

**GROUP 1**

papillose cells and a strong single costa

often pinnate

paraphylla among leaves

**GROUP 2**

papillose cells, costa weak, double or absent

stringy, shaggy, or pinnate

**GROUP 3**

smooth cells, strong single costa, and either slender leaves or differentiated alar cells

alar groups

**GROUP 4**

smooth cells, strong single costa, average leaves and undifferentiated alar cells

may be treelike, wormlike, shaggy, or flattened

**GROUP 5**

smooth cells, costa weak, double or absent, and either leaf tips slender and curved or cells inflated

alar groups

**GROUP 6**

smooth cells, costa weak, double or absent, leaf tips not slender and curved, alar cells not inflated

shoots may be flattened

often have broad bodies or brood branches

The diagram illustrates the evolution of leaf structure in mosses, showing various adaptations and their corresponding moss genera. The diagram is organized into three rows, each representing a different type of papillae (small projections on the leaf surface) and their associated leaf characteristics.

- Top Row: Multiple papillae (at least on apical cell of branch leaves)**
  - Thuidium, Raietella, Pelekium*: pinnate, with paraphyllia. Often fern-like.
  - Anomodon*: never pinnate, no paraphyllia. Leaf tips intact.
  - Haplomyenium triste*: broken leaf tips.
- Middle Row: Single papillae at ends of cells**
  - Cratoneuron commutatum*: paraphyllia on stems, basal or alar cells enlarged.
  - Rhytidium rugosum*: alar cells small, leaves both pleated & wavy.
  - Helodium*: paraphyllia on stems & leaf bases.
  - Bryhnia*: either inflated alar cells or small sharp teeth.
- Bottom Row: Single papillae in middle of cells**
  - Thelia*: spiny teeth, tall forking papillae. Tightly overlapping leaves.
  - Haplodadium*: paraphyllia, no teeth pinnate. Like *Thuidium* but with single papillae on all cells.
  - Lindbergia brachyptera*: shorter costa, longer cells.
  - Leskea*: no paraphyllia or teeth, branches stringy & irregular.

The diagram illustrates the evolution of leaf structure in mosses, showing three rows of mosses with increasing complexity in leaf shape and branching. Each row includes a moss name, a description of its leaf structure, and a small diagram of the leaf and stem.

**Row 1: Schwetzhkeopsis fibronia**  
 short cells → thick-walled cells, square cells running up margins  
 leaves spreading, branches somewhat flattened

**Row 2: Myurella**  
 deeply concave spoon-shaped leaves, loose or tight branches  
 thin-walled cells, basal marginal cells not differentiated

**Row 3: Heterocladium dimorphum**  
 heart-shaped leaves, shaggy branches, paraphyllia on stems

**Row 4: Pterigandrium filiforme**  
 small moss with skinny thick-walled cells and spoon-shaped leaves  
 a small, dark creeper with stringy branches

**Row 5: Rhytidadelphus triquetrus**  
 large mosses with skinny thin-walled cells and pointed leaves  
 main stems erect & very shaggy branches irregular

**Row 6: Hylacomium splendens**  
 stipepladder growth, 3x pinnate  
 main stems arching, branches more or less pinnate

**Row 7: Ctenidium molluscum**  
 1x pinnate, heart-shaped stem leaves

**wetland mosses with long slender leaves**

*Tomenthypnum nitens*  
Erect, pinnate, with straight pleated leaves

*Drepanocladus*, *Hematocaulis*, *Sanionia*, *Warnstorfia*, *Limprichtia*  
Leaves often curved, alar or basal cells usually differentiated

*Dichelyma*  
Leaves very slender, sharply keeled, in three rows

*Leptodictyum riparium*  
Leaves broader, not keeled, in more than three rows

**enlarged and often decurrent alar cells**

*Brachythecium (i)*  
long cells, short capsules, slender tips, often pleated

*Catoneuron filicinum*  
short cells, stem & branch leaves differentiated, few paraphyllia

*Hygrohypnum (i)*  
short upper cells, long lower cells, often concave, costa often variable

*Calliergon*  
rounded concave tip, no teeth

**many small square alar cells**

*Forststroemia trichomitria*  
with a band of square cells running up the edges

*Leskeella nerosa*  
dark moss with thick-walled cells

*Campylopus (i)*  
leaf tips channeled and bent outwards or spreading

*Brachythecium (ii)*  
long cells, short capsules, slender tips, often pleated

*Hygrohypnum (ii)*  
concave leaves, costa often variable

**small square alar cells, plants small to tiny**

*Leskeella nerosa*  
dark moss with short thick-walled cells and many broad branches

*Fabronia ciliaris*  
leaves with white needle tips, cells short-rhombic

*Homalotheciella*  
Plants tiny, leaves deeply concave and sharply toothed

large, broad-leaved mosses of rocks & soil with jagged teeth

*Thuidium alghanensis*  
widest above base, paraphyllia absent, costa toothed

shaggy, horizontal, flattened branches

*Climacium*  
widest near base, paraphyllia present, costa smooth

often tree-like

*Hylocomium pyrenaeum*  
sharp, slender tip, pleated leaves, loosely pinnate branching

erect or sprawling

rounded mosses of various habitats with small teeth or none

*Homalia trichomanoides*  
branches very flat, leaves not concave

tip often twisted

*Bryodendron illecebro*  
rounded, concave leaves with abrupt, skinny tips

broad leaves, fat wormlike branches

*Cirriophyllum piliferum*  
skinny leaves, looser branches

short cells at tip

*Torteria (Eurhynchium) riparioides*  
alar cells undifferentiated, toothed almost to base

stringy moss of rocks in brooks

few or no square alar cells

*Rhynchostegium serulatum*  
pale, toothy, twisted tip

spreading leaves, flattened shoots

*Anacamptodon splachnoides*  
erect capsules with recurved teeth

leaves turn up at branch tips

*Eurhynchium*  
very toothy, short upper cells and long lower ones

*Platylorella lescurei*  
slender, stringy, irregularly branched with a border of elongate cells

*Amblystegium, Hygroamblystegium*  
strong costa, inclined capsules, no border or teeth

Diagram illustrating the evolution of plant leaves, showing various morphological adaptations and their functional implications. The diagrams are arranged in a 3x4 grid, with each row representing a different evolutionary stage or adaptation.

**Row 1: Leaf Shape and Venation**

- Brotherella:** Leaf tips all curved in one direction, plants often pinnate. *very shiny* (likely referring to the leaf surface). *toothed margins, inflated alar cells, skinny pseudoparaphylla*.
- Hypnum:** If toothed then with small alar cells or broad pseudoparaphylla. *erect & feathery*.
- Ptilium crista-castrense:** Leaves strongly pleated, fronds erect and feathery. *Leaf tips arch outwards*.
- Campylophyllum (Campyllum):** Alar cells differentiated. *long hooked tips*.
- Rhytidelaphus squarrosus:** Tip strongly toothed, alar not differentiated.

**Row 2: Leaf Shape and Venation**

- Sematophyllum:** Few, abrupt, thin-walled, bubble-like alar cells. *capsule cells with thickened corners*. *stringy branches*. *alar cells enlarged, leaves tapering to tips*.
- Callicladium haldanionum:** More & less abrupt alar cells, often thick-walled. *slender capsules*. *branches somewhat flattened*.
- Herzogella striatella:** Edges toothed to base, outer stem cells inflated. *leaves widely spreading, with slender tips*.
- Fontinalis:** Large, limp, stringy, aquatics with concave leaves in 3 rows. *leaves widely spreading, with slender tips*.

**Row 3: Leaf Shape and Venation**

- Pleurozium schreberi:** Red stems, orange alar cells. *erect & pinnate*. *alar cells enlarged, tips rounded or deeply concave, with short apical cells*.
- Calliergonella cuspidata:** Rounded tip, inflated stem cells. *erect & pinnate*. *slender inrolled tips*.
- Scorpidium scorpioides:** Branches cylindrical or worm-like, outer stem cells inflated. *leaf tips curved*.

branches strongly flattened, & comblike

*Taxiphylum deplanatum*  
few weak teeth, few square alar

leaves tightly overlapping

*Isopertigopsis muellerianum*  
no teeth or differentiated alar cells, outer cells of stem inflated

leaves wavy, branches flattened

*Neckera pennata*

leaf bases run down stem as a slender strip of cells, branches often flat

*Plagioglossum*

leaves asymmetrical in flattened species

numerous square alar cells running up edge

*Leucodon*  
middle cells short, leaves loosely arranged, broad branches common

loose curling fringes on trees

*Entodon*  
middle cells long, leaves tightly overlapping, deeply concave

branches flattened or cylindrical

strongly toothed margins

*Lycopodium*  
large, pinnate, erect coarsely toothed, with paraphyllia

*Herzogiella turfosa*  
small, not pinnate, toothed to base

rounded concave leaves, variable costa, tips often curved

*Hygrohypnum (iii)*  
usually arises with stringy branches

small, creeping, somewhat difficult mosses

*Platydictya*

short curved ascending branches

*Pylaisiella*  
no beak, flat edges

bright & shiny

*Homomallum adnatum*  
round leaves short cells inclined scales

*Platydictya, Serpolesea*  
very tiny, no features

*Isopertigum, Pseudotaxiphylum*  
long middle cells, often has broad branches

differentiated alar cells, fairly short middle cells

Stem and branch leaves

Smooth leaf

Papillose leaf

Pleated leaf

Recurved leaf edge or thickened border

Inrolled margins

Hooded or deeply concave tip

Coarsely toothed edge

Finely toothed edge

Variable costa

Inflated alar cells, with detail

Square alar cells in small group

Elongate middle cells

Long middle cells, shorter upper ones

paraphyllia at base of leaf

Leaf tips curved one way (secund)

Leaves slender, curved forward and down (falcate-secund)

Leaves ascending

Leaves spreading

Leaves squarrose

Shoots cylindrical with tightly overlapping leaves (julaceous)

Shoots somewhat flattened

Shoots strongly flattened

Once-pinnate branching

Twice-pinnate branching

Single papilla on both sides of cell

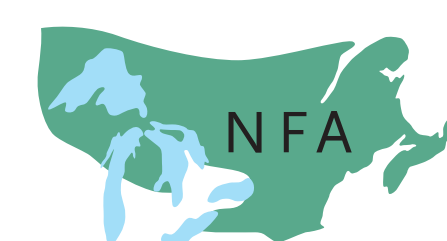
Multiple papillae on both sides of cells

Single papilla on lower end of cell

Tall single papilla on lower side of cell

P

Paraphyllia



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