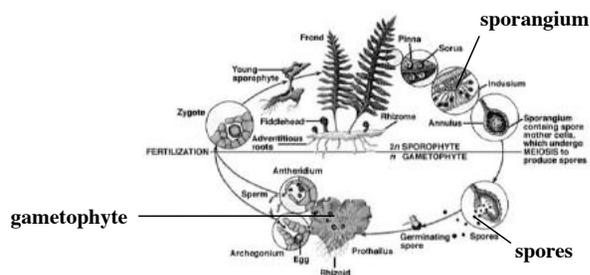


Vascular Plants - a quick review

Why were the seed-free plants “grouped” together?

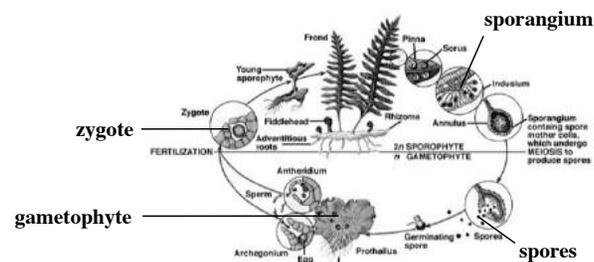
Spores germinate and develop into **gametophytes** that exist **independently** of the spore-producing plants. The gametophytes (haploid, n) tend to be inconspicuous and short-lived.



Vascular Plants - a quick review

Why were the seed-free plants “grouped” together?

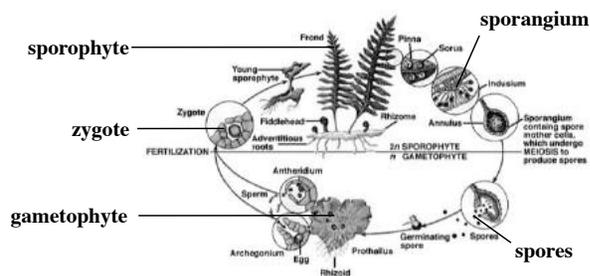
Like all plants, seed-free plants produce two kinds of **gametes** in their gametophytes: **sperm** and **egg** that unite to form a **zygote** (2n or diploid) via **fertilization**



Vascular Plants - a quick review

Why were the seed-free plants “grouped” together?

The **sporophyte** (2n) develops from the zygote and is more conspicuous, usually perennial and lives for an indefinite period



Wisconsin Seed-free Plants

The best website to identify and see images of Wisconsin’s seed-free plants is Gary Fewless’ at UW-Green Bay; links provided below



[Key to Ferns and Fern Allies of Wisconsin](#)
[List of Pteridophytes of Wisconsin](#)
[Glossary of Fern Terminology](#)

also:

[Michigan Online Flora](#)

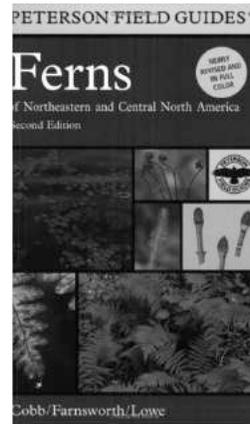


Wisconsin Seed-free Plants

The best manual to identify lycopods and ferns is *Ferns of Northeastern and Central North America* (2nd ed.) in the Peterson Field Guides

Warning:

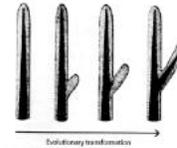
Families and genera (and thus species names) are changing quickly in the seed-free plants



Phylum Lycopodiophyta

club mosses, spike mosses, quillworts

Leaves **microphylls**: generally small, simple, one-veined leaves. Microphylls evolved by the process of **enation** and vascularization. An enation is a veinless, lateral protrubence on the stem. When the enation becomes vascularized it is termed a microphyll.



Sporangia: the spore producers on the sporophytes are located singly on the upper surfaces or in axils of the bracts of a cone or of green leaves



Phylum Lycopodiophyta



Carboniferous forest from Illinois

This group arose in the Later Silurian about 420 million years ago and was dominant in the Carboniferous and used to be much more diverse.

Phylum Lycopodiophyta

Lycopodiaceae - club mosses

15 genera and about 375 species

Lycopodium now split into several genera

cosmopolitan distribution, most diverse in tropics

Evergreen, stems elongate and dichotomously branching. Leaves often densely covering the stem.

Oily compounds in the cell walls ignite rapidly into a flash of light and were used by magicians and sorcerers in the Middle Ages. More recently they were used as a flash early in photography and in experimental photocopying machines. Many species over-collected for Christmas wreaths.



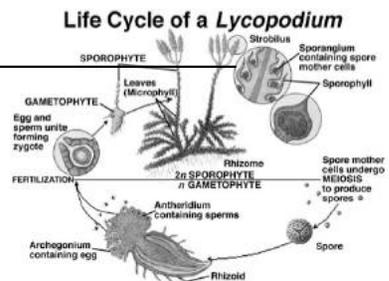
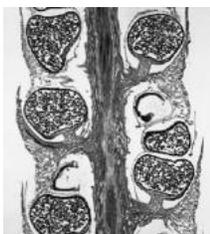
Diphasiastrum complanatum

Ground cedar, crowfoot



Phylum Lycopodiophyta

Lycopodiaceae - club mosses



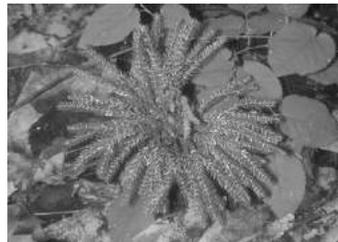
Homosporous: "same spore" - one kind of spore produced; cones terete (rounded)

Phylum Lycopodiophyta

Lycopodiaceae - club mosses
other examples



Dendrolycopodium obscurum
Ground pine



Phylum Lycopodiophyta

Lycopodiaceae - club mosses
other examples



Lycopodiella inundata
Bog club moss



Phylum Lycopodiophyta

Lycopodiaceae - club mosses
other examples



Huperzia lucidula
Shiny club moss

Alkaloid for Alzheimers?





Phylum Lycopodiophyta

Huperzia lucidula
Shiny club moss







Polytrichum
forest mosses



Phylum Lycopodiophyta

Selaginellaceae - spike mosses
1 genus and about 750 species

Mainly tropical family with some species extending into arctic regions of both hemispheres

Leaves spirally arranged and often 4-ranked on the secondary and ultimate branches.

Spores borne in or near the axils of well-differentiated sprophylls, usually on 4 sided stroboli.



Phylum Lycopodiophyta

Selaginellaceae - spike mosses
1 genus and about 750 species

Mainly tropical family with some species extending into arctic regions of both hemispheres

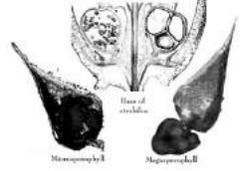
Leaves spirally arranged and often 4-ranked on the secondary and ultimate branches.

Spores borne in or near the axils of well-differentiated sprophylls, usually on 4 sided stroboli.

Heterosporous: "different" spores

Unlike Lycopodiaceae, Selaginellaceae are heterosporous with different types of spores: microspores and megaspore (not related to size) the micro give rise to male gametophytes and the mega give rise to the female gametophytes.





Microspore
Megasporophyll
Megasporophyll

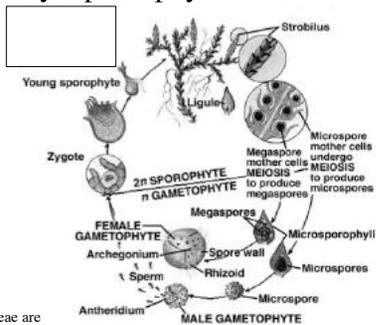
Phylum Lycopodiophyta

Selaginellaceae - spike mosses

Life Cycle of *Selaginella*

Heterosporous: "different" spores

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Phylum Lycopodiophyta

Selaginellaceae - spike mosses



Selaginella eclipes
meadow spike moss

Phylum Lycopodiophyta

Selaginellaceae - spike mosses



Selaginella rupestris
Rock spike moss



Selaginella selaginoides
Northern spike moss
Endangered!

Phylum Lycopodiophyta

Isoetaceae - quillworts

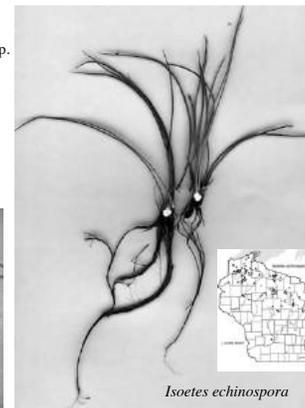
1 genus and about 150 species; worldwide; 2 spp. in WI - *Isoetes echinospora* most common

Aquatic or semi-aquatic plants with corm-like stems with secondary growth. Absorb carbon through their roots.

Leaves with ligules and quite long (15+ cm) for microphylls.



I. butleri -
not native

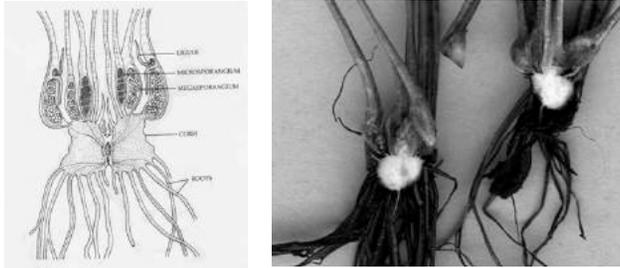


Isoetes echinospora

Phylum Lycopodiophyta

Isoetaceae - quillworts

Heterosporous plants with sporangia borne at the base of sporophylls which are similar to vegetative leaves. Megaspore + microspore



Phylum Polypodiophyta - ferns & horsetails

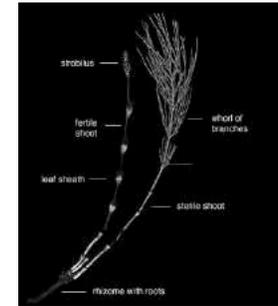
Equisetaceae - horsetails, scouring rushes (previously placed in own phylum - Equisetophyta)

1 genus, *Equisetum*, 15 species with a cosmopolitan distribution except for Australia or New Zealand [9 species in Wisconsin]

Plants are primarily colonizers of unforested areas, lake margins and wetlands

Shoots monomorphic or dimorphic (see right).

Often highly branched (horsetails) appearing like leaves. Others not branched (scouring rushes).



Internodes with conspicuous vertical ridges; jointed stems; stems hollow (both important taxonomic features for keying species)

Phylum Polypodiophyta

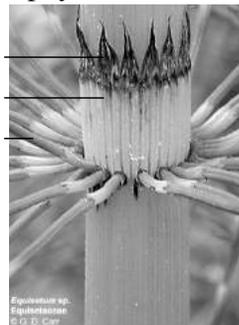
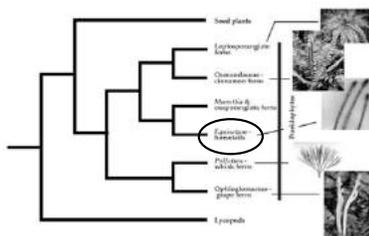
Equisetaceae - horsetails, scouring rushes

Leaves in whorls; leaves one veined, verticillate, united to form a **sheath** around the stem; these leaves are probably reduced **megaphylls**; Megaphylls are larger than microphylls have a blade that has a complex system of veins.

megaphyll

sheath

branch



Megaphyll theory is supported by placement of *Equisetum* among primitive ferns using DNA.

Phylum Polypodiophyta

Equisetaceae - horsetails, scouring rushes

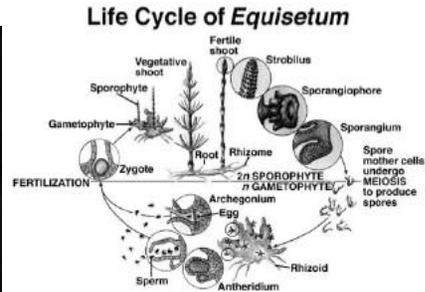
Sporangia clustered terminally in **cones** composed of polygonal, umbrella-like structures with sporangia beneath.



Phylum Polypodiophyta

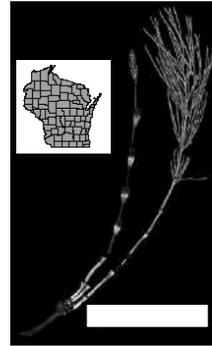
Equisetaceae - horsetails, scouring rushes

Horsetails are homosporous, have green spores with hygroscopic elaters, and form conspicuous green gametophytes



Phylum Polypodiophyta

Equisetaceae - some examples of native horsetails & scouring rushes



Equisetum arvense
Field horsetail



Equisetum sylvaticum
Woodland horsetail

Phylum Polypodiophyta

Equisetaceae - some examples of native horsetails & scouring rushes



Equisetum laevigatum
Smooth scouring rush



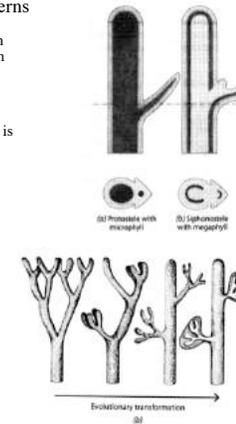
Equisetum scirpoides
Dwarf horsetail

Phylum Polypodiophyta

the true ferns

Most diverse of the vascular cryptogams, both in species number (ca. 11,000 worldwide) and form (small aquatics to trees).

Like the horsetails (which may be thought of as specialized ferns), leaves are **megaphylls**; blade is called a **frond** and the petioles as **stipes**.



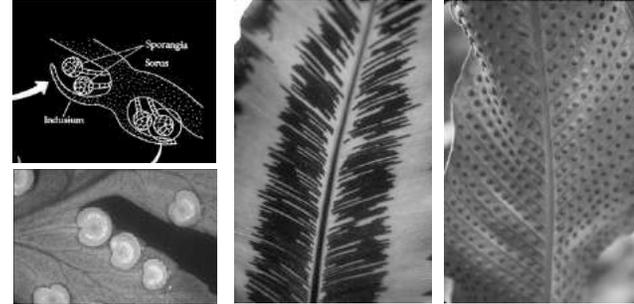
Phylum Polypodiophyta ferns

Circinate vernation: vernation is the arrangement of folded leaves in a bud, forming a crozier or fiddlehead, i.e. coiled or rolled up at the tip and unfolding lengthwise when emerging - due to auxin and differential growth of tissue. Protects young bud.



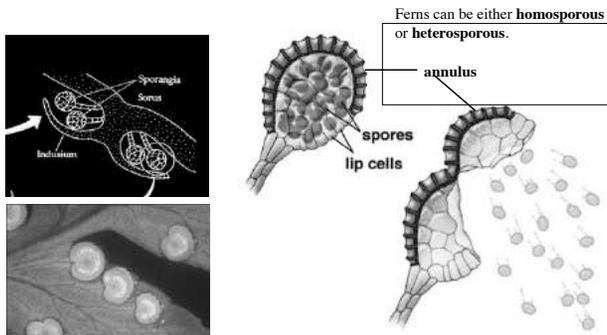
Phylum Polypodiophyta ferns

Sporangia borne on the margin or the lower surface of the leaf; often grouped in **sori** (pl.) sorus (sing.); a sorus may be protected by a flap-like structure called the **indusium** - an important feature for identification of ferns due to its remarkable variation in size, shape, and position.



Phylum Polypodiophyta ferns

The sporangium is often associated with an **annulus** a cluster or row of cells with thick walls that open the sporangium and catapult the spores into the air.



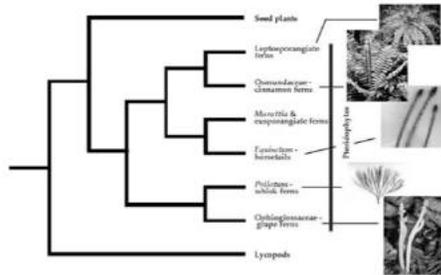
Phylum Polypodiophyta ferns



Phylum Polypodiophyta

There is major disagreement on what are the fern families, but 30 are generally recognized worldwide. In Wisconsin there are 9 families.

Characters used to circumscribe families often relate to cryptic features such as the presence or absence of annulus and its orientation, the length and diameter (number of cells) of the sporangial stalk, spore shape, stem and petiole cross-section anatomy. The primitive ferns include horsetails and whiskferns.



Phylum Polypodiophyta

Ophioglossaceae - adder's tongue family

Primitive ferns; 2 genera in Wisconsin:
Ophioglossum and *Botrychium* (now 3 genera)

Sporangia are on an erect axis with a green blade attached below the sporangia bearing part



Ophioglossum pusillum
Adder's tongue fern

Phylum Polypodiophyta

Ophioglossaceae - adder's tongue family

Primitive ferns; 4 genera in Wisconsin:
Ophioglossum and *Botrychium* (now 3 genera)



Botrychium lunaria
Moonwort fern

Botrychium mormo
Goblin fern



Botrychium virginianum
Rattlesnake fern

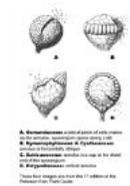


Phylum Polypodiophyta

Osmundaceae - royal fern family

Primitive ferns;
1 genus in Wisconsin: *Osmunda*

Fertile and sterile leaves dimorphic and the fertile portion is non-green at maturity. Sporangia not clustered in sori, but naked.



Phylum Polypodiophyta

Osmundaceae - royal fern family

3 species of *Osmunda* in Wisconsin; easily separated by position of fertile portions



All wide-spread & Bot 401 exam plant!



Osmunda cinnamomea
Cinnamon fern



Osmunda claytoniana
Interrupted fern



Osmunda regalis
Royal fern

Phylum Polypodiophyta

Dennstaedtiaceae - bracken family

2 genera in Wisconsin. Includes one of the most widespread of all vascular plants.

Clonal with rhizome; large compound leaves. Ubiquitous in Wisconsin.



Pteridium aquilinum
Bracken fern



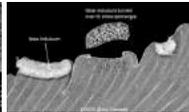
Marginal sori with no indusia but with **revolute** (rolled over) leaf edge protecting sori.

Phylum Polypodiophyta

Pteridaceae - maidenhair fern family

4 genera in Wisconsin

Sori that lack indusia or are protected by a reflexed or revolute margins



Distinctively compound frond with dark purple stipe and rachis

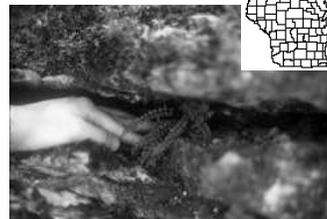


Adiantum pedatum
Maidenhair fern

Phylum Polypodiophyta

Aspleniaceae - spleenwort family

1 genus in Wisconsin. Defined by linear or kidney shaped sori.



Asplenium viride
(*A. trichomanes-ramosum*)
Green spleenwort



Asplenium platyneuron
Ebony spleenwort

Phylum Polypodiophyta

Onocleaceae- sensitive fern family

2 genera in Wisconsin (also *Matteuccia* – ostrich fern). Sensitive ferns has dimorphic fronds. Sterile frond pinnately lobed. Fertile frond turning black.

Onoclea sensibilis
Sensitive fern



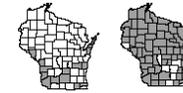
Phylum Polypodiophyta

Dryopteridaceae - woodfern family

Large and diverse group of ferns; often broadly defined to include other smaller families. 2 genera and 13 species in Wisconsin.



Polystichum acrostichoides
Christmas fern



Dryopteris intermedia
Shield fern

Phylum Polypodiophyta

Polypodiaceae - rockcap family

40 genera and over 500 species in tropics and subtropics, but a single species in Wisconsin.

Distinctive fronds: simple, pinnately lobed; leathery. Colonizes bare rock.



Sori in two rows on each lobe.



Polypodium virginianum
Rockcap fern

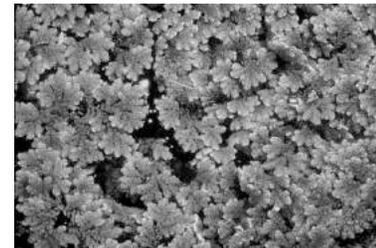
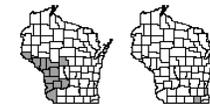
Phylum Polypodiophyta

Salviniaceae (Azollaceae) - mosquito fern family

2 species in Wisconsin. Floating aquatic, reduced ferns with 2 ranked leaves, each 2 lobed. Symbiotic relationship with N₂ fixing blue green bacteria *Anabaena azollae*.

Heterosporous!

Western & SE coastal elements



Azolla mexicana & *A. caroliniana*
Floating fern