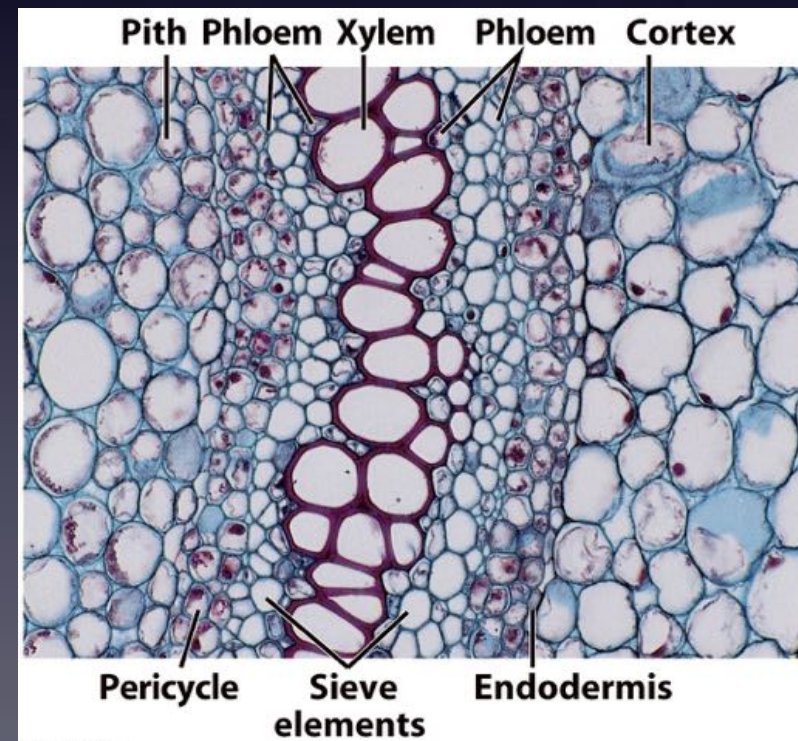
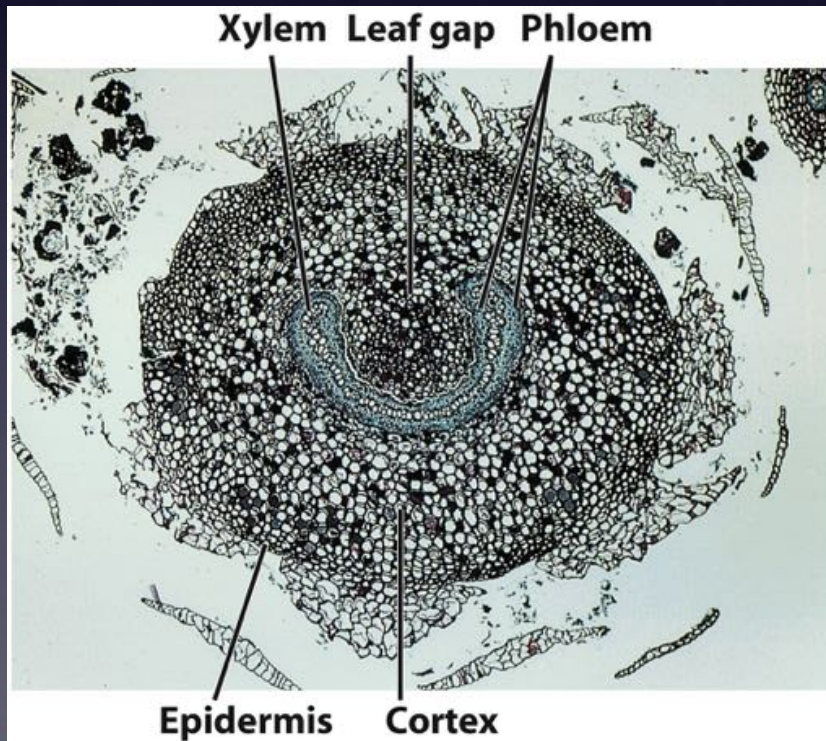


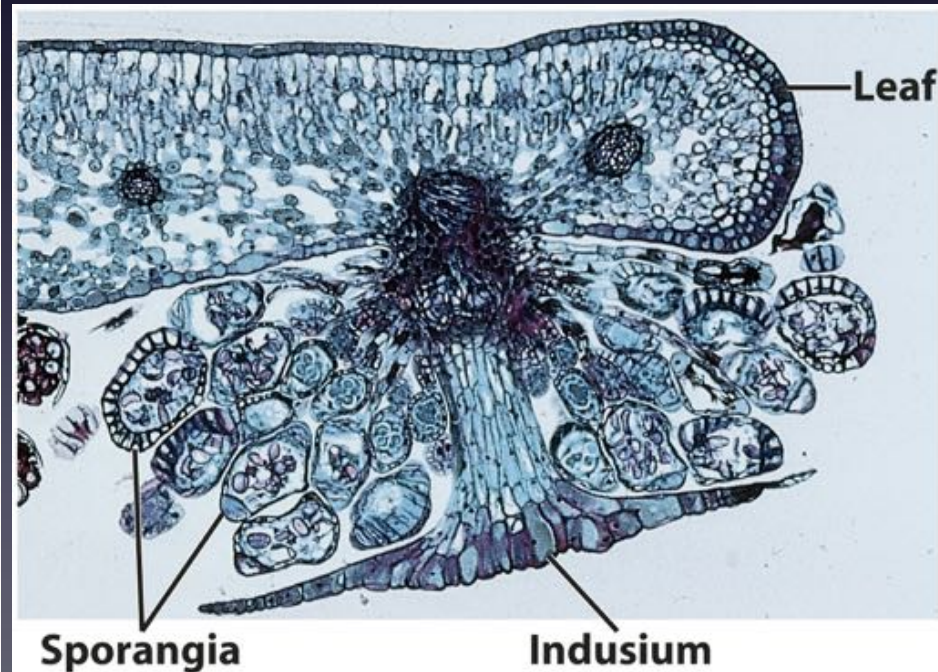
Class Polypodiopsida

Most Polypodiopsida are homosporous leptosporangiate ferns

- Mostly all familiar ferns
- 320 genera and 10,500 spp
- Rhizomes: **siphonosteles** (amphiphloic or ectophloic)
- Leaves or **fronds** are **megaphylls**
- Only the “Water Ferns” are **heterosporous**



- **Lamina** can be simple or divided into leaflets or **pinnae** attached to the **rachis**
- **Circinate vernation**: young leaves are coiled or circinate (fiddleheads)
- Sporangia occur in clusters or **sori**
- **Indusia**: specialized outgrowths of the leaf covering the sori

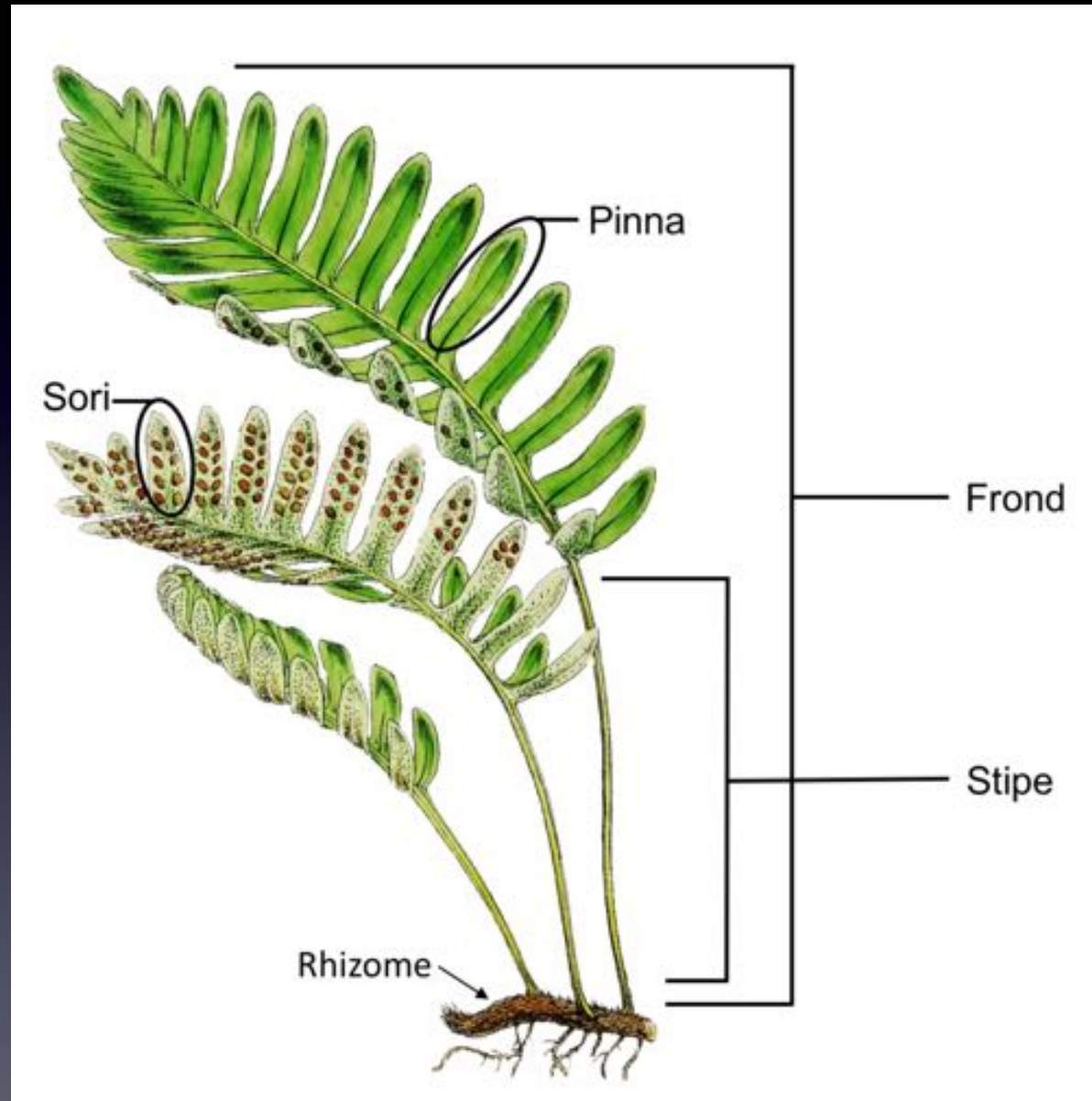




Naked indusia



False indusia or pseudindusia

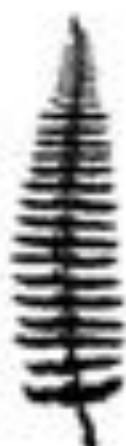




simple



pinnatifid



pinnate



pinnate-
pinnatifid



bipinnate



bipinnatifid



tripinnate

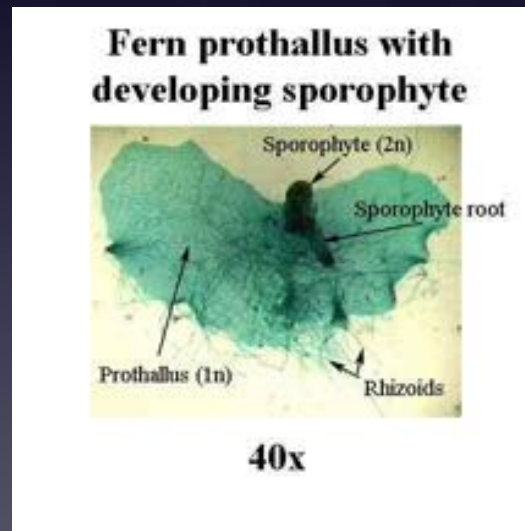
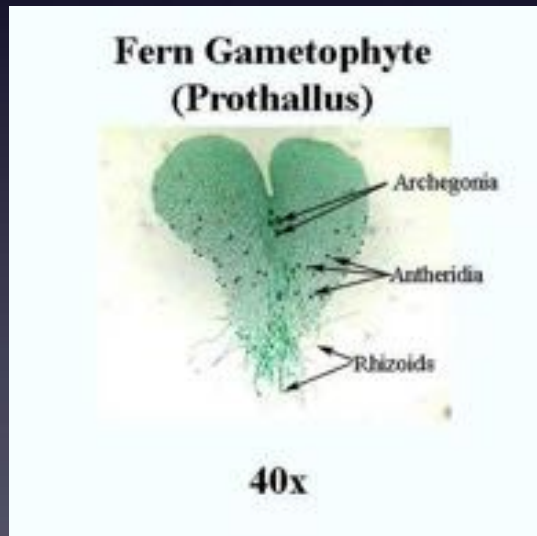


tripinnate

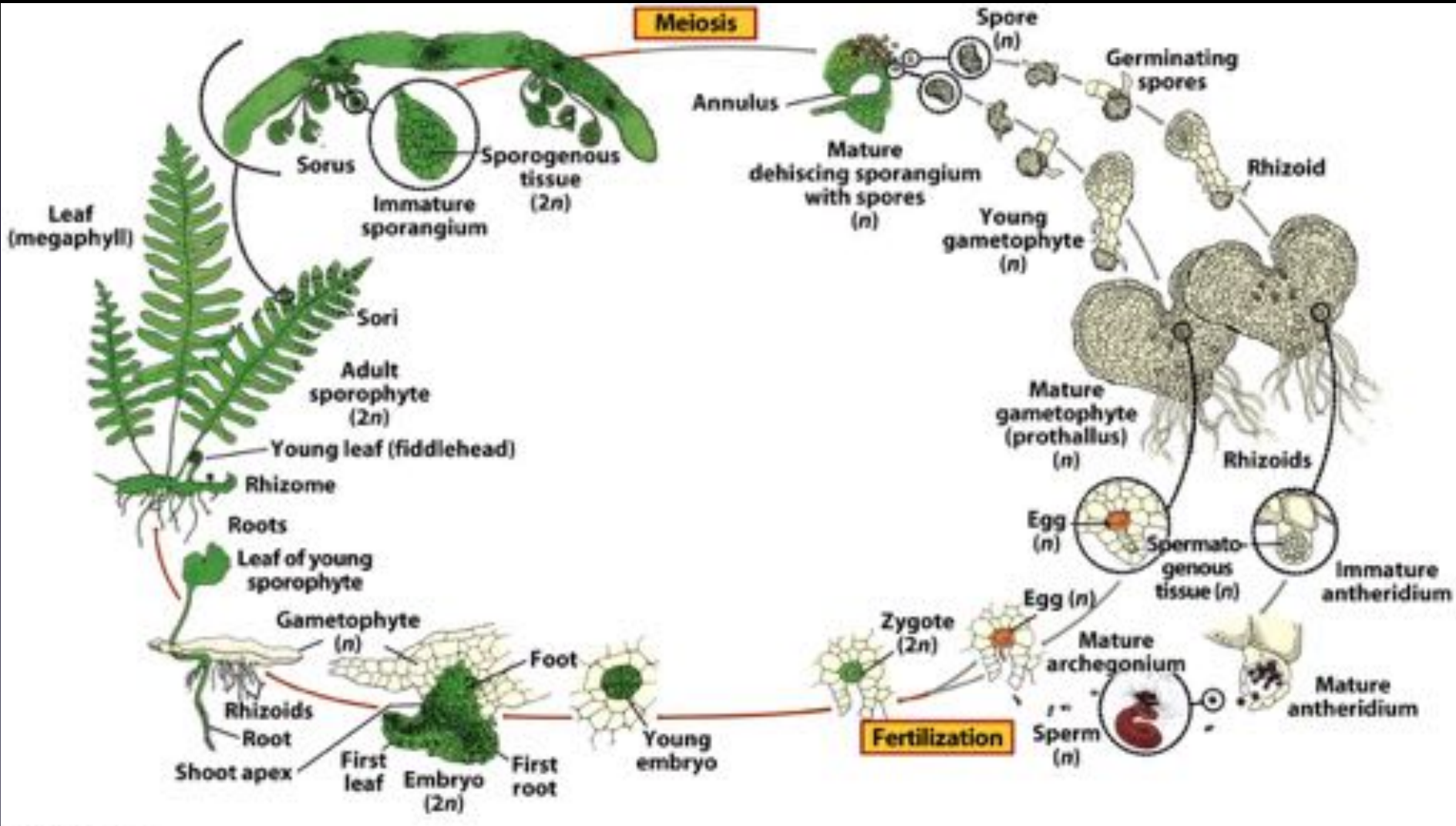


bipinnate-
pinnatifid

- Bisexual gametophytes are free-living developing into **prothallus** with antheridia, archegonia, and rhizoids
- Water is required for fertilization
- The embryo or young sporophyte receive nutrients from the gametophyte through a **foot**
- Sporophyte is perennial, while gametophytes are short-lived



Life cycle of *Polypodium*



In some ferns the gametophytes reproduce asexually by gemmae and sporophytes are never formed

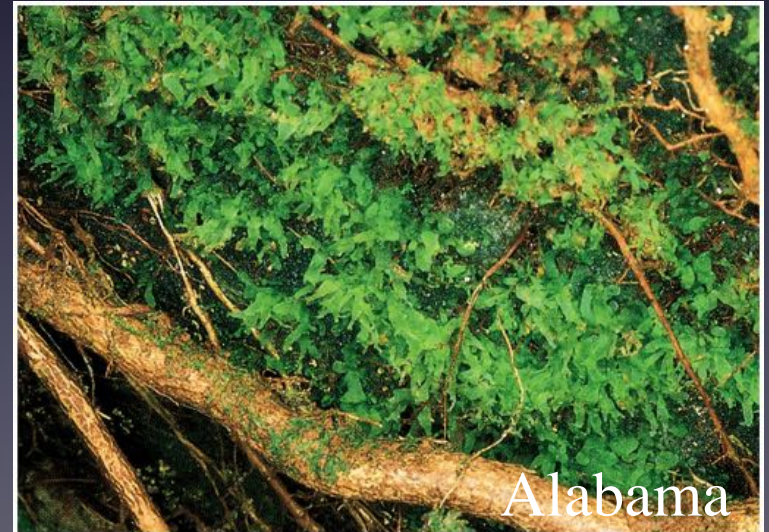
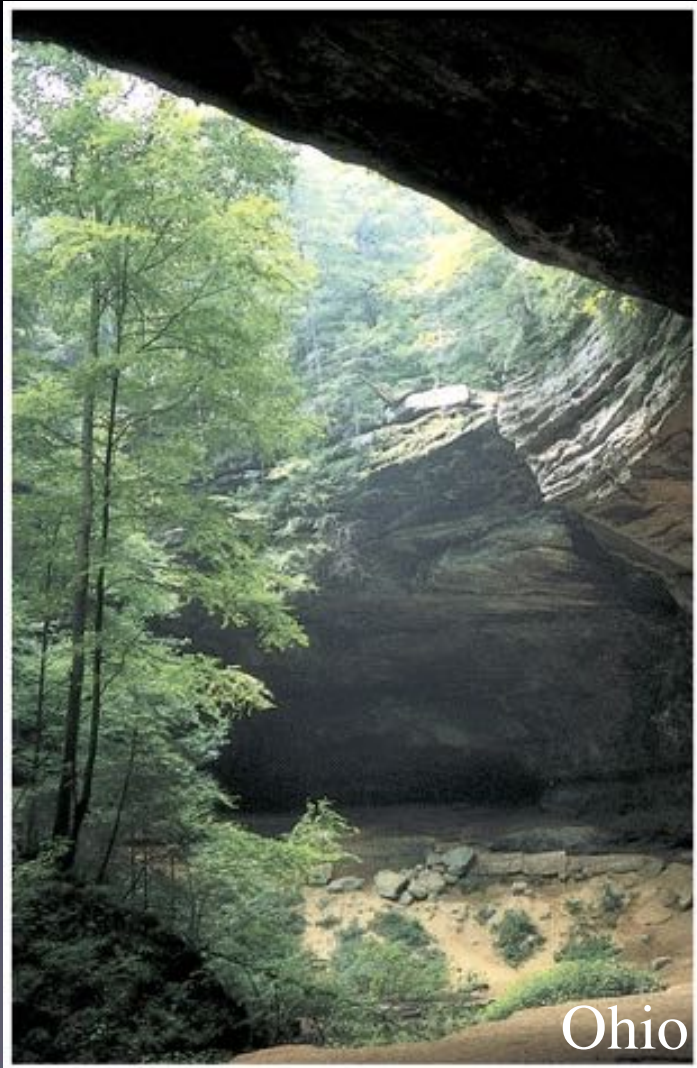


Figure 17-34c
Raven Biology of Plants, Eighth Edition
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Systematics of living Polypodiopsida

- Most abundant and diverse ferns, especially in the tropics, but well represented in the temperate zone
- Two species are **poisonous** to livestock, *Onoclea sensibilis* and *Pteridium aquilinum*
- Some ferns are **edible** by humans including the fiddleheads of *Osmunda* and *Athyrium esculentum*
- From small, delicate, filmy plants to large tropical tree ferns
- Classified in 7 Orders:
 1. Osmundales
 2. Hymenophyllales
 3. Gleicheniales
 4. Schizaeales
 5. Salviniales
 6. Cyatheales
 7. Polypodiales

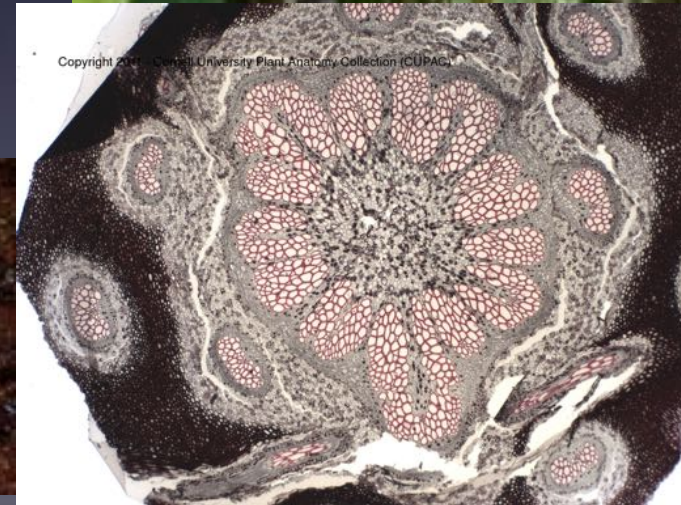
1. Osmundales

- This group represent a **transitional form** between the eusporangiate and the leptosporangiate ferns
- Many **primitive features** such as:
 - Sporangium large and not associated in sori
 - Lack of indusium
 - Simultaneous maturation of sporangia or **Simple**
 - Absence of annulus, only a group of thickened cells
 - Spores and sperm in large number
 - Spores thin-walled and green



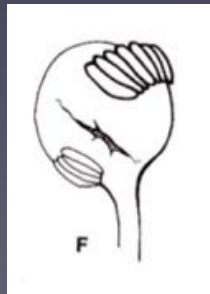
Osmunda

- Cosmopolitan with 3 spp in USA
 - *O. regalis*, the royal fern
 - *O. cinnamomea*, the cinnamon fern
 - *O. claytoniana*, the interrupted fern
- **Perennial ferns** found in hydric habitats
- Leaves are once or twice pinnately compound
- Vascular tissues in a circle of strands separated by narrow parenchyma leaf gaps
- Stele **ectophloic siphonostele**
- Gametophytes are liverwort-like and long-lived



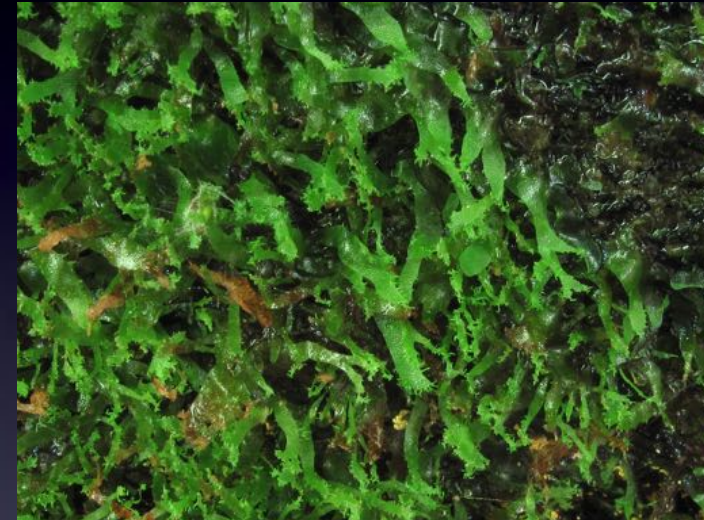
2. Hymenophyllales the “filmy ferns

- Small ferns, usually epiphytic in habitats consistently humid
- Mostly tropical
- *Hymenophyllum* and *Trichomanes* represented in USA
- Blade unistratose or rarely with 2-4 cells
- No intercellular spaces or stomata
- Sori terminal on the veins
- Involucre cup-shaped to bivalvate
- Sporangia with obliquely vertical annulus uninterrupted, opening irregularly



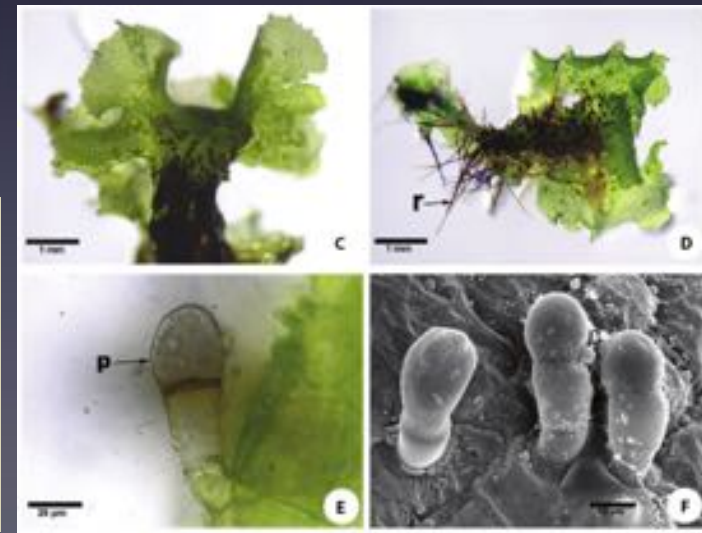
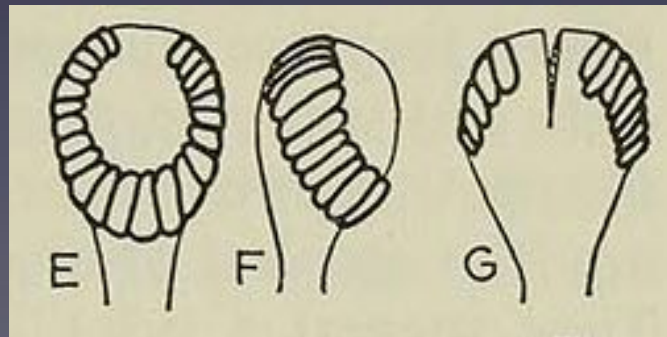
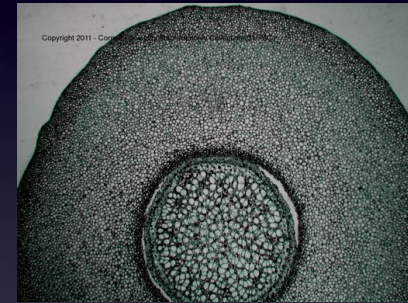
Hymenophyllum and *Trichomanes*

- Delicate-leaved ferns
- *Trichomanes* found in extremely moist habitats (rocks bathed in spray from waterfalls)
- **Gradate** organization of the sorus: the oldest sporangium at the apex and the youngest sporangia at the base
- Sporangium opening transversely
- *Hymenophyllum* with gametophytes branching and straplike
- *Trichomanes* gametophytes branching filamentous



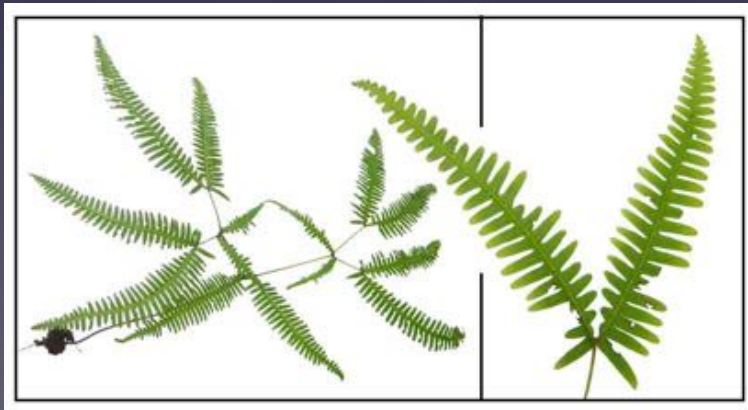
3. Gleicheniales

- Tropical and south temperate regions
- Over 100 spp
- *Gleichenia*
- Rhizomes with protosteles
- Leaves indeterminate
- Lamina **pseudodichotomously** forked or simple
- **Abaxial** sori with 5-15 sporangia
- Sporangia with a transverse-oblique annulus
- Lacking indusium
- Gametophytes on soils or underground, with club-shaped hairs



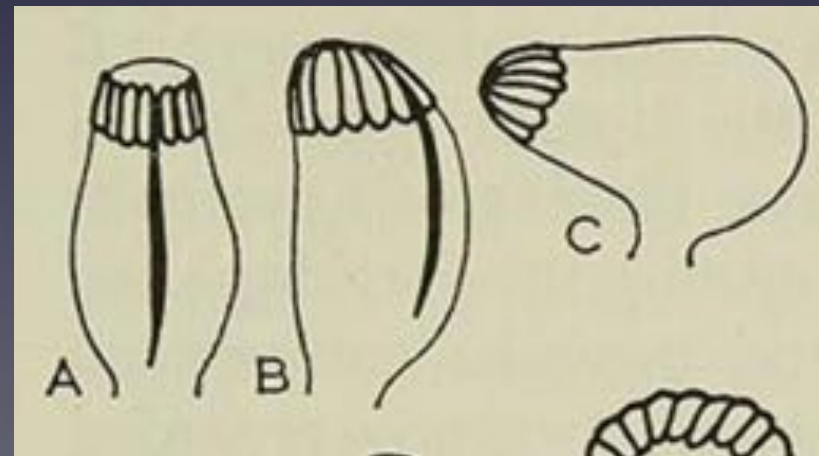
Gleichenia

- This fern has prostrated, dichotomously branching rhizomes with long **internodes**
- Leaves, which are twice or more times **pinnately** compound, grows for long periods and are vine-like
- Can attain up to 50 m
- Gametophytes cordate with a thick mid-region
- Antheridia producing large numbers of sperm



4. Schizaeales the “climbing ferns”

- Leaves differentiated in fertile (sporophylls) and sterile leaves (trophophylls)
- Absence of well defined sori
- Sporangia with transverse, subapical, continuous annulus
- Sporangia aperture is vertical
- Stele is protostelic or siphonostelic
- Very old family, fossils from the Carboniferous



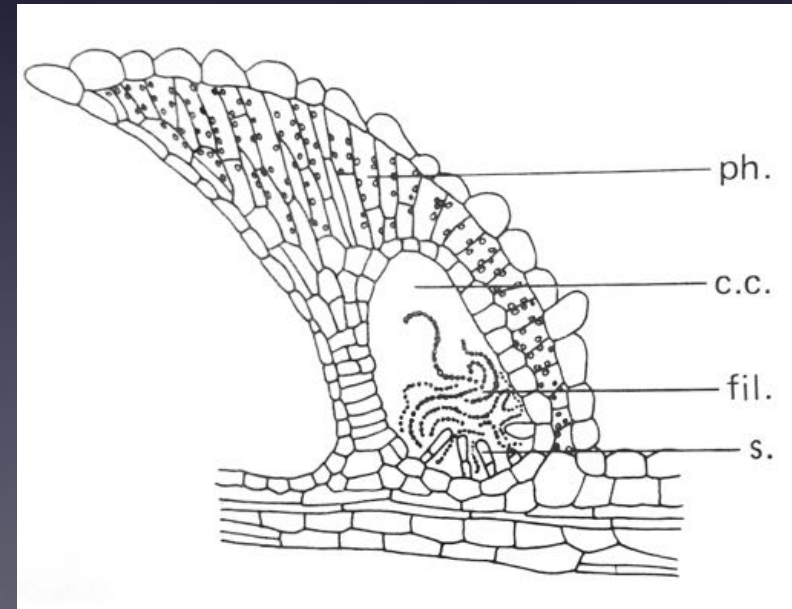
Lygodium and *Anemia*

- Best known genera of the family
- Common in the USA
- *Lygodium*, the climbing fern
- Petioles and rachises of the compound leaves of *Lygodium* are almost indeterminate growth
- Leaves almost 30m long
- Growing 3.4-6.5 cm/day
- Rhizomes are short
- Sporangia on leaf margins
- Gametophytes from **chlorophyllous** and filamentous to fleshy and subterranean



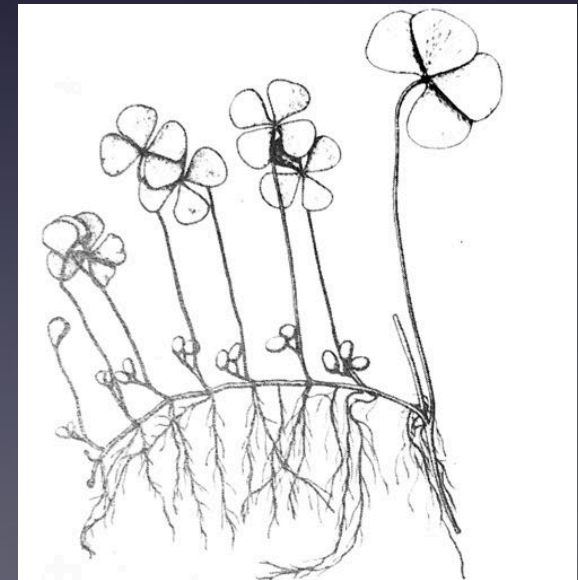
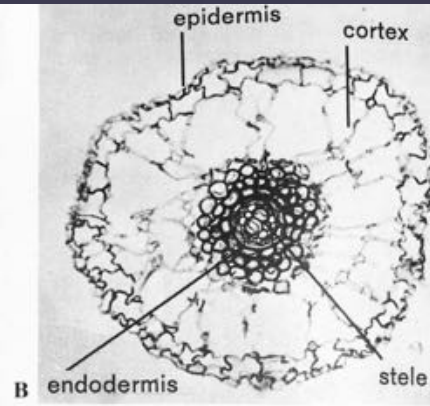
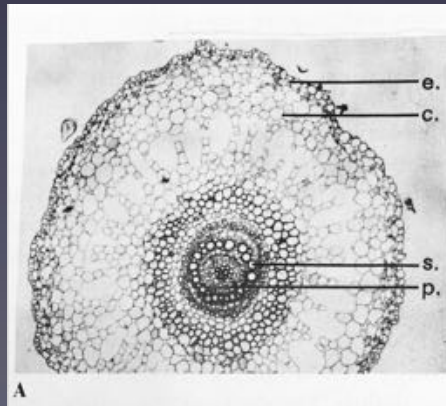
5. Salviniales or “the water ferns”

- Heterosporous ferns
- Plants **monoecious**
- **Aerenchyma** tissue often present in roots, rhizomes and petioles
- Annulus absent
- Spores with **endosporic** germination
- Reduced gametophytes
- Two families: **Marsileaceae** and **Salviniaceae**



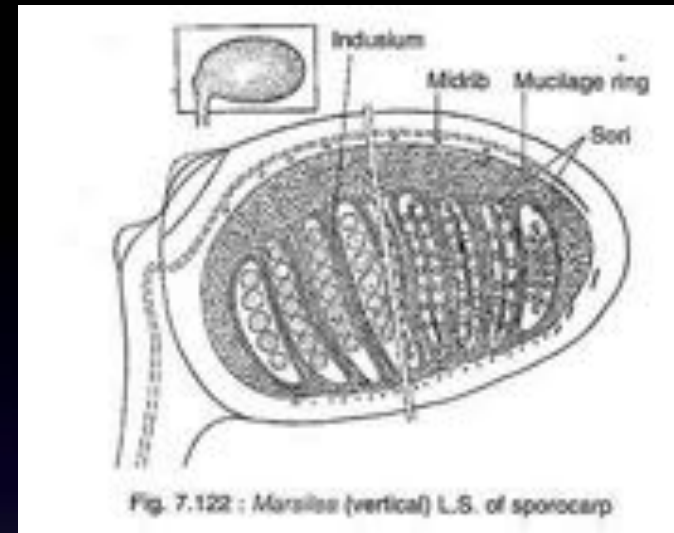
- **Marsileaceae: *Marsilea***

- 50-70 spp
- **Amphibious**, growing on damp or wet soil or with the leaves floating on the water surface
- Rooted aquatics
- Leaves resemble a four-leaf clover
- Plant body elongate, branching, stolon-like stem
- **Stolon** on the surface of the mud or below it
- **Leaves** are in two rows, alternately on opposite sides of the stem, arising in circinate fashion
- **Stele** is an **amphiphloic siphonostele**



•Reproduction: the sporophyte

- Sporangia are borne in specialized structures known as **Sporocarps**
- Sporocarps are found on short lateral branches of the petioles and they are resistant to drought
- First soft and green then brown and nutlike at maturity
- They may **represent** a fertile pinna that has become folded with the margins united and enclosing the fertile surface
- They contain the sori with **megasporangia** and **microsporangia**
- Gradate** sori



- Sporocarp wall is degraded over time, water is imbibed into the sporocarp
- The swelling forces the two halves apart and a vermiform gelatinous structure, the **sorophore**, emerges, bearing the sori
- Sporangial walls gelatinize releasing **microspores** and **megaspores**
- Megaspore has two layers, inner **endospore** and outer **exospore**
- Exospore has 5 layers and expands into a complex structure
- The **basal envelope** is folded horizontally while the **papilla envelope** is folded longitudinally
- Within the papilla, a bell shaped structure, the **sperm lake**, is filled with a fluid

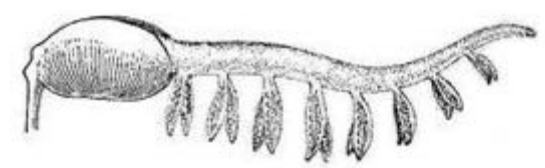
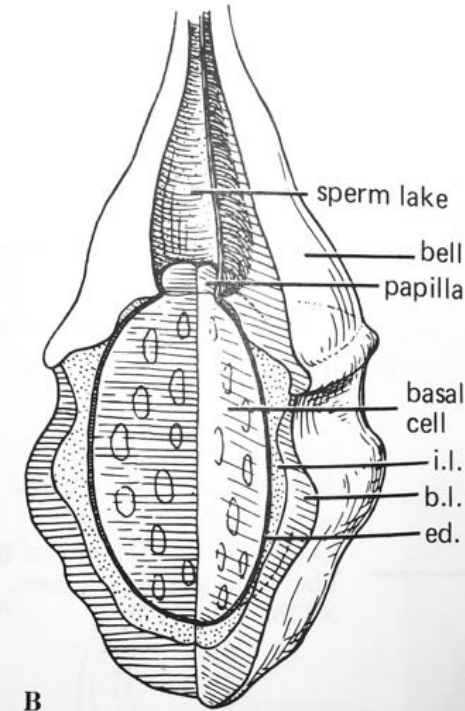
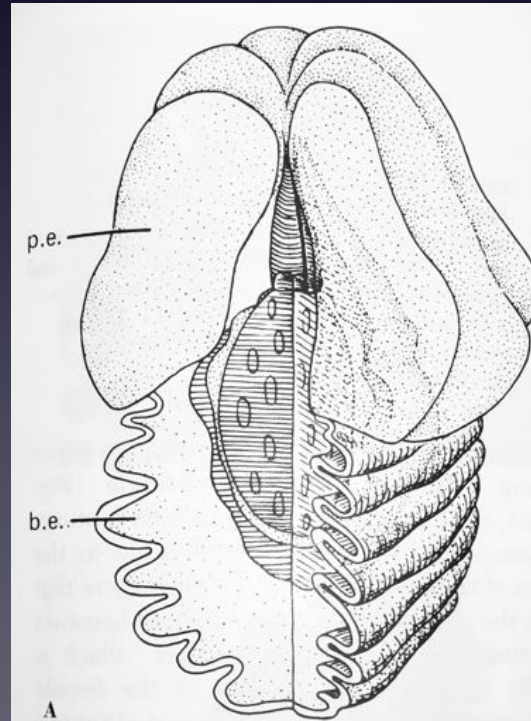
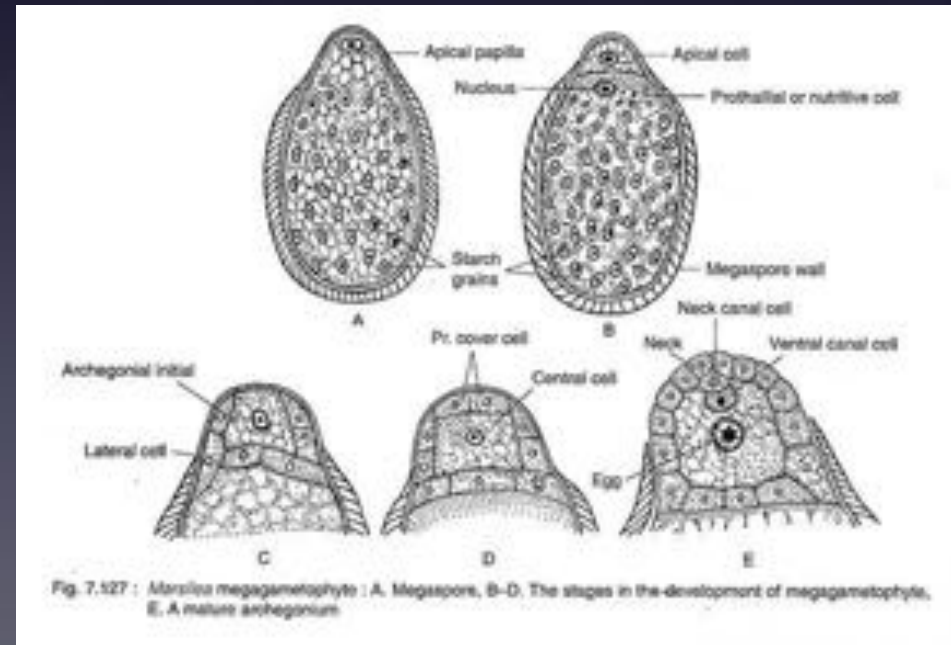
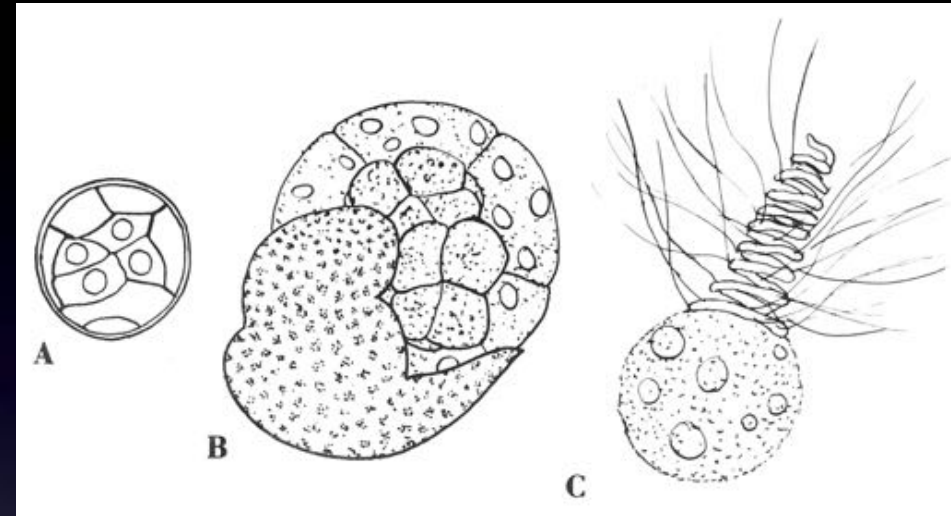


Fig. 7.125 : *Marsilea* : Extrusion of the sori on the mucilaginous cord



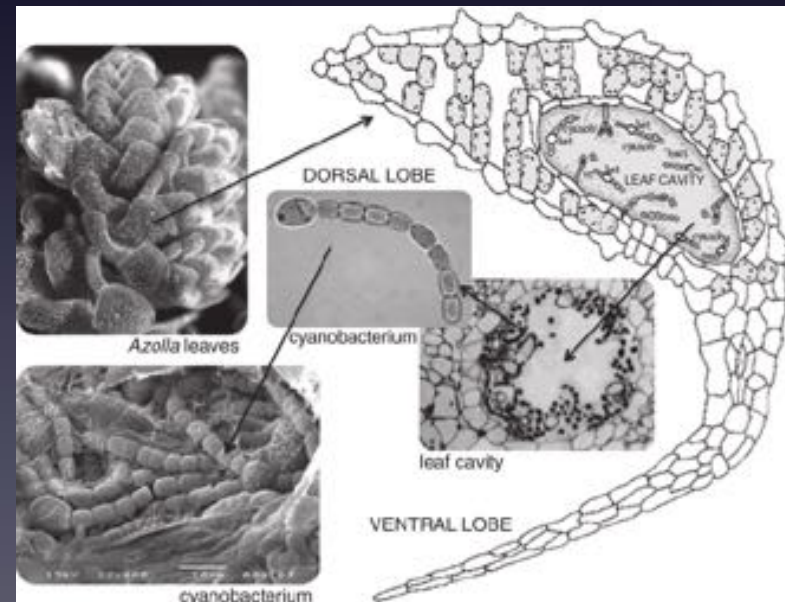
Reproduction: the gametophytes

- Microspores form **microgametophytes** or male gametophytes
- The microspore wall rupture and release the antheridia
- **Antheridia** release one single, large sperm
- Sperm are **coiled** and **multiflagellated**
- **Megagametophytes** with a single apical archegonium
- Megaspore wall form a gelatinous matrix
- Sperm are attracted chemotactically, swarm into the matrix and fertilization occurs

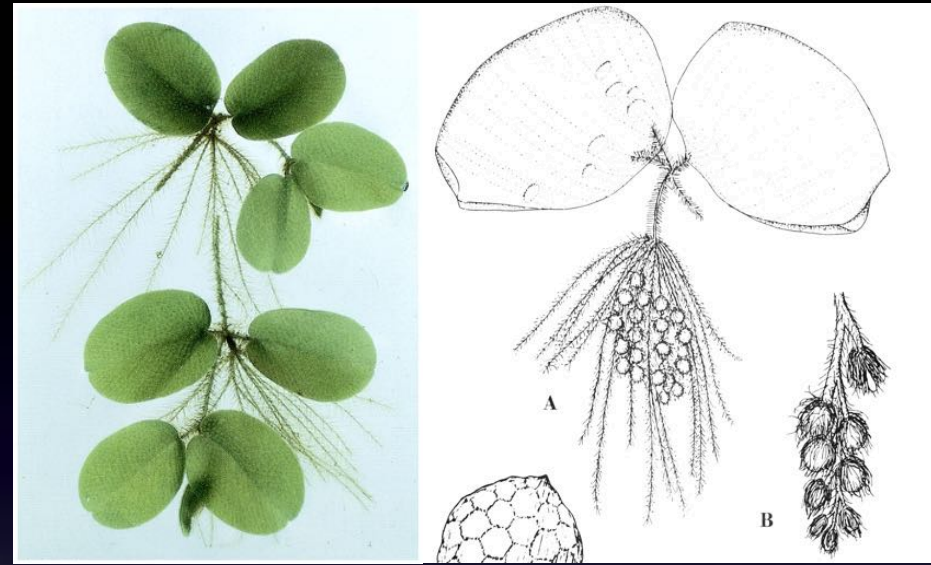


•Salviniaceae

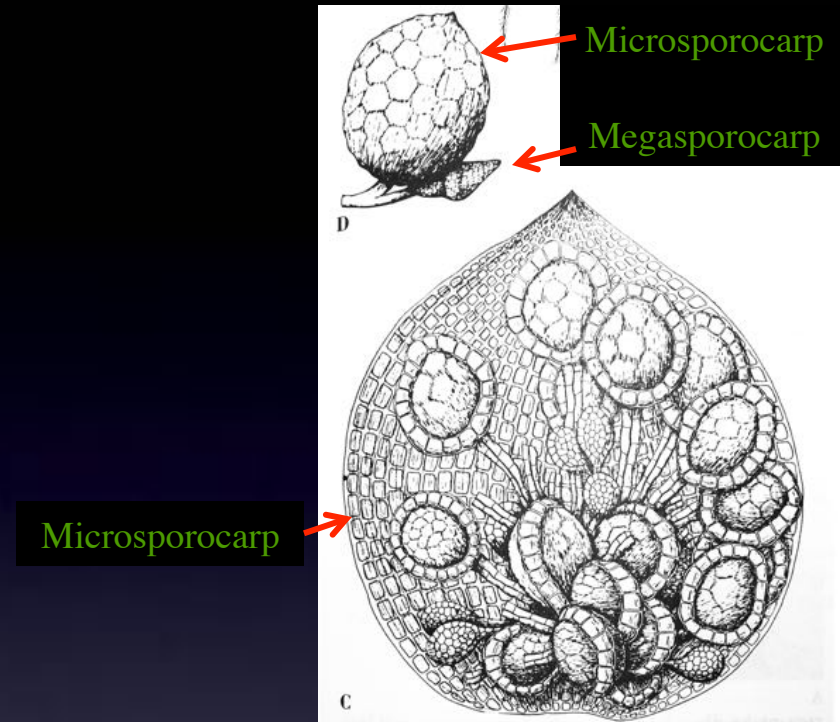
- Floating ferns with sporangia in **sporocarps**
- Sporocarps either **micro- or megasporocarps**
- Azolla**, with 2 spp in USA, “mosquito fern”
 - A. caroliniana* in the Eastern USA
 - A. filiculoides* in the Western USA
 - With **roots**
 - Ponds and swamps often colored in red by blooms in intense light (**anthocyanin**)
 - with tiny alternate crowded **bilobed leaves** on slender stems
 - Each leaf is composed of a **chlorophyllous dorsal lobe** and a **submerged achlorophyllous ventral lobe**
 - Dorsal lobes contains cavities with colonies of a cyanobacterium *Anabaena azollae*



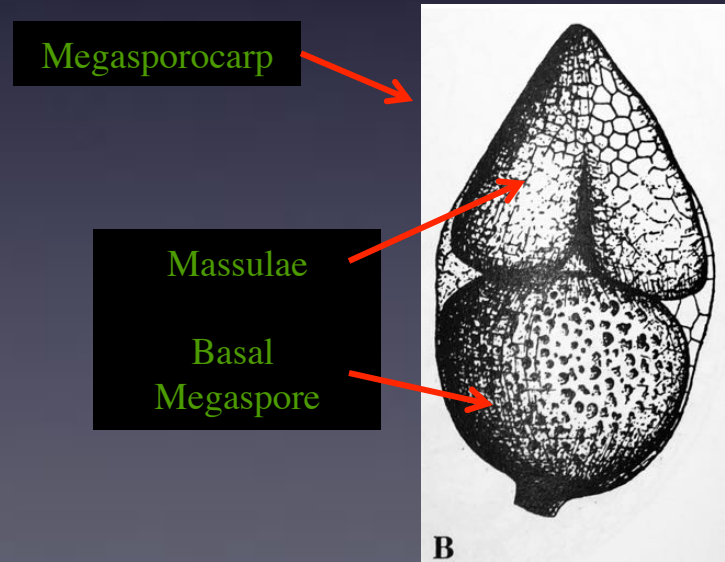
- *Salvinia*
- *S. minima* in USA, “water spangles”
- Rootless
- Leaves in whorls of three, two are floating
- The third leaf hangs down below the water and is highly dissected resembling a mass of roots
- Floating leaves are covered with hairs and waxy papillae
- Sporocarps with a single sori enclosed by modified indusium



- **Megasporocarp** developing 1 megasporangium and 1 megaspore
- Tapetal cells develop a **tapetal plasmodium** which becomes a lobate **massulae** over the megaspore
- The massulae directly surrounding the megaspore is called **perispore**



Microsporocarp

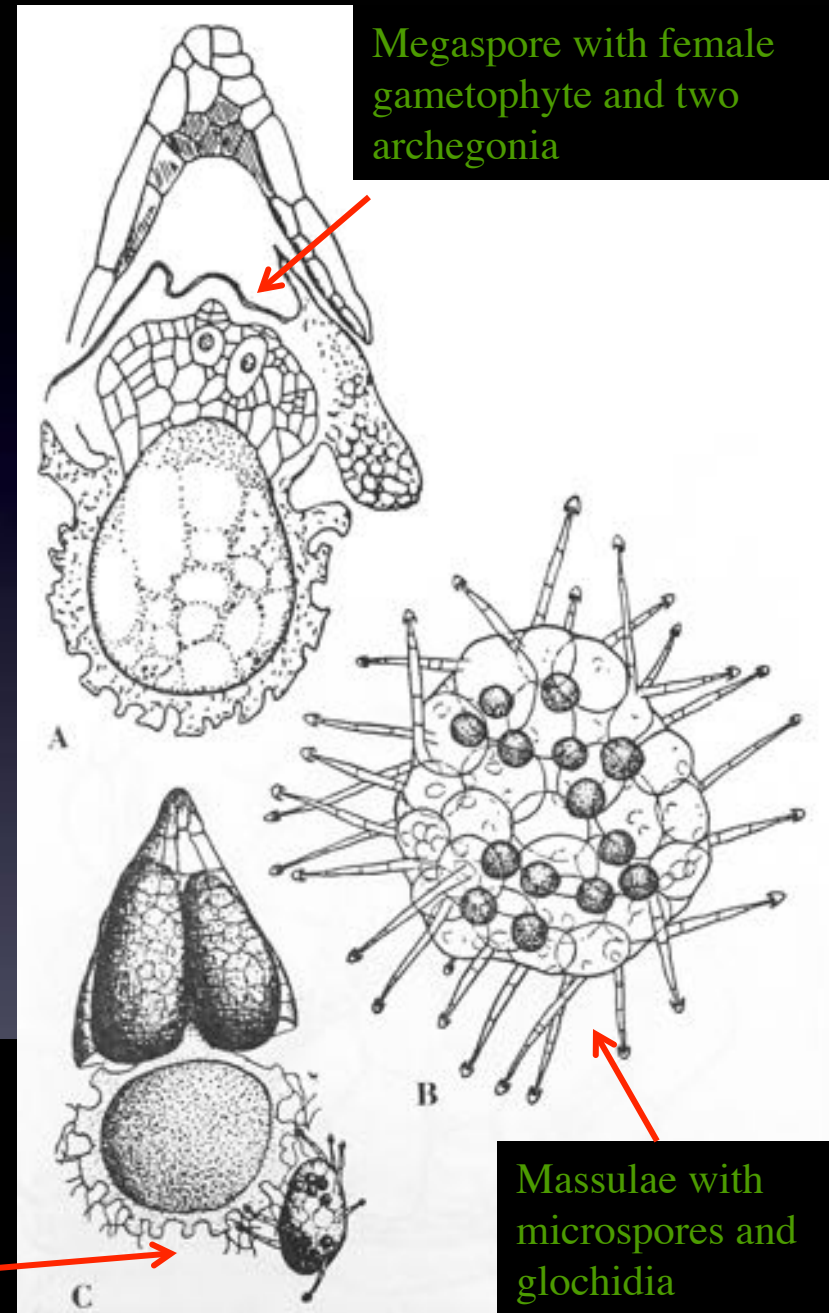


- The larger **microsporocarp** contain several microsporangia

- Microspores** remain attached to their massulae and develop hook-like protuberances called **glochidia**, that become attached to the megasporic massulae or perispore

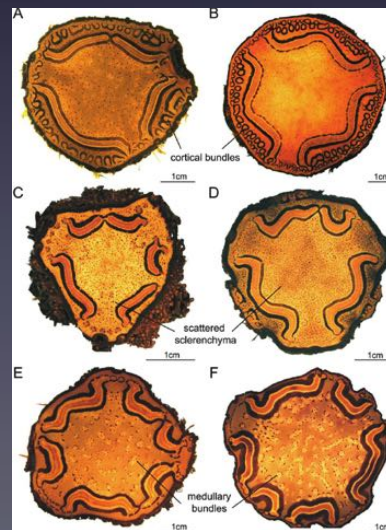
- Microgametophyte** develops one antheridia with 8 sperm cells

- Megagametophytes** forming one or more archegonia

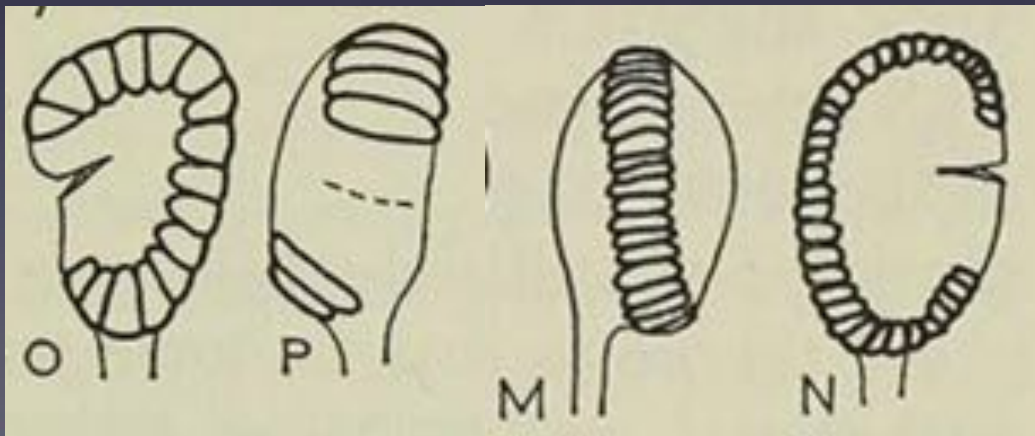


6. Cyatheales or “tree ferns”

- Native to tropical rain forests
- Up to 20m in height
- Widely cultivates indoors
- The trunks (stems) rarely branched and covered by a dense mat of **adventitious** roots and leaf bases
- Others with **creeping** stems
- Stem base with a dense, supportive, buttress-like covering of persistent roots
- **No cambium, no secondary growth**
- Stele simple and protostelic when young, becoming complex with age
- Trunk apex with a crown of leaves
- Leaves are circinate and up to 4 m



- Sporangia born on **gradate** sori
- In some, sori are marginal and subtended by a **cuplike indusia**; in others they are **abaxial** and **exindusiate**
- **Annulus** is obliquely vertical with a **transverse** sporangial dehiscence with the help of lip cells or **stomium**
- Gametophytes are **cordate** and green
- Archegonia with long curved necks



7. Polypodiales

- Most familiar ferns
- From temperate to tropical areas
- Mostly perennial, few evergreen
- **Advanced** characters
- Indusia lateral or centrally attached, or secondarily reduced
- Sorus is a **mixed** type
- Sporangia with a vertical **annulus** interrupted by **long stalk** and **stomium**
- Number of spores 64 to 32
- **Green gametophytes**, usually cordate or ribbon-like, above soil
- **Reduced antheridium** to 3 cells and few sperm
- Common ferns: *Polypodium*, *Thelyperis*, *Adiantum*, *Polystichum*, *Woodsia*, *Pteris*, *Pteridium*, and *Nephrolepis*



Polypodium



Polystichum



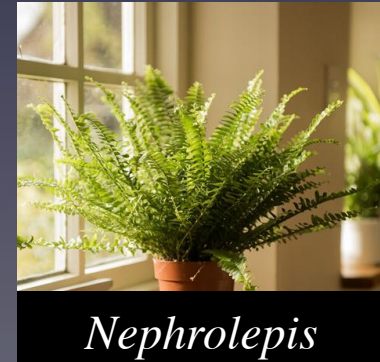
Woodsia



Pteris



Pteridium



Nephrolepis

Adiantum capillus-veneris
Venus Maidenhair Fern

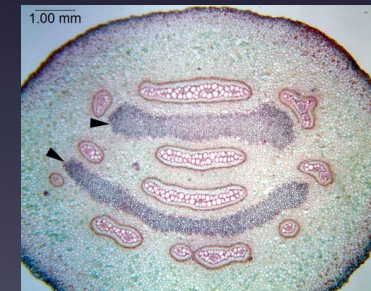


Thelypteris dentata
Downy Shield Fern

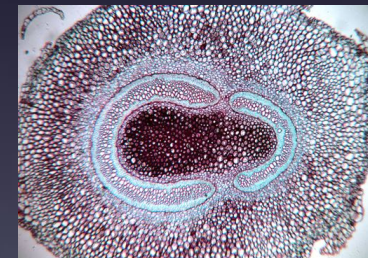
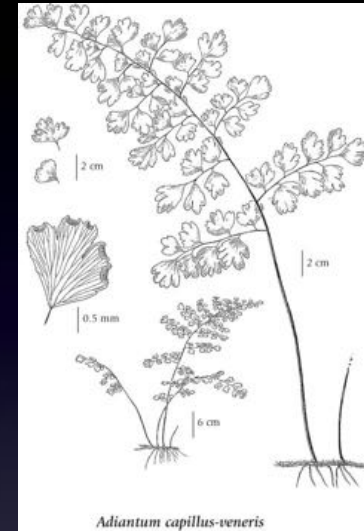


- Stem is subterranean
 - In *T. dentata* is ascending
 - In *Adiantum* is horizontal rhizome
- In both the stems are clothed with a dense mass of adventitious roots
- Apical cell on the stem tip often concealed by scalelike organs known as **paleae**
- Young stems are protostelic
 - Adult *Adiantum* is **solenostelic** (siphonostele with no overlapping leaf gaps)
 - Adult *Thelypteris* is **dictyostelic** (siphonostele with overlapping leaf gaps)
- Leaves are **compound** and circinate
 - *Adiantum* venation is dichotomous
 - *Thelypteris* venation is pinnate

Thelypteris

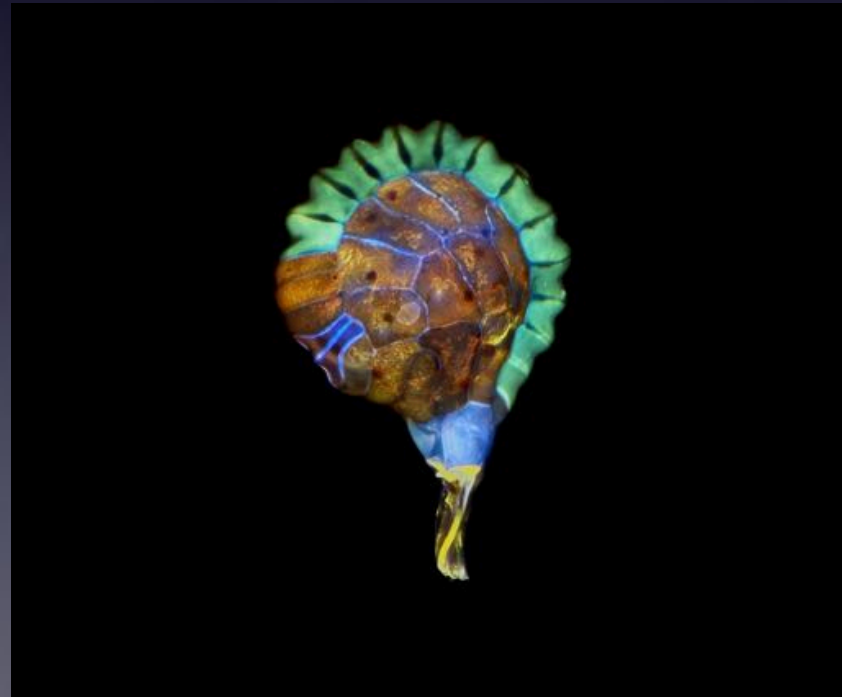
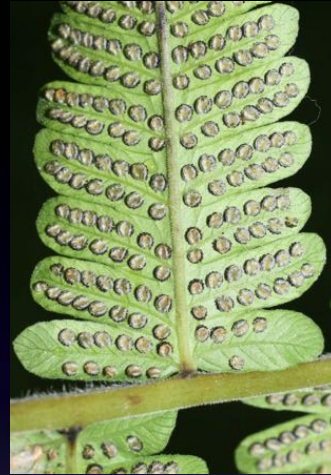


Adiantum



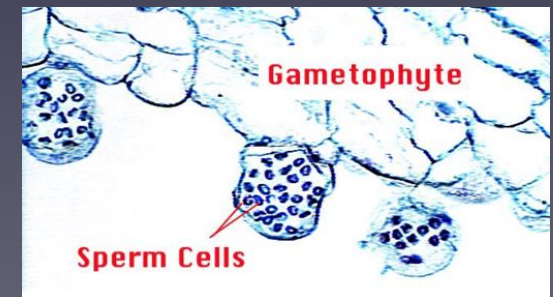
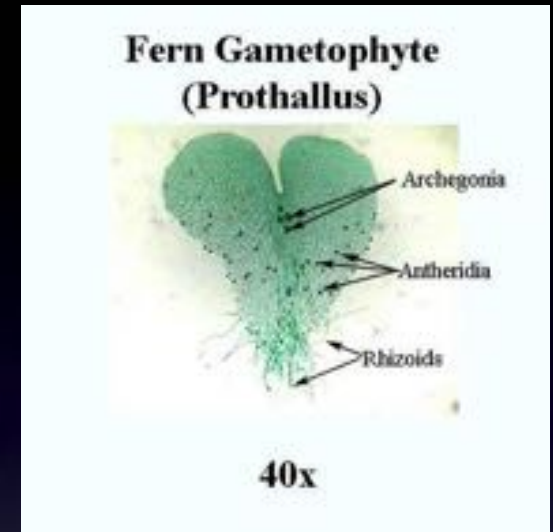
Reproduction: Sporophyte

- Leaves are both vegetative and fertile
- Sporangia in sori
- In *Adiantum*, sori are marginal and covered by a false-indusium or **pseudoindusium**
- In *Thelypteris*, sori lie over the veins of the pinnules and each is covered by a true **indusium**
- Sporangia arise from the lower leaf surface from a region known as **receptacle**
- Order of development is **Mixed**
- With a **vertical annulus** forming an incomplete ring about the sporangium
- Usually four lip cells or **stomium**
- Spore dissemination by a catapult-like dehiscence



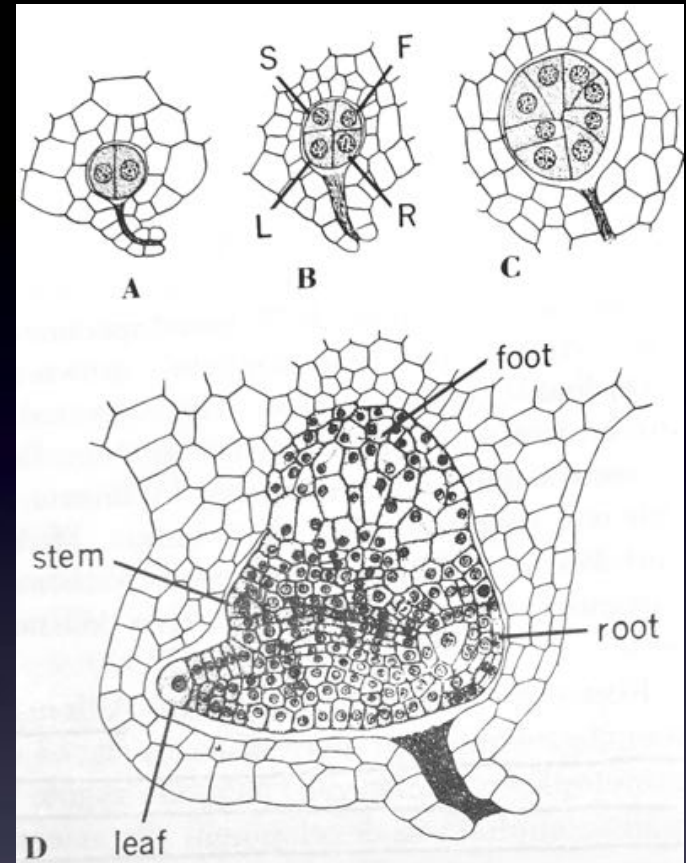
Reproduction: Gametophyte

- Germination of spores affected by **allelopathic** substances
- Gametophytes are cordate
- **Prothallia** (gametophytes) are **monoecious** but **protandrous**
- Antheridia form nearer the posterior portion of the gametophyte
- **Archegonia** develop on the thickened, central cushion nearer the apex
- Antheridia are **protuberant**
- Archegonia only the necks project from the surface
- Sperm multiflagellate
- Other ferns are under **antheridiogens**
- The moist habitat of the gametophytes, along with the ventral position of the sex organs enhance the fertilization events



Reproduction: Embryogeny

- Zygote divide to form a **Quadrant**
- Organs develop from this stage
 - ✓ Foot
 - ✓ Primary leaf
 - ✓ Root
 - ✓ Stem
- Root and primary leaf burst forth
- The **root** penetrates the substrate
- The **leaf** emerges through the apical notch
- After several leaves are formed the gametophyte turns brown and the sporophyte initiates an independent existence
- From spore to young sporophyte it takes from 53 to 113 days



SUMMARY

- The primary vascular tissues are arranged in steles of three basic types
- Roots and leaves evolved in different ways
- Vascular plants may be either homosporous or heterosporous
- Seedless vascular plants exhibit an alternation of heteromorphic generations
- The oldest fossils of vascular plants belong to the Phylum Rhyniophyta
- The living seedless vascular plants are classified in two phyla
- Lycophytes are characterized by the presence of microphylls; the members of the other phyla of vascular plants have megaphylls