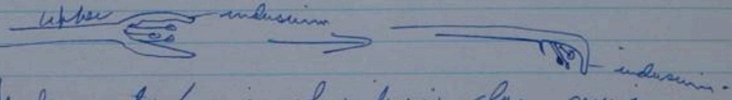
Sketch cellular detail of 3 sp. of Hymenophyllum.
(from an ultimate division)

10/20

Draw a sorus + indusium + relation to veins
Dennstaedtia
Hemitelia
Alsophila -

10/22 - examine material - for soral development + try to make a phyletic relationship.

Dicksoniaceae - mostly several times pinnate leaves.
Several evolutionary tendency
1. Tree ⟹ creeping habits
2. Oblique to vertical annulus in Dennstaedtia
3. Sorus gradate → mixed sporangia " "
4. General tendency of indusium tends to become modified so that lower part becomes smaller, + upper part becomes larger + more a part of margin.



5. Tendency to fusion of indusia along margin, giving effect of simple marginal indusium.

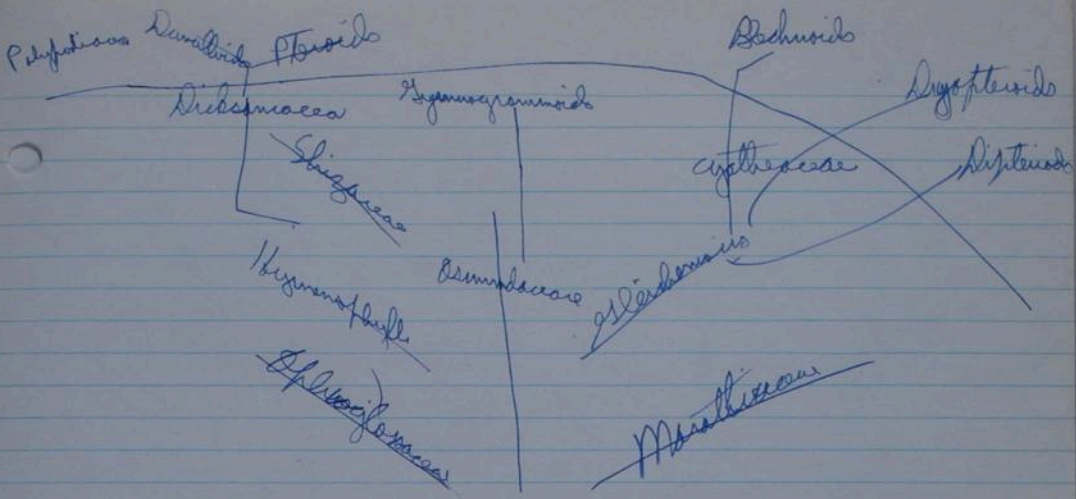
Dicksoniaceae def. gives rises to Polypodiaceae, esp. Pteris.

Cyatheaceae

Lophosoria	1	- Mex + S America	Hairs; siphonostele; simple sorus; short stem
Metaxya	1	- Brit Honduras - Brazil.	
Alsophila	300	Tropics + S. Hemisphere	Scales, dictyostele, gradate sorus, tall stem
Hemitelia	100	" " " "	
Cyathea	300	" " " "	

Genera not too well defined -
Two monotypic genera
The large n.d. families have large nos. of endemics.
Mostly tree ferns w/ leaves several times compd.
Sori superficial, round, + either w/ infer. cup-shaped indusium or lacking
Prothallus long-lived. bristles + scales.
Spore output - 64 per sporangium.

Tendencies in Phylogeny -
1. Primitive hairs ⟹ scales
2. Sorus simple, not grade
3. Siphonostele ⟹ dictyostele.
The characters relate back to Gleicheniaceae.
An indusium is developed by



10/22/46 - 451

Copeland's "Genera Filicum" breaks the Polypodiaceae into several families

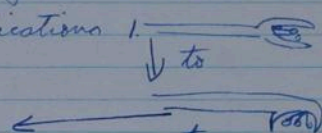
The Pteroid line of Polypodiaceae -

Now 3 -

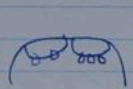
Table - detail of Pteroids & sketch of whole Polypodiaceae

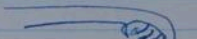
1. Character of family -
2. Phyletic position of group
3. Characters placing family in its relative position.
4. General group or type from which the family came.
5. Derivatives - to be mentioned by name only.

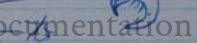
Dennstaedtia - indusium modifications 1.



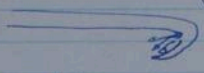
Hypolepis



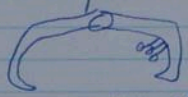




to Pteris - final condition - inner indusium completely lost + sporangia covered by outer (marginal) indusium



Further development in Acrostichum praestantissimum receptacle spreads over quite an area

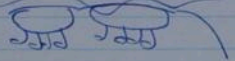


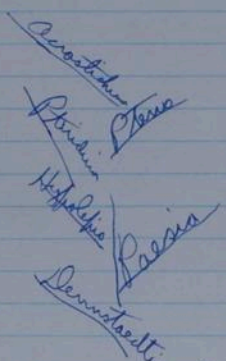
Final condition - entire under surface of blade bears sporangia - this in Acrostichum aureum.

666

c) In Pteris, segments with a continuous marginal indusium

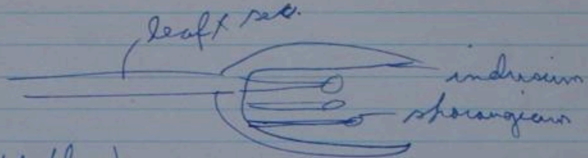
Tendency of sori to become fused - Hypolepis is an intermediate in this condition.





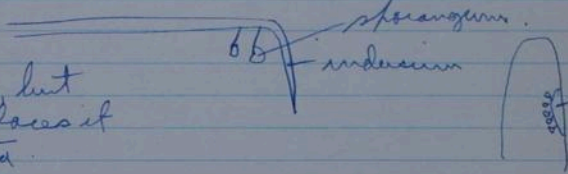
General tendency is loss of indusium in evolutionary line -

Dicksoniaceae
Dennstaedtia



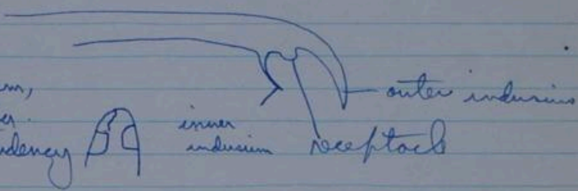
has upper & lower indusium
(V. similar to Hymenophyllum)

Hypolepis



Has lost inner indusium, but vegetative characters places it close to Dennstaedtia.

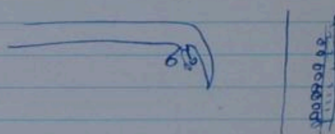
Paesia —



but because of inner indusium, is close to Dennstaedtia. There are sori, but with a tendency toward lateral fusion

Pteridium
next in sequence, has inner indusium, but less well developed than Paesia. Continuous marginal sporangia, not separated into separate sori

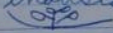
Pteris the marginal indusium is continuous — also, no sori, but continuous sporangia.



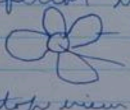
Acrostichum — has no sorus, no indusium, but sporangia thickly covering abaxial surface of pinnae. Also has areolate venation to show advanced character.

Oct 27 - Bty 451.

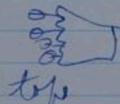
Dryopteroids
Primitive forms start with Cyatheaceae, esp. Hemitelia (extended receptacle, w/ 1 or more indusial scales attached at base.

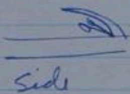


Starting out with inferior indusium -
Most primitive of Polypodiaceae is
Woodsia - inferior indusium, double

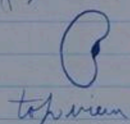


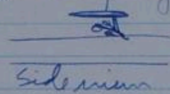
From this a transition to Cystopteris Indusium single, attached at base





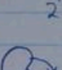
To Dryopteris - reniform indusium developed by lateral spread of Cystopteris type indusium.

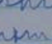




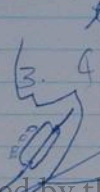
From Dryopteris type, 3 tendencies
1. Loss of indusium, with transitions.

Polybotrya - has no sori - sporangia all over under surface of pinnae - similar to the Acrostichum
2. Goes to Polystichum + Tectaria, with a further development of indusium laterally, until completely united - mushroom, or peltate) shape, attached in center - from a continued lateral growth of reniform type

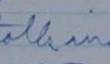




3. Indusium + stalk increasing along the vein



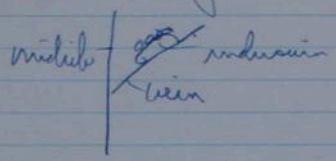
Xsec -

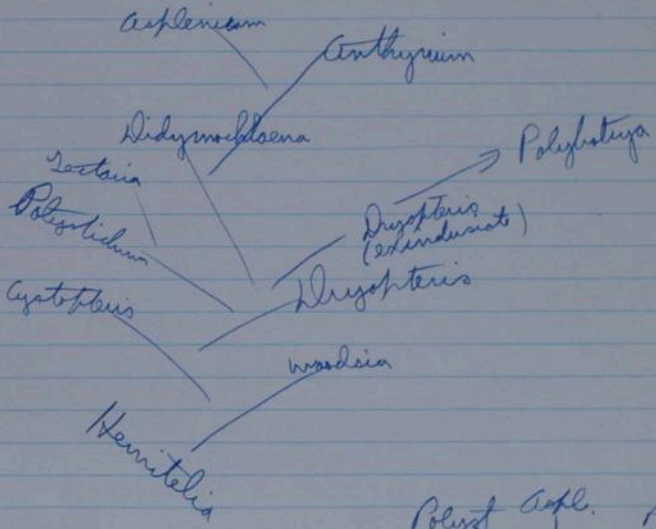


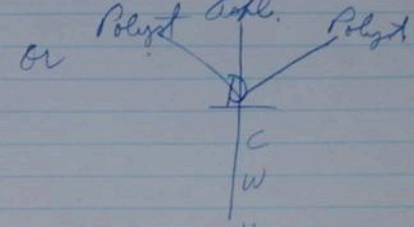
in Didymochlaena

in Athyrium, start of a line of reduction outer ½ of indusium lost

Final form in Asplenium, with ½ completed last, and ½ toward midrib the only part remaining.

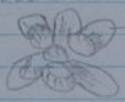






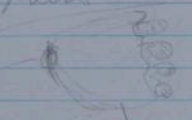
Evolution in this group is change in indusia and in receptacle - firm inferior thin superior indusium - to a loss of indusium.

Woodsia



dissected inferior indusium
View from top

Cystopteris



one side attached

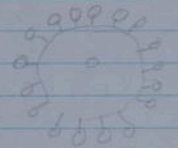
Dryopteris marginalis

Dryopteris hexagonoptera
exindusiate

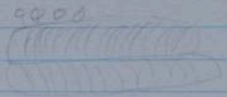
Polystichum munitum

Polybotrya

Peltata



Didymochlaena



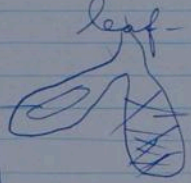
10/29/48 - Bty 451 -

Salviniaceae

Salvinia 10 sp } Small floating aquatics, w/ sporocarps of a
Azolla 6 sp } single sorus, male or female, not both sexes together.
Sporocarp may be actually the indusium, although is more hardened.

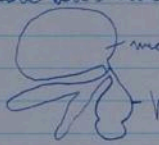
Salvinia - has in whorls of 3, 2 of which are floating, the other greatly dissected & suspended in H2O. This 3rd functions as a root, - called water leaf.
Spores - 1 megaspore per sporangium + 64 microspores per.

Azolla - has roots - leaves divided into 2 lobes.

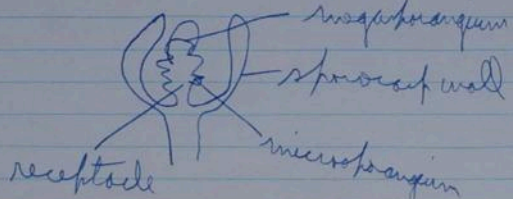


Median with clusters of Anabaena (algae) (under surface of upper lobe

Mega - & microsporocarps borne at base of leaf, looks something like an inverted acorn.

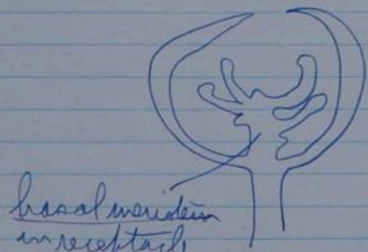


Has most complicated reproductive structure.

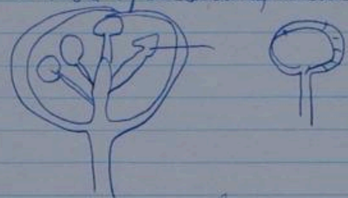


If the megasporangium of Azolla aborts, get development of microsporangium + vice versa.

Development of microsporocarp

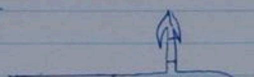


causes production of additional microsporangia

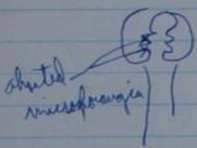


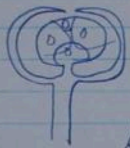
Sporangia when mature are long-stalked with a vestigial annulus (complete)
From 7-100 sporangia developed in sporocarp.

Material inside sporangium becomes vacuolate, 4-9 being formed. ~~Into these~~ In this stage a periplasmodium (multi-nucleate) formed. The nuclei forming spores lie in periphery of each vacuole, with various partitions forming. Dries up, forming a dry vacuum, with microspores borne in massula. Glochidia are barb-shaped structures sticking out of massula.



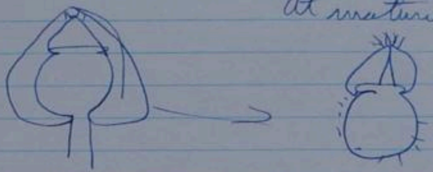
The megasporocarp -





~~Three~~ Four megaspores formed, basal one fully mature.

Degenerated megaspores form a 3-lobed cap for fertile sporangium (called a "swimming apparatus".
At maturity, cap remains,



On fertilization this megaspore sinks to bottom where glochidia latch on to megaspore.
Then germination produces mega- or micro prothallia, with only 1 antheridium - Megaspore gives rise to 2 archegonia.

Relationships of family

1. Sporangium typically leptosporangiate
2. Gradate sorus (as far as microsorus is concerned)
3. Sporangium looks just as it should.
4. Sorus is marginal.
5. Annulus is oblique & complete.
6. Basal meristem in receptacle.

So related to Hymenophyllaceae, highly modified to very humid environment.
See Martius, Icones Plant. Cryptogam - 1834

Sketch of the Polypodiaceae.

The family is such a heterogenous collection that it is hard to give any precise character which applies to most - the following are the only ones which most authors agree upon:

1. The soros is of the mixed type (sporangia maturing at uneven intervals.
2. Sporangia are small, flattened, borne on a slender stalk, contain few spores.
3. Has an elaborate vertical, incomplete annulus, with a definite stomium.
4. In those genera where the prothallus is known, generally is heart-shaped and delicate.
5. Antheridia are small and projecting. They occupy the usual position (mixed in with the Rhizoids on under surface of prothallus), and are composed of 3 cells - 2 ring shaped, one above the other, with a third cell filling the opening of the higher ring-cell.

The typical condition in the family, but hardly sufficiently general to be called a character, is to have chaffy scales rather than hairs. But in all the series, hairs occur. As far as sori are concerned, all forms from marginal, with indusium, to ~~true~~ superficial without indusium occur. The latter is most common (3).

Polypodiaceae has the widest distribution of all the families, being world wide in tropics, temperate and some arctic forms. It is the largest family with various estimates as to number of genera and species, up to 115 genera and 3000 species.

Its vegetative forms are diverse - from small trees to creeping rhizomatous ferns only a few centimeters tall. There are a few annuals in the family, namely Anogramme leptophylla + A. chaerophylla.

In the geological record, no representatives of the Polypodiaceae are found in strata older than the Early Cenozoic (60 million years ago).

The family has evolved from a complex represented by the two families Cyatheaceae and Dicksoniaceae. The subgroups recognized in the family have reached numbers the peak of evolutionary trends, but no one sub-group is more advanced than the others.

The Pteroid group is derived from the Dicksoniaceae, more particularly the Dennstaedtia type.

Starting with the epidermal hairs, marginal sori, upper and lower indusia present, a good evolutionary sequence is found as given in lecture. It is hardly necessary to repeat this.

~~Dryopteris~~ Acrostichum ~~group~~ seems to be the highest in this chain, ~~and~~ no derivatives of this ~~group are mentioned in any text. This does not mean that~~ no further changes are to take place. ~~There is good evidence to show that fern trees are being evolved today.~~ Especially the sp. aureum.

The derivatives of this line are Heterophlebium, Fee, with Pteris grandifolia, and Campteria Presl, exemplified by Pteris biaurita. Others are the genera Litobrochia Presl and Amphiblestria Presl.

The most advanced genus is Acrostichum and in this genus, the species aureum as the most greatly evolved.

Gymnogrammoids - polyphyletic - from Mohria, and from Osmundaceae

11/5/46 - Additional families of Filicinae -

Matoniaceae - related to Gleicheniaceae
Saxsonaceae " " Dicksoniaceae
Hymenophyllopsidaceae " " Cyatheaceae
Plagiogyriaceae " " Osmundaceae (distantly)

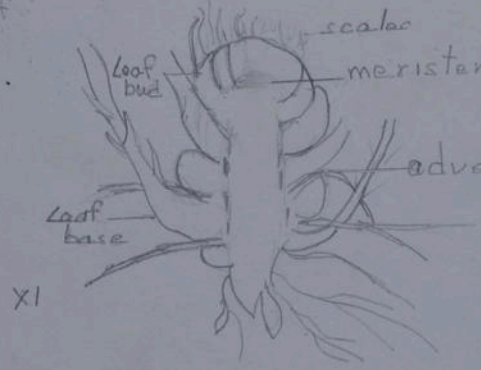
Fern allies -
Psilotinae - Psilotaceae - Psilotum
~~Mesipteris~~ Tmesipteris

Lycopodinae - Lycopodiaceae
Lycopodium
Phylloglossum
Selaginellaceae
Selaginella
Isoetaceae
Isoetes
← Equisetinae
Equisetaceae
Equisetum.

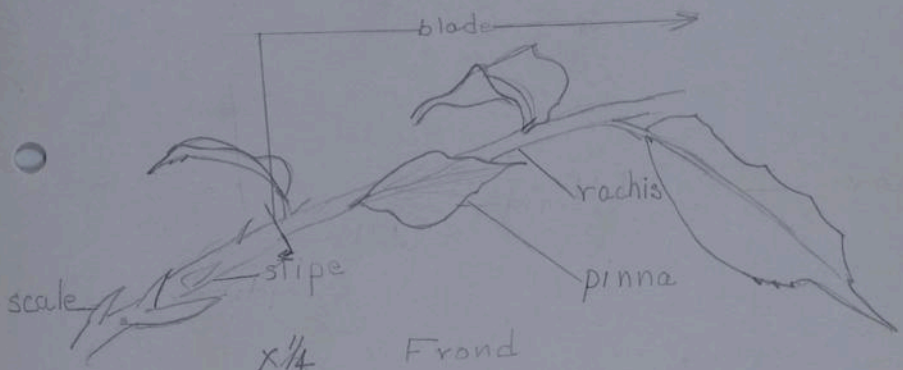
Psilotaceae
Psilotum 1-2 spp. - tropics + subtropics adjacent Oceans.
Tmesipteris ~~Mesipteris~~ 1 sp. - local in Tasmania, N. Zealand, E + S. Australia + I
In both genera, quite a bit of local variation, so species no is uncertain.
Family characters
1. Green stem
2. Apparently no leaves
3. No roots
4. Plants ~~strongly~~ mesophytic
5. Sporangia ~~on~~ terminal + lobed + chambered.
6. Psilotum has 3 chambers + lobes; ~~Mesipteris~~, 2 chambers + lobes.

Rogers
Bty 451
9/29/48

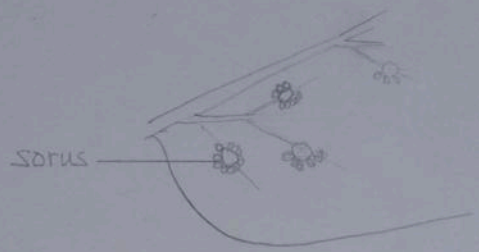
Cyrtomium sp.
Long. Sec. of
Rhizome



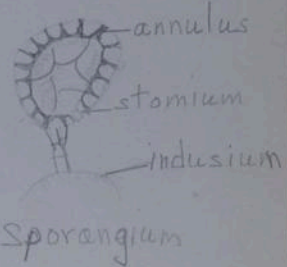
X1



X 1/4 Frond

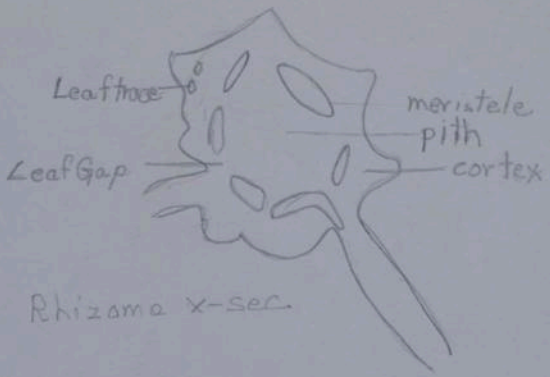


X1 Pinna

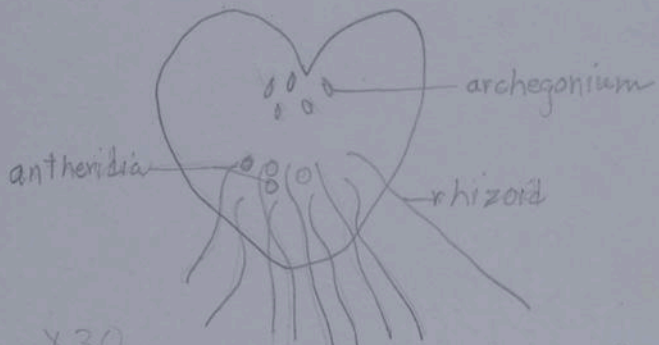


Sporangium

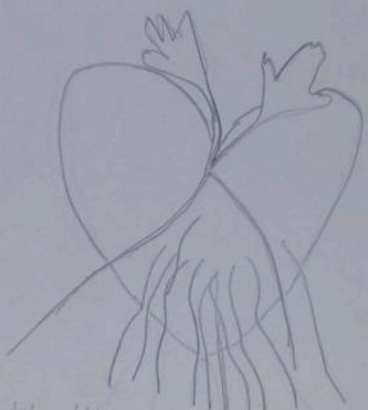
Cyrtomium



x2 Rhizoma x-sec.



x30 Prothallium



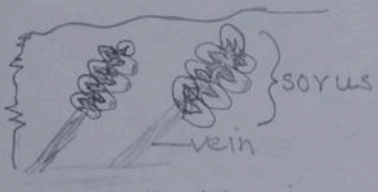
x30 Prothallium, sporophyte attached

Ophioglossaceae
Botrychium sp.

Portion of fertile pinna
x 40

Sporangium
x 60

Marattiaceae
Angiopteris sp.



Portion of fertile pinna
x 30

x 70
Sporangium

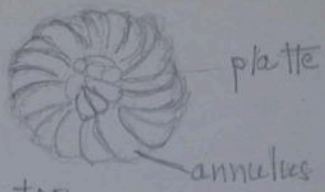
Osmundaceae
Osmunda regalis

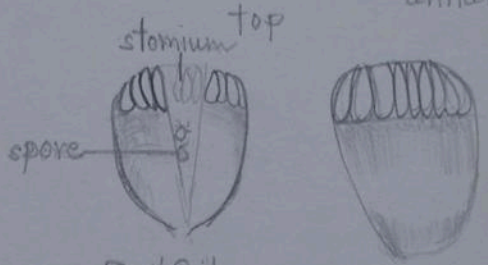
Portion of fertile pinna
x 35

x 70
Sporangium

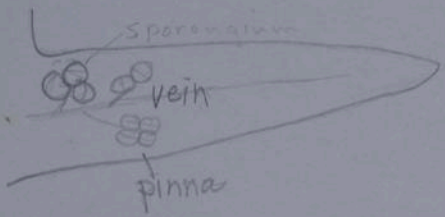
Schizaeaceae.
Anemia sp.

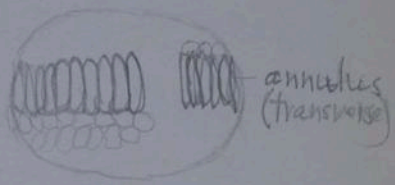
x20 Portion of fertile frond





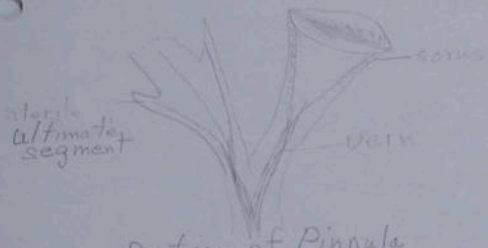
Gleicheniaceae
Gleichenia sp



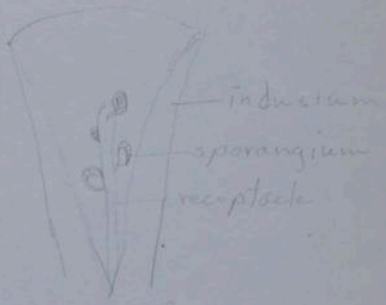


Sporangium X80

Hymenophyllaceae
Trichomanes

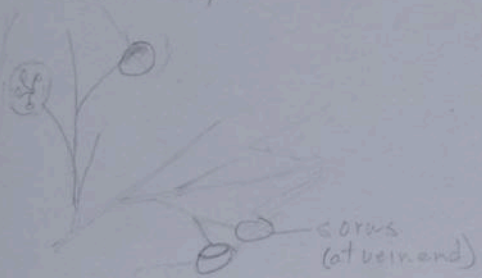


Portion of Pinnula

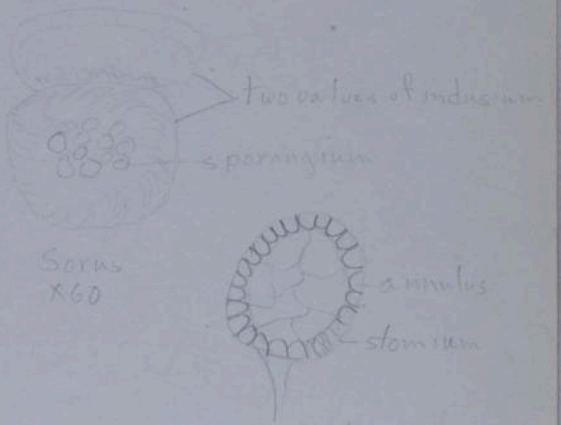


Portion of sorus

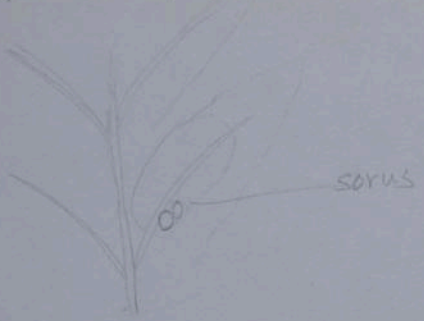
Dicksoniaceae
Dicksonia sp.



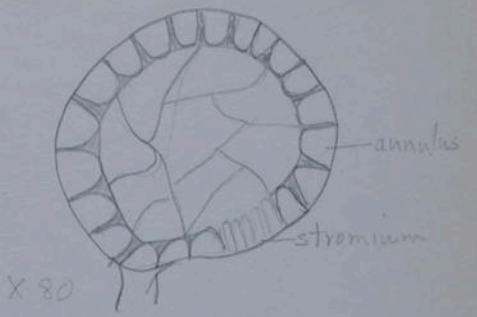
Portion of Pinnula
X40



Polypodiaceae
Asplenium sp.

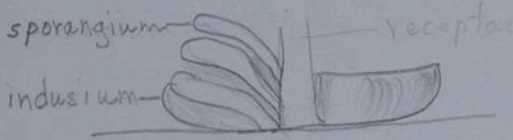


X 60
Portion of fertile pinna



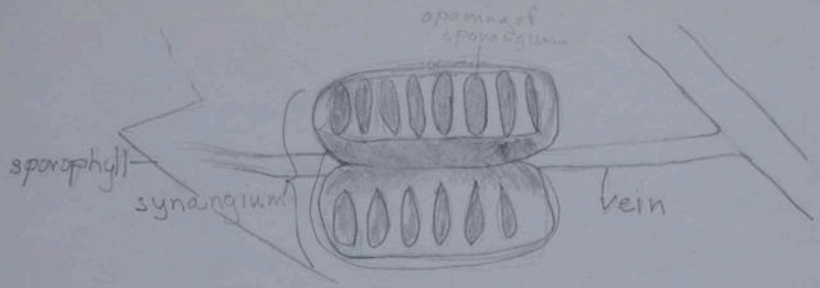
X 80
Sporangium

Cyatheaceae
Cyathea

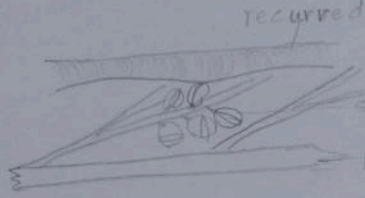


X 40 pinnule (inverted)

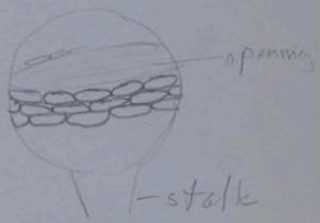
Marattiaceae
Marattia



Osmundaceae
Todea

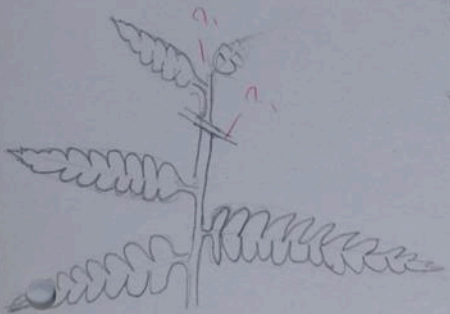


Section of pinnule
X 12



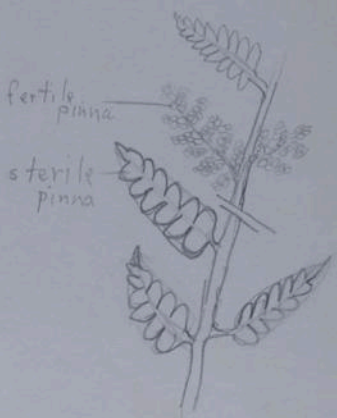
X 40

Osmundaceae



sterile frond (separate)

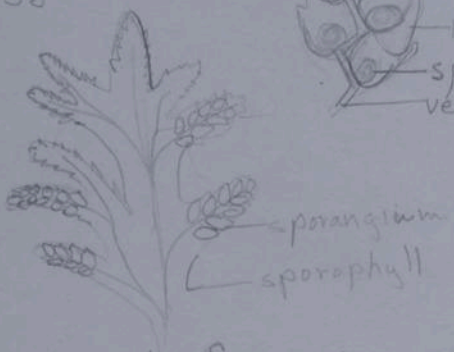
fertile frond (separate)



O Claytoniana

Osmundaceae
Osmunda regalis L.

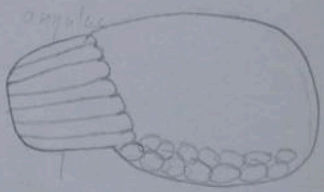
Schizaceaceae
Lygodium



Segment + Sporangia

Schizaeaceae
Schizaea

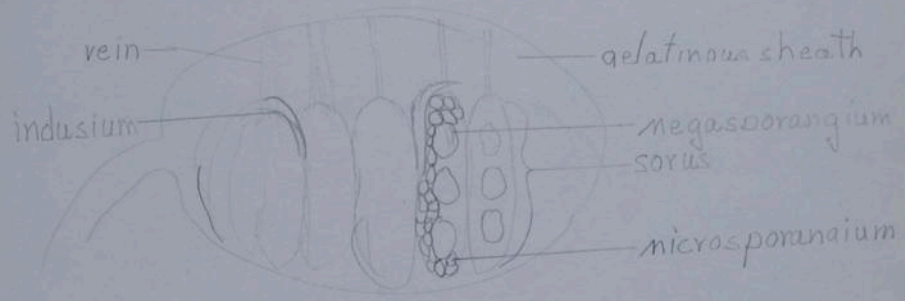
x40 Sporophyll



Sporangium x60

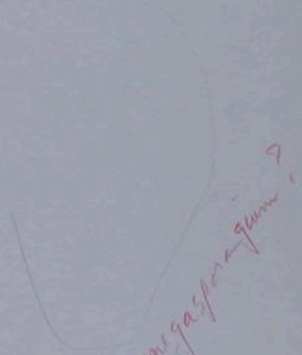
Fertile pinna
x50

Marsiliaceae
Marsilea sp.



Sporocarp x 10

microsporangium
x 60



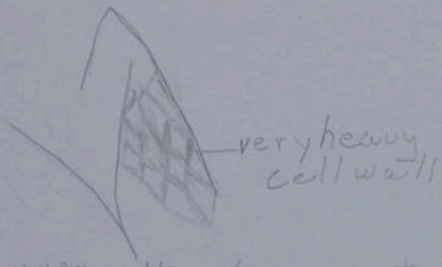
x 80

megasporangium?

Cyatheaceae
Hemitelia

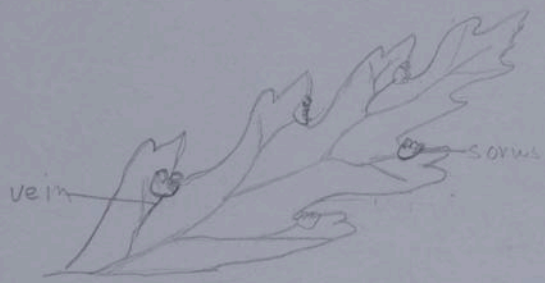
Cyatheaceae
Alsophila

Hymenophyllaceae
Hymenophyllum polyanthos

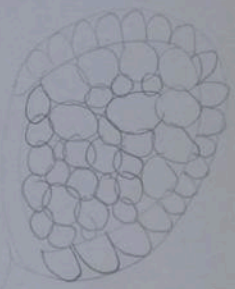


X 100 ultimate segment

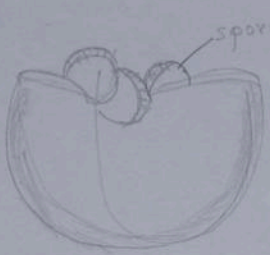
Dicksoniaceae
Dennstaedtia



ultimate segment
X 40



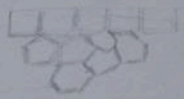
X 180



sorus x 30

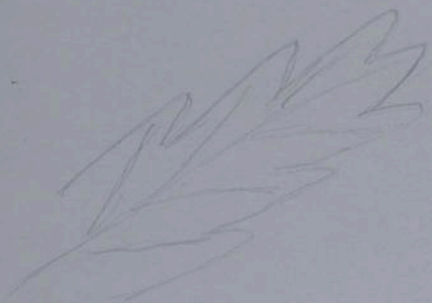
Hymenophyllaceae
Hymenophyllum sanguinolentum

ultimate segment
×50

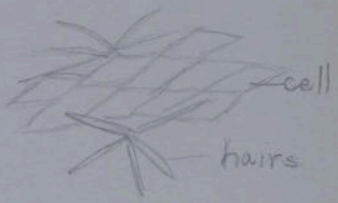


cellular detail
×100

Hymenophyllum sericeum

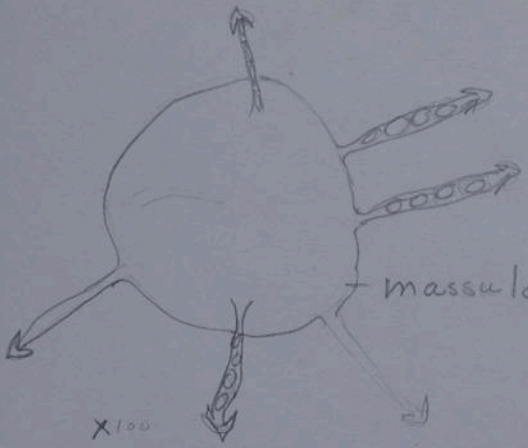


ultimate segment
× 30

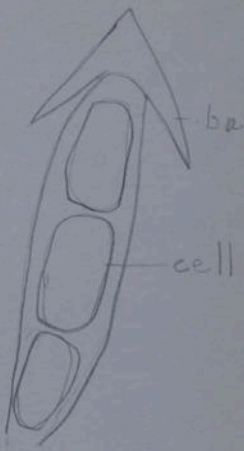


cellular detail
×100

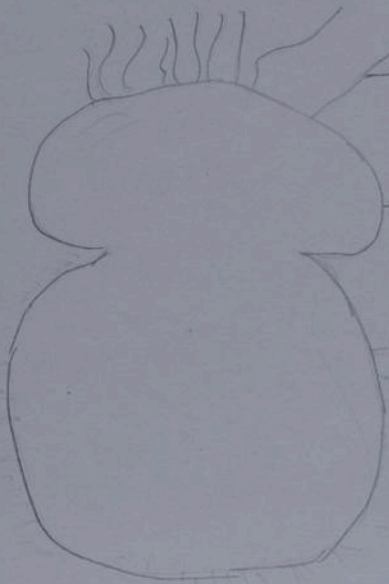
Salviniaceae
Azolla mexicana



X100

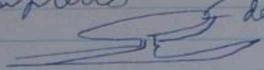


Glochidia x 150



x200 Megaspore

Tmesipteris



sporangium.
definite stalk makes sporangia terminal

Psilotum - same idea - vascular tissue shows that

Spores all the same
Prothallus superficially like Ophioglossaceae, small, brown, subterranean, elongate (irregularly) cylindrical.
Antheridia + Archegonia borne all over the prothallus.

Lab - Draw a part of a stem of Psilotum, including sporangium, small ie lateral branch + spores -

Quiz

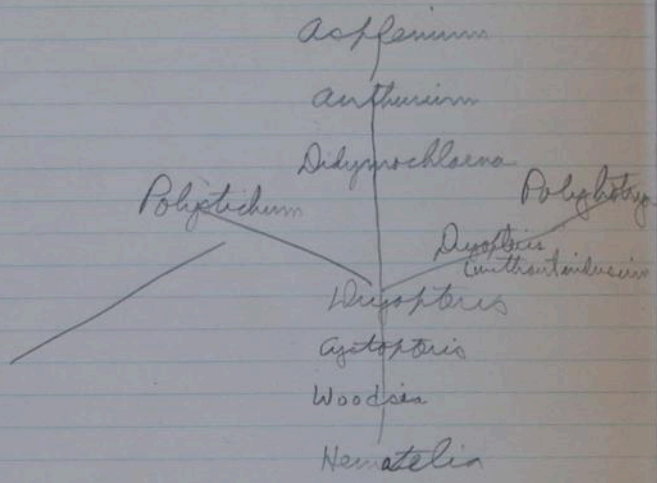
1. Draw and label with the names of genera a phyletic bush of the Dryopteroids, starting with the most closely related genus in the family from which it is derived.

2. List 5 primitive characters of the Eusporangiatae.

3. List 4 characters in which Cyathea is advanced of Gleichenia.

4. Identify to family and genus the specimens presented.

(1)



(2) Five primitive characters of the Eusporangiatae
(1) Sporangia developed from several cells — no
(2) " more than one cell thick
(3) Massive sporangia, not in sori.
(4) Large numbers of spores per sporangium.
(5) No annulus

(3) Four characters in which Cyathea is advanced over Gleichenia.
(1) Annulus of Cyathea is oblique, complete, with stamium.
No stamium in
(2) Spore ~~number~~ output of Cyathea lower than Gleichenia
(3) Sorus of Cyathea is godate, that of Gleichenia simple,

14

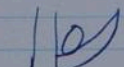
4 Next page

14) 1 Cyatheaceae - Cyathea
~~2 Polypodiaceae - Dryopteris~~
3 ~~Cyatheaceae - Cyathea~~ Dicksoniaceae Dennstaedtia
4 - Gleicheniaceae, Anemia
5 - Gleicheniaceae - Gleichenia

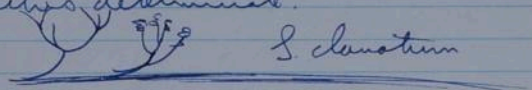
Nov 10, 1945-

Lycopodiaceae
Lycopodium 180 spp - cosmopolitan
Phylloglossum 1 sp. Australia + N.Z.

Characters
1. Usually a long creeping stem
2. Adventitious roots.
3. Leaves small, in spirals or whorls.
4 Sporangia borne singly at base of leaf

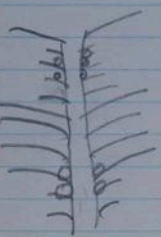


adaxial, very near base, occasionally is axial
5 Sporophylls aggregated into strobili or cones.
6. Homosporous
7. In Lycopodium, there are six sections based on characters of cone + type of branching.
8. Types of growth -
1. Growing point at tip of stem, aerial branches bearing (Underground) strobili at their tips.
Stem is decumbent, giving rise continuously to aerial branches, which as they mature, may become decumbent again. Vegetative branches indeterminate, strobili-bearing branches determinate.



S clavatum

2. Erect stem - example - S. lucidulum - branches unequal dichotomy. Produces no cone, sporangia borne on vegetative leaves - alt. sets of vegetative + fertile leaves
with a set of short and a set of long leaves, producing each year a set of long + a set of short.
Short leaves not all fertile (sporophylls) Some long leaves bear sporangia

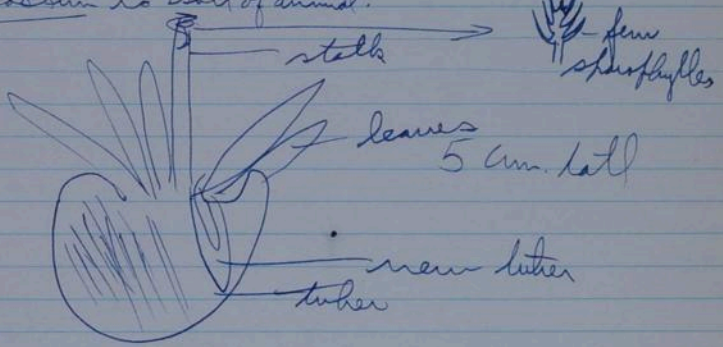


9. Gemmae - veg. reproduction - apparently a modified branch. Fall off & take root - found best in fall, and especially on tip of all branches.
10. Spores have great quantities of oil - (used previously to make light for night photography).
11. Gametophyte of 2 types - species having one or other

mycotrophic

1. Small 2-3 mm long, germination of spore rapid (week or month) prothallus short-lived, on surface of substrate. Green.
2. Grows up to 2 cm long. Spore germination 3-8 years. Prothallus 6-15 years to mature. Long-lived after fertilization, subterranean, brownish (not green).

12. All northern evergreen spp. are of type 2 - tropical spp. are usually of type 1.
13. Gametophytes irregular in structure, convoluted in structure with antheridia + archegonia borne at expanded region near top of prothallus. Archegonia similar.
14. All above for Lycopodium.
15. Phylloglossum is sort of annual.



16. Roots (2-3 A) produced.
17. New tuber formed at end of growing season, leaving only tuber as overwintering agent.
18. Each tuber lasts only 1 year.
19.

Selaginellaceae

1. One genus - 700 spp. mostly tropical, cosmopolitan.
2. Similar tendency as in Hymenophyllaceae - mostly in deep shade, mesophytic, thin leaves, others at other extreme - xerophytes, big & large, are as former.
3. Leaves 4-ranked, borne on (usually) creeping stem or short erect + other variations of branching (partially erect).
4. Roots adventitious - sometimes called rhizophores.
5. Sporangia borne in axils of sporophylls.
6. Selaginella is heterosporous - m/1 kind of spore per sporangia -
7. Usually 4 megaspores per sporangium, but sometimes 1-2.
8. Microsporangium - several hundred microspores.
9. Sporophylls in a cone or strobilus, differentiated from other part of branch.
10. ~~Gametophyte~~ - Sporangia either m/1 or both on same strobilus. The megaspores are basal, if m/both.
11. Prothallus very small, bulges out of spore wall.
12. Occasionally, prothallus develops in axil of leaf, right where megasporangium rests in axil.

Lab work -

Examine Lycopodium + selaginella -

Make a key to 6 species of Lycopodium - based on as many characters as possible -

11/12/48 - Talk - Gametophyte of Equisetum -

Isoetaceae

Isoetes - 65 spp - cosmopolitan, mostly for N. Am. + Europe.

Family characters

1. Biggest leaves of fern allies.
2. Bi- or trilobed "corm"
3. Leaves arranged in close spiral arrangement, linear & pointed
4. Depressed center of corm contains meristem.
5. Young leaves + buds progressively toward outer.
6. Outer leaves are sporophylls, or sometimes all leaves bear.
7. Basal part of corm is the rhizomorph, bears roots.

Key to Six Species of Lycopodium

A. Sporangia borne in definite strobili--B
  B. Strobili excerted, or extended by means of a peduncle from apex of vegetative branches--C
    C. Leaves short, compressed----------1.L. complanatum

    CC. Leaves longer, not compressed----------2.L. clavatum

  BB. Strobili not borne on peduncle, vegetative leaves borne to base of strobilus--D
    D. Determinate fertile branches seldom more than 3-branched, leaves large, acuminate----------3.L. annotinum

    DD. Determinate fertile branches many branched, giving aspect of a brush, leaves small, acute--------4.L. obscurum

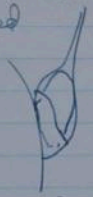
AA. Sporangia borne on ordinary vegetative leaves, not distinctly separated into a strobilus.--E.-------
  E. Stem erect, leaves linear, awl-shaped------5.Lalopecuroides

  EE. Stem decumbent, leaves elliptic.----------6.L. lucidulum

A Sterile leaves longer than .8 cm –
B Main stem erect, dichotomously divided –
1. lucidulum.
BB – Main stem decurrent, dichotomous or otherwise
C – Sporophylls similar to sterile leaves –
Serrations of leaf filiform, 2. alopecuroides
CC – Sporophylls specialized, in a compact strobilus –
Serrations of leaf short, saw toothed, 3. annotinum
AA. Sterile leaves less than .8 cm
D – Leaves scale-like, compressed, decussate, very short peduncles 4. complanatum –
DD – Leaves awl-shaped, lanceolate, or not compressed, alternate –
E – Peduncles of strobilus elongated, the leaves of the peduncle smaller than those of vegetative branches – Leaf tip acute
5. clavatum.
EE. Peduncles not elongated, the leaves all the same size, leaf tip long attenuate
6. obscurum.

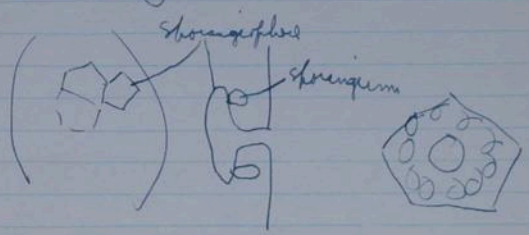
A Sporangia borne in definite strobili – B
B Strobili exerted, or extended on long peduncles – C
C – Leaves short, compressed,
L. complanatum
CC Leaves longer, not compressed
L. clavatum.
BB Strobili not borne on peduncle, vegetative leaves borne to base of strobilus. D
D – Determinate fertile branches seldom more than 3-branched – leaves large, acuminate.
L. annotinum
DD Determinate fertile branches many branched, giving aspect of a bush – lvs. small, acute.
L. obscurum
AA – Sporangia borne on ordinary vegetative leaves, not distinctly set into a strobilus –
E Stem erect, leaves linear, awl shaped
L. alopecuroides
EE Stem decumbent, leaves elliptic,
L. lucidulum

8. Production of sporangia on adaxial side of leaf.
   a very large sporangium produced in the hollow, expanded, base of leaf.



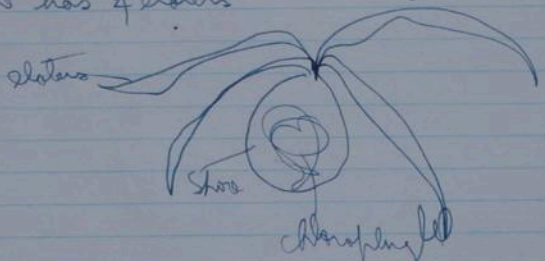
9. Velum - thin cover of sporangium.
10. Only 1 sporangium / leaf.
11. Heterosporous - megasporangia + microsporangia.
12. Outside one usually " + inner is "
13. Megasporangium produces 50 - 300 megaspores } same size sporangia.
14. Microsporangium " 200,000 — 1,000,000 }
15. Spores germinate in spring following shedding in fall.
16. Each kind of spore produces its own gametophyte.
17. Microspore → 1 antheridia, but megaspore produces several archegonia.
18. No vegetative propagation known.
19. Frequently aquatic - some amphibious or terrestrial.

Equisetaceae -
Equisetum - 25 spp - mostly N. temperate.
1. Underground stem giving rise to green aerial stems.
2. Stem manufactures food.
3. Stem jointed + ridged + hollow.
4. Leaves greatly reduced, appear as teeth, whorled around node + form a sheath.
5. Bases of leaves fused - tips occur. deciduous.
6. Branches also in whorls.
7. Silica deposited
8. Sporangia in cones terminally.



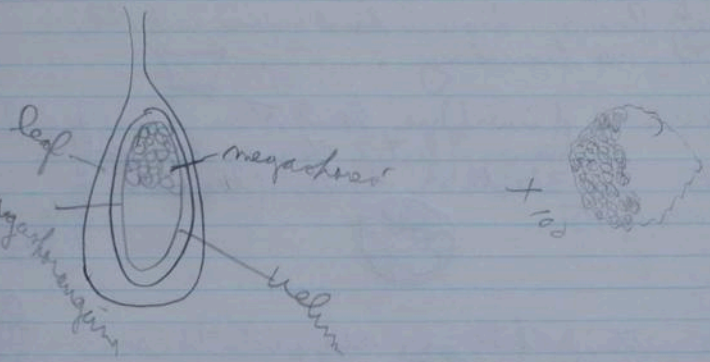
9. Equisetum is homosporous - spores contain chlorophyll. Remain viable only 2-4 days - only when moist.

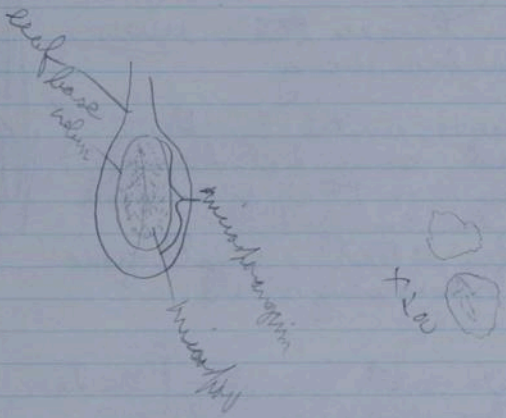
10. Each spore has 4 elaters

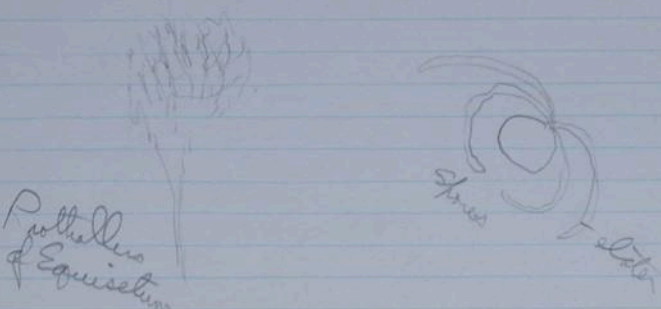


11. Prothallus of equisetum is irregularly lobed. Antheridia + archegonia borne at base of lobes.

The fern allies are end lines phylogenetically, mostly each family represented by a single genus. Of this no. of genera, more monocty than in any other group. Abundant fossils.





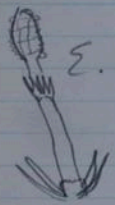


Equisetum hyemale

1. Deciduous leaves – brown band 2-4 mm wide at base of sheath – no branching.

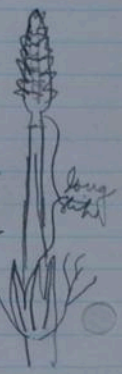
Equisetum arvense – dimorphic, sterile stem many branched leaves of fertile stem many long 3 teeth on sheaths of bundles

E. fluviatile – stem & fertile separate



segments the same scales – many

Plant is larger than arvense sparser branching



E. sylvaticum – long leaves, united by their tips & red, somewhat dimorphic, branches more than once divided (tertiary branches included)

Sheaths are spiny, giving effect of hairs.

E. scirpoides – 6 ridges, 4 teeth – small, grass like – stems very small.

E. variegatum – simple, erect branches from base, no branching above. Sheath, conspicuous spicules, alternate black & white

Gametophyte of Equisetaceae -

1. Equisetaceae appeared as early as the Middle Devonian.
Rapid evolution - in Carboniferous arborescent - like to 75'. Conspicuous element of flora.
After this period, no longer conspicuous in fossil flora, + after Jurassic no other known members but Equisetum.

2. The gametophytes green, thalloid, branched -
Grow in wet soil, shaded places - long lived, in culture to 2 yrs.
Seldom fruit in nature.
Dimensions 1-10 mm in diam.
Easily grown in culture.
Sp. E. hiemale, grew to be 3 cm in diam, red in bright light.
Look like green pinheads.
Have rounded cushion-like base, many and delicate lobes.
Base has outer meristematic rim which increases diameter of cushion radially, gives rise to new erect lobes, + to rhizoids on lower surface.
Vertical lobes - irregular plate like ~~lobes~~ expanses of photosynthetic tissue, usually 1-cell thick.
Base w/o chlorophyll.
Archegonia - arise on normal young gametophytes soon after differentiation into disc + lobes - (30-40 days)
Located in meristematic margin where upright lobes are beginning to develop -
Arch. mixture with lobes + lie at their bases + between them.
Distributed over upper part of thallus
Base sunk in prothallus + extending neck.
Antheridia formed in large nos in marginal region after archegonia formed in central part of young gametophyte.
Usually in meristematic region w/o chlorophyll, where no lobes developed -
No definite arrangement of sex organs, other than formation of archegonia 1st.
Sperms large + multiciliate, usually 256 per antheridium -
Two kinds antheridia 1 - massive + sunken (normal
2 - [illegible] (dwarf)

Homothallic, except E. arvense, which seems to be heterothallic

Dorsiventral prothallus of Equisetum sets it off from others which have radial (cylindrical) prothalli.

I. Introduction
1. Title
2. Miscellaneous - classification
- age - distribution
resemblance to sporophyte
disposition (subterranean)
No of species.
3. General asexual & gametophyte (morphology)
1. General shape.
2. Branched?
3. Meristem?
4. Internal features.
5. External
a. rhizoids, archegonia
4. Habitats
5. Unusual or interesting features
6. Conclusion.

1. Dennstaedtia punctilobula -
The cup shaped, terminal ~~---~~ indusia are characteristic.
2. Polystichum acrostichoides
Scales (brown on rachis -
3. Botrychium dissectum
The stalk of sterile blade separate from the stalk of the fertile pinna.
4. Dryopteris marginalis
Sori borne very near the margin of the segments
5. Dryopteris spinulosa (typica)
Ultimate segments with spiny projections.

1. Selaginella –
Roots – adventitious – X
Stem – herbaceous – decumbent or erect
Leaf – microphyllous (one vascular bundle). ~~Two~~-ranked
X
Sporangia – in definite strobili, terminal, one per leaf or bract or sporophyll.
Spores – heterospores, one or both sexes in same strobilus, if with both, the ~~female~~ megaspores are lowest.
Several hundred microspores per sporangium, 3-4 megaspores.
Gametophyte – Micro – and megaprothallia formed, Radially symmetrical, green, sporangia borne on lower upper surface.

2. (1) Equisetum variegatum – 2
(2) Equisetum hyemale ←
(3) Lycopodium clavatum ←
(4) Equisetum arvense ←
(5) ~~Lycopodium scoparium~~ Equisetum scirpoides ←
(6) Lycopodium complanatum ←
(7) Lycopodium alopecuroides ←

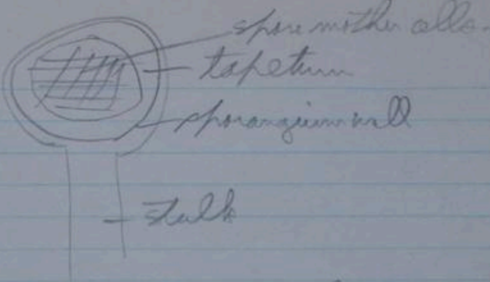
QUIZ: FERN ALLIES

1. Write as complete a description as possible for Selaginella: sporophyte and gametophyte.
   root, stem, leaf, sporangia,
   spores; gametophyte.

2. Identify to genus and species the 7 specimens given.

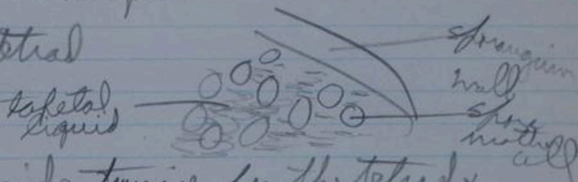
11/24

Fern spores -



as sporangium matures, spore mother cells separate, & the tapetum breaks down & intrudes between spore mother cells as a liquid -

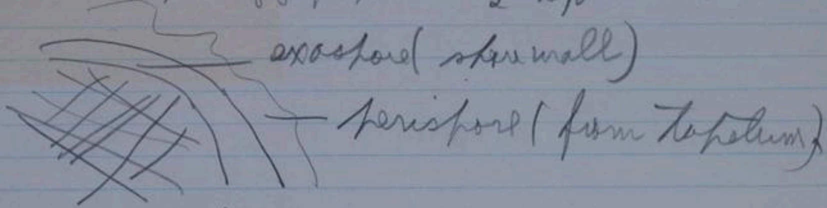
This just prior to tetrad stage



spore mother cells divide twice for the tetrad & tapetal liquid may be either absorbed by spores or only part of tapetum absorbed & rest dries up to form a coating on outside of spore.

When spores mature, sporangium is dry.

External morphology of spore   1- with perispore
2- w/o "



Types of tetrad scare

1. Tri-radiate (trilete)

Formed from all 4 spores meeting at one point.

2. Single tetrad scar

Single (undivided) scar — Monolete
bean shaped spore

3. [illegible] lite,

Significance of types of spores.

1. With, or w/o perispore -
   Primitive ferns lack perispore.
   Only in advanced Polypodiaceae is perispore found.
2. Common Polypodiaceous genera
   Trilete -
      Pteridium
      Adiantum
      Polypodium (some sp).
      All allies -
   Monolete
      Polypodium (some)
      Asplenium
      Dryopteris
      Polystichum.

Ferns to be keyed out & named.

Ophioglossaceae
1. Botrychium lunaria
2. " dissectum
3 " virginianum

Osmundaceae
4 Osmunda regalis var. spectabilis.
5 " cinnamomea
6 " claytoniana

Dicksoniaceae
7 Dennstaedtia punctilobula

Polypodiaceae
Pteroids
8. Pteridium aquilinum var. latiusculum

Gymnogrammoids
9. Pellaea glabella
10. " atropurpurea
11. Notholaena dealbata
12 Cryptogramma stelleri
13. Adiantum pedatum
14. " capillus-veneris
15. Cheilanthes lanosa
16 " Feei

Blechnoids
17. Woodwardia areolata
18 Pteretis pensylvanica (P. nodulosa)
19 Onoclea sensibilis

Dryopteroids
20. Woodsia obtusa
21. " ilvensis
22. Cystopteris bulbifera
23. " fragilis
24. Dryopteris thelypteris var. pulcherrima. (Thelypteris palustris).
25. " marginalis
26 " cristata
27 " Goldiana

28. Dryopteris spinulosa (typical) (Thelypteris sp.)
29 " " var. intermedia (" " ")
30 " " " americana
31 " hexagonoptera
32 " phegopteris
33 " disjuncta (D. Linnaeana)
34 Polystichum Braunii var. Purshii
35 " acrostichoides
36 Athyrium pycnocarpon (A. angustifolium)
37 " thelypteroides (A. acrostichoides)
38. " angustum
39 Asplenium trichomanes
40 " cuspidatum
41. " resiliens
42 " platyneuron
43 " pinnatifidum
44 " viride
45 Camptosorus rhizophyllus

Dipteris

46. Polypodium virginianum
47. " polypodioides, var. Michauxianum

Ferns to learn

Pteris cretica
Polystichum munitum
Polypodium aureum
Phyllitis scolopendrium [var americana
" typica]
Asplenium serratum
" septentrionale
" montanum
Woodwardia fimbriata
" virginica
Blechnum spicant
" serrulatum
" occidentale
Notholaena sinuata
Pityogramma ~~calomelanos~~ triangularis
Cheilanthes andromedaefolia
Vittaria lineata

12/10/48

History of Pteridology

1. Begins w/ Linnaeus - Sp. Pl. 1753
   Gen. Pl 1754
   14 Genera + 182 spp of ferns treated.
   Genera entirely artificial
2. J. E. Smith, Bernhardi, Cavanilles + Swartz worked up to 1806.
3. Swartz O - Synopsis Filicum -
   (Sweden) 38 Genera + 720 spp.
4. J. E. Smith - Englishman who purchased Linnaean Herb.
3. Bernhardi -
6. Cavanilles prof. at Madrid -
7. Willdenow - at Berlin - Sp. Pl.
   5th Vol, 1810 - contains ferns.
   Sp. Plant - carried thru several editions, like Engler's manual.
   Willdenow published 2nd edition with 41 genera + 1000 spp.

Up to this time ferns largely distinguished by characters of sorus + indusium. With only these 2 characters no. of genera remained small.

8. Presl - Tentamen Pteridographicae 1836
   + addition in 1845
   Also several monographs.
   First to use characters other than sorus + indusium, especially vein characters - made 165 genera -
9. 1838-42 - Hooker (W. J. Sir) + Bauer - "Genera Filicum".
   Hooker wrote descriptions + did taxonomy - essentially a large + accurate description of Presl's work -
   Work contains 162 genera - largely an acceptance of Presl's work. Filicum Hooker
10. 1844-64 - Species ~~Plantarum~~ - 15 Vols - treated 2500 spp. left out Marattiaceae, Osmundaceae and others.
    Recognized 75 Genera.
11. John Smith - 1876 Curator at Kew - Pub. Historia Filicum in 1875.
    Pub. first on ferns in 1841 - this classic summary of Presl's work -

Smith knew more about live ferns than all others since he cultivated some 2-3000 sp. in greenhouse. Very strongly advised using several characters for generic description thus the use of vegetative characters. With a total of 217 genera.

12. A.L.A Fed - 1850-52 - Genera Filicum -

13 Memoirs

181 - Genera

The last 3 workers 1st to attempt natural classification.

13. 1867 - Hooker - Synopsis Filicum - 1 Vol. Destroyed other works - because of prestige of author + convenience of 1 vol.

14. Christ - 1893 - "Farn vegetation of the world" new classif.: recognized 140 Genera.

15. Diels in 1898 - Pteridophyten in E+P. Naturlichen Pflanzenfamilien - 141 genera.

Christ was prof. of Pterid. at Switzerland.

Present -

1. Carl Christensen - died 1946 - Danish - Copenhagen. 1906 - Index Filicum - has supplements kept up to date until 1935. Monographed Dryopteris most of ferns for world - wide floras.
2. Copeland - same time as E. D. Merrill in Philippine ferns of Philippines + Oceania - same fame for this area as Christensen for rest of world. Recently retired at Berkely.
3. Maxon - died in 1948 - at U.S. Nat. Herb. - 1900-1948 Specialty - trop. Amer. ferns.
4. C. V. Morton - successor to Maxon - at U.S. Nat Herb. Published one monograph of section of Hymenophyllum.
5. R. C. Ching - active in China.
6. Holttum - Singapore Bot. Gards. specialty - Malayan ferns
7. Alston - British Museum - revised genus Selaginella - only authority - of all spp.
8. Mme Sardieu Blot - curator of Pteridophytes at Paris.

Workers in N. Am. Ferns.

1. D. C. Eaton - 1st + last extensive treatment of N. Am. Ferns. 1871-80. Prof. at Yale.
2. George Davenport - N. Am. sp. of ferns 1900
3. A. A. Eaton - Equisetum + 9 isoetes. collection of Isoetes at M.B.G.
4. C. A. Weatherby - active - cheilanthes + Notholaena.

Trends exhibited -

1. General increase in no. of genera + species.
2. From 1800 - increase in genera due to change in concepts. Due to attempt of Lee + Paul to make genera natural.
3. As for species - large no. actually discovered new. today 5500 sp. as compared w/ 1000 at time of Willdenow + particularly as a result of British Colonial expansion. Due to recent critical explorations in New Guinea, Fiji islands and other areas, previously unknown.
4. As far as specific concept, many pres. sp. should be reduced to synonomy, since many named by others than a monographer.

Eusporangiatae
1. Ophioglossaceae
 Massive, naked sporangia, many spores, simple protostele or siphonostele — Sporangia borne on a modified pinna. w/o annulus, sessile
 Three genera Helminthostachys, Botrychium, Ophioglossum.

2. Marattiaceae — sporangia in sori under surface of pinnule.
 Sporangia large, massive, sessile w/o annulus except in Genus Angiopteris.
 Seven genera
 Angiopteris, Macroglossum, Archangiopteris } sori free —
 Marattia, Protomarattia, Danaea } sori united
 Kaulfussia & Christensenia — Sori groups subdivided.
 Stipules present — Mucilage canals & tannin cells.

Leptosporangiatae —
3. Osmundaceae — Some or all of the pinnae of the blade completely fertile. No separate part of blade fertile. Sporangia naked, no sori, short stalked, rudimentary annulus.
 3 Genera
 Osmunda — sporangia marginal.
 Todea — thick leaves, Leptopteris — filmy " } sporangia superficial (under surface of blade)
Simplices Stipules +, in Osmunda, resin canals.
4. Schizaeaceae — Fertile pinnae much reduced (except in Mohria)
 Sporangia large, annulus +, no sori, stomium +.
 Annulus distal & complete, opening by a longitudinal slit.
 Four genera
 Lygodium — climbing vine. — protostele, areolate venation
 Schizaea —
 Anemia — } hairs —
 Mohria } scales & hairs.

5. Marsileaceae - heterosporous; sporocarps borne in axils of leaves, contain sori inside. Simple sorus contains minor + mega sporangia. Sporocarp is modified leaf -
Aquatic or semi-aquatic.
Three genera
Marsilea - Frond of 2 pr of opp. pinna.
Regnellidium - Simple frond, deeply 2-lobed
Pilularia -
64 spores per microsporangium; 1 spore per megasporangium.

6. Gleicheniaceae - climbing ferns; sporangia in sores under blade. No indusium. Complete transverse annulus. Leaf has indeterminate growth; creeping, scaly rhizomes.
3 genera
1. Gleichenia -
2. ~~Gl~~ Stromatopteris - dimorphic leaves.
3. Plagiogyria - insipient heterospory.

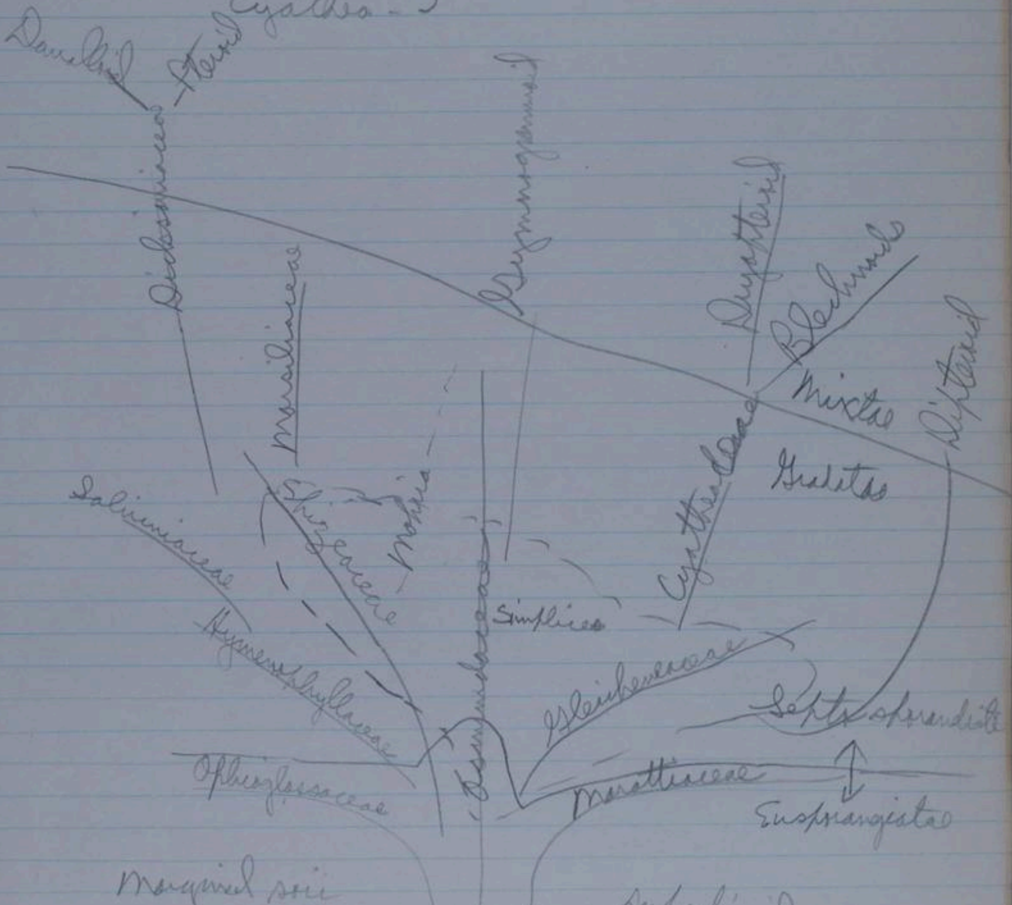
7. Hymenophyllaceae - filmy ferns -
Blade one cell thick in many members.
Sporangia in sori terminal on vein ends - Indusium present, all shapes or 2-valved. Receptacle long cylindrical
2 Indistinct genera
Trichomanes - indusium tubular, receptacle exserted
Hymenophyllum - indusium 2-lipped, receptacle not exserted

8. Dicksoniaceae - tree ferns - Sori terminal on vein ends. Indusium 2-valved or cup-shaped. Receptacle short. Hairs, but no scales. Sorus modified
Five genera
Thyrsopteris
Dicksonia
Cibotium
Culcita
Dennstaedtia

9. Cyatheaceae — tree ferns — sorus under (superficial) blade; indusium none or cup shaped at base [illegible] Sporangia have complete oblique annulus and a stomium.

5 Genera

- Lophosoria } hairs, simple sorus, siphonostele, short stem
- Metaxya }
- Alsophila } scales, dictyostele, gradate sorus, tall stem.
- Hemitelia }
- Cyathea }



Final Exam: Pteridophytes Dec. 1948

1. Identify as indicated the 22 specimens given. (22 points)

2. Write a brief key to the genera of "Fern Allies" ie. Pteridophyta exclusive of Filicinae. (2 points for each genus)

3. Write a brief key to 4 species of Lycopodium. (8 points)

4. Compare the gametophytes of Equisetum and Lycopodium (large type) on 7 characters. (14 points)

5. Sketch a phyletic bush of the Filicinae. Label families and main groups of the Polypodiaceae. List under each family one distinctive feature of that family. (32 points)

6. Compare the Eusporangiatae and the Cyatheaceae, listing 5 primitive characters of the Eusporangiatae and the comparable advanced characters of the Cyatheaceae. (10 points)

Lycopodium clavatum =
" complanatum —
" obscurum
" annotinum

Gymnogrammoid Ferns

1. Material

Eight sheets including several genera and at least three species in one of the genera. Names have been obliterated; they will be given later.

2. Objective

To prepare a synoptical treatment of a group of species of the Gymnogrammeoideae. To consist of the following:

A. K y to the genera you recognize.

B. Description of the critical characters of each genus. Illustrate these or the most important of them.

C. Key to the species of each genus with more than one species.

D. Description of each species. General characters of size and shape; characters that are or seem to be of specific value. Repeat characters used in the key to species (if there is one) but do not repeat those used in the generic description.

E. Chart showing the general phyletic position of your genera. This is to be prepared in manuscript only and will serve as a basis for discussion later.

3. Procedure

A. Make out a numbered list for each sheet. Each number represents a character (see master list on next page). If additional characters are needed add them to the list in the appropriate place: 9, 9a, 9b, etc.

B. Make necessary dissections and record your observations. Boil or moisten material for dissection. Clear a portion of each specimen in KOH.

C. Integrate data: decide upon generic and specific limits.

D. Write key to genera, then keys to species. Write generic descriptions and illustrate. Write specific descriptions.

E. Prepare phyletic chart and report on your genus.

F. Write up treatment in final form, leaving space to fill in the names of the genera and species.

List of characters to observe for each specimen.

(insofar as the material will allow; add other characters if necessary)

1. Rhizome, type
2. , scales or hairs.
3. Stipe, color
4. , vascular bundles
5. , indument (scales, hairs or glands or glabrous)
6. Fertile blade, division
7. , size
8. , shape
9. , venation
10. , indument
11. Rachis, color
12. , indument
13. , sessile or stalked
14. Pinnae, size
15. , shape
16. , sessile or stalked
17. Pinnules, size
18. , shape
19. , sessile or stalked
20. Sorus, shape
21. , extent
22. , relation to veins and margin.
23. Indusium, shape
24. , extent
25. , relation to veins and margin
26. Receptacle, shape
27. , extent
28. , relation to veins and margin
29. Sporangia, size
30. , type
31. , number of cells in annulus
32. , long or short-stalked
33. Spores, shape
34. ,color
35. , markings
36. , perispore present or not

Key to Genera of Certain Gymnogrammoid Ferns

1. The fertile blade with areolate venation; blade simple, but deeply lobed. The blade covered on the under surface with multi-cellular hairs.----------#3 Hemionitis

1. The fertile blade with open venation, at least one pinnate, indument absent or waxy, or if hairy, the hairs one-celled.----------2

2. The sporangia borne in a continuous cluster along the margins of pinnule and confined to a definite marginal region.----------3

3. Fertile blades imparipinnate. Fronds 2-2.5 dm tall.--------4

4. Pinnules elliptic or ovate, with a definite auricle at their base. Margin not forming a partial indusium.

#36 Notholaena

4. Pinnules linear, without auricles, The reflexed margin forming a partial indusium.------#11 Pellaea

3. Fertile blades paripinnate, blade less than 2 dm. tall.

#4 Doryopteris

2. The sporangia either borne in separate sori, or without definite arrangement along the veins, but never continuous along the margins.--5

5. The sporangia in definite sori, no indument on fertile blade.

#29 Adiantum

5. The sporangia not in definite sori, the blade covered with a waxy, granular indument on one or both surfaces.

#'s 13, 16, 19 Pityrogramma

Key to Species of Pityrogramma

1. Blade broadly triangular in outline, the under surface covered with a golden, waxy indument.----------P. chrysophylla (13)

1. Blade long triangular, the indument on under surfaces white.--2

2. Inner lower basal pinnules 1-2 cm. long, ovate-elliptic, the tips rounded.----------P. tartarea (19)

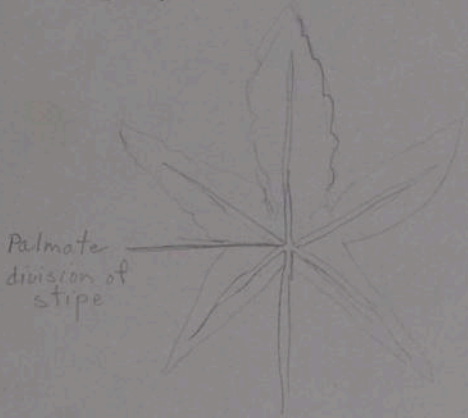
2. Inner lower basal pinnules 0.5 cm. long, triangular, the tips acut. P. calomelanos (16)

#3 Hemionitis palmata

The fertile frond simple, pedate, the margin dentate; stipe with a hairy indument. Venation areolate. Sporangia 280 μ in diameter; 12-14 cells per annulus. The spores trignose, with a definite perispore present.

Sp. description

Fertile frond 1.5-2.0 dm tall, 0.3-0.5 dm broad. Both surfaces with a sparce hairy indument. Sporangia borne along veins; no evident sorus, indusium or receptacle. The spores trilete, brown.



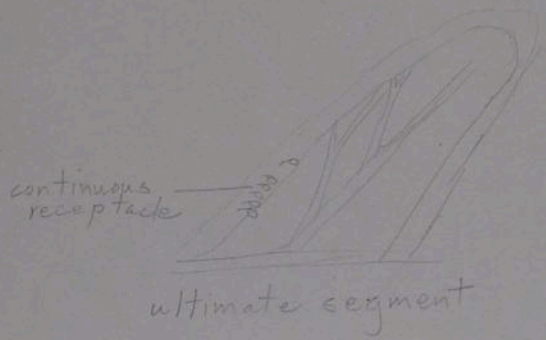

areolate venation

#4 Dryopteris concolor podata

Venation of fertile frond open, dichotomous. Sori borne at tips of veins, confluent, so as to appear as a continuous sorus at the margin of the pinnules. No indusium nor definite receptacle present. Sporangia 170 μ in diameter; annulus of 19-21 cells; sporangium short-stalked. Spores orbicular, with no evident perispore.

Sp. description

Fertile frond 1-1.5 dm. long 1-1.2 dm wide, broadly triangular, pinnate-pinnatifid, at least the lower pinnae, the upper merely pinnatifid, the basal lower inner pinnule twice as long as others of the basal pinnae. The bases of the pinnules decurrent to the next lower insertion. Spore light-yellow.



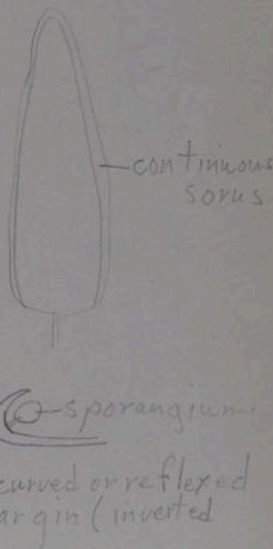
#11 Pellaea atropurpurea

Fertile frond imparipinnate; the margins inrolled to form a rounded upper surface and a false indusium. Venation open dichotomous. Sori continuous along the pinnule margins, no indusium (except as mentioned above) no receptacle. Sporangia approximately 260 μ in diameter, annulus of 20-21 cells. Sporangia long stalked. Spores with a definite perispore.

Sp. description

Fertile frond 8-12 dm. tall, 6-10 cm. broad. Pinnate above, bi-, or tripinnate below, the pinnules linear. Rachis hairy. Spores trignose, brown.

Imparipinnate frond



Pityrogramma

Fertile fronds paripinnate. The blade covered with a granular waxy indument, either on one or both surfaces. Rachis red- or purple-brown, sparsely hairy. Vascular bundles two in the stipe, forming a definite, 2-parted groove along one side.

Spp. description

P. ~~triangularis~~ (13) chrysophylla

Fertile frond 2-3 dm. tall, .8-1.2 dm wide, broadly triangular, the under surface only covered with a granular golden waxy indument. Bipinnate below. Stipe purple-brown. Spores evenly yellow-brown.

covered with a waxy indument

vascular bundle

x-sec. of stipe

#16 Pityrogramma calomelanos

Fertile frond 1-3 dm tall, .3-.8 dm broad, long triangular. Lower surface only covered with a granular white waxy indument. The upper surface dark green. Stipe purple brown. Spore with definite red-brown "stripes".

#19 Pityrogramma tartarea

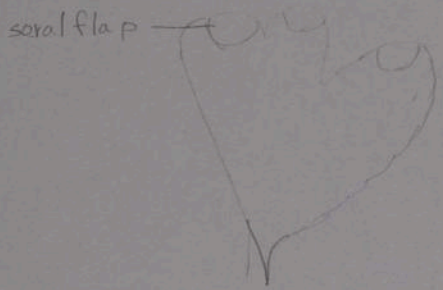
Fertile frond 1-2.5 dm. tall, 0.5-0.8 dm. broad, long triangular; lower, and to some extent the upper, surfaces covered with a granular white, waxy indument. The lower pinnae bipinnate. Stipe red-brown. Spore with definite red-brown linear markings.

#29 Adiantum aff. coccinum

Veins free, imparipinnate, the sori definite, borne on the upper margin of the pinnules, the margin of the pinnule forming a false indusium. The compound sorus contains from 2-6 receptacles. Sporangia 33 0 μ in diameter, 16-20 cells per annulus; short-stalked. Spores trignose, without perispore, the surface granular.

Sp. description

Fertile frond 3-4 dm. long, 1-1.5 dm. broad, broadly triangular. Four-pinnate, the pinnules flabelliform



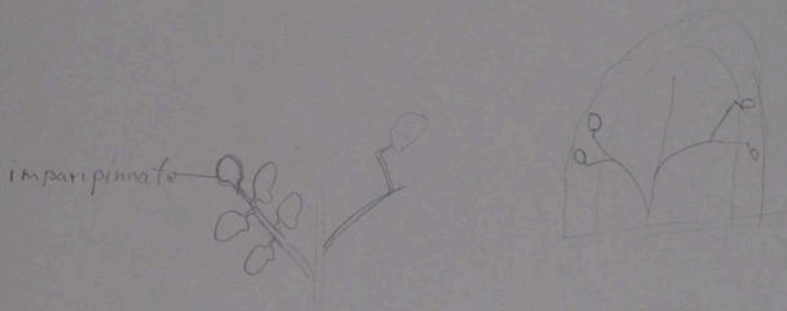
Part of single sorus showing 2 separate receptacles

#36 Notholaena nivea

The fertile frond imparipinnate. Venation open, dichotomous. Sporangia confined to a more or less marginal position, but with no definite soral structure, the receptacles not evident. Sporangia borne along veins; 325 μ in diameter; the annulus of 17-20 cells. The spores orbicular, with a definite perispore.

Sp. description

Fertile fronds 1-2.5 dm. tall, 0.5-0.8 dm broad, long triangular. Bi-, or tripinnate, at least the lower pinnae. The ultimate segments small, usually 5 mm or less, widely separated on the rachises.



Key to six species of ferns on spore characters

Spores with a definite perispore

Spores ellipsoid

Perispore uneven, with a torn appearance 21.3 x 28.8 μ

Phyllitis scolopendrium var. typicum

Perispore even, no torn surfaces, 22 x 44.4 μ

Dryopteris spinulosa

Spores spheroid

Slightly rugose, 29 x 38 μ Polystichum munitum

Spores without a definite perispore

Spheroid, rugose, cuneate scales, 21.2 x 25 μ

Botrychium virginicum

Trignose, trilete, somewhat spinulose or finely granular, 26 x 30 μ

Pteridium aquilinum

Reniform, rugose, monolete. 27.2 x 50.1 μ

Polypodium virginianum

Key to Six Species of Lycopodium

A. Sporangia borne in definite strobili--B

B. Strobili exerted, or extended by means of a peduncle from apex of vegetative branch--C

C. Leaves short, compressed----------L. complanatum

CC. Leaves longer, not compressed------L. clavatum

BB. Strobili not borne on peduncle, vegetative leaves borne to base of strobilus--D

D. Determinate fertile branches seldom more than 3-branched, leaves large, acuminate.----------L. annotinum

DD. Determinate fertile branches many branched, giving aspect of a brush, leaves small, acute----L. obscurum

AA. Sporangia borne on ordinary vegetative leaves, not distinctly separated into a strobilus--E.

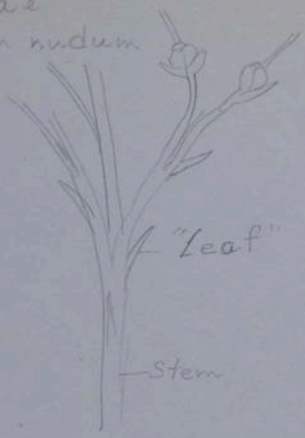
E. Stem erect, leaves linear, awl-shaped---

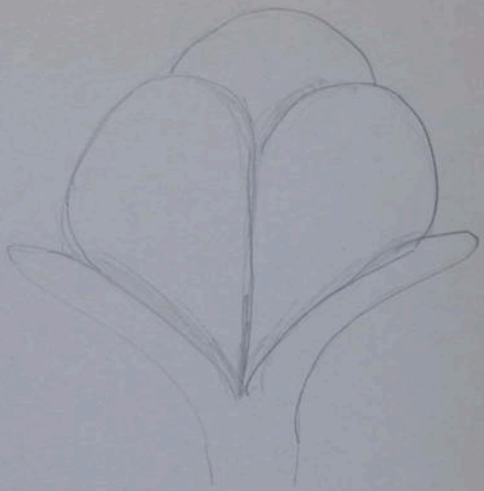
L. alopecuroides

EE. Stem decumbent, leaves elliptic-------L. lucidulum

Psilotinae

Psilotum nudum





Sporangium — x40

Spores x100