

# Biological Collections

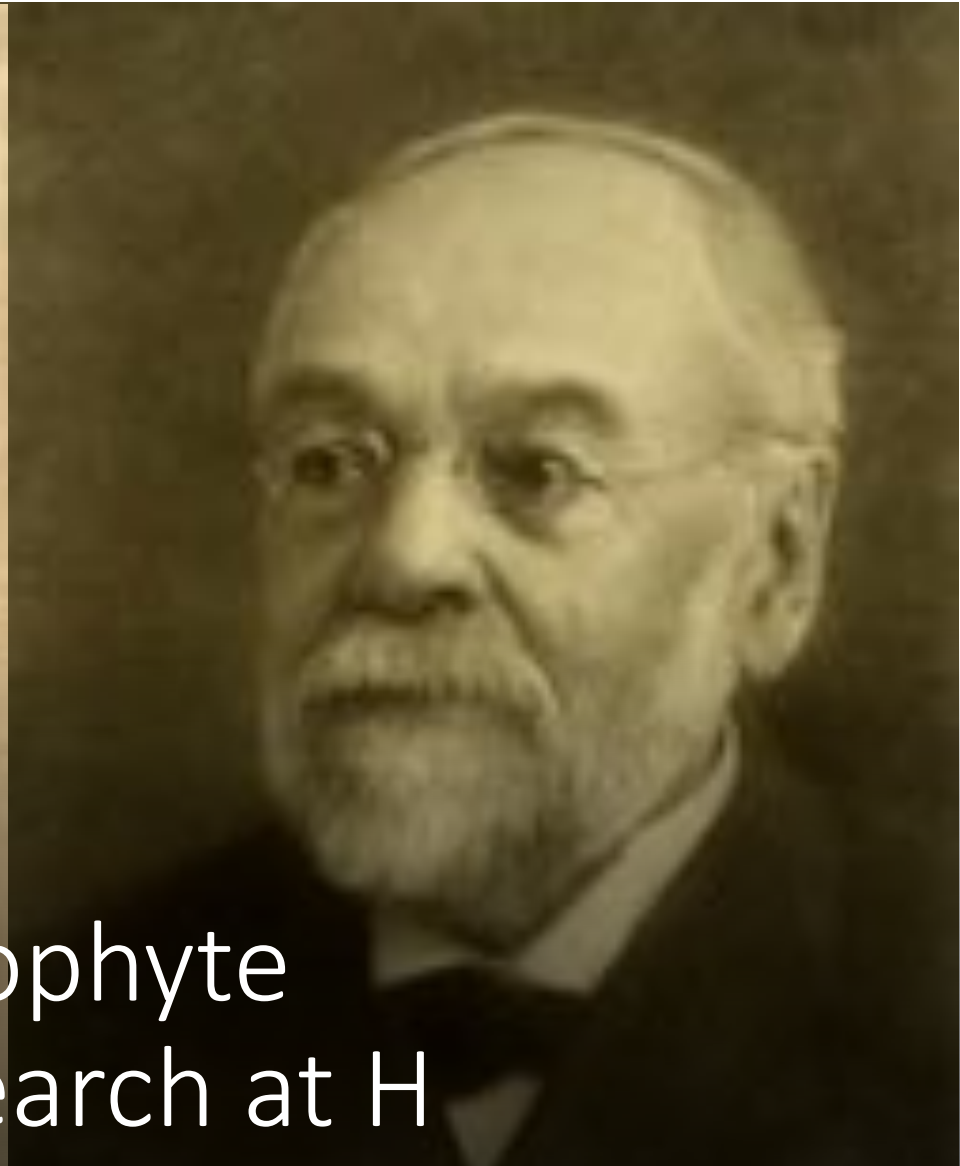
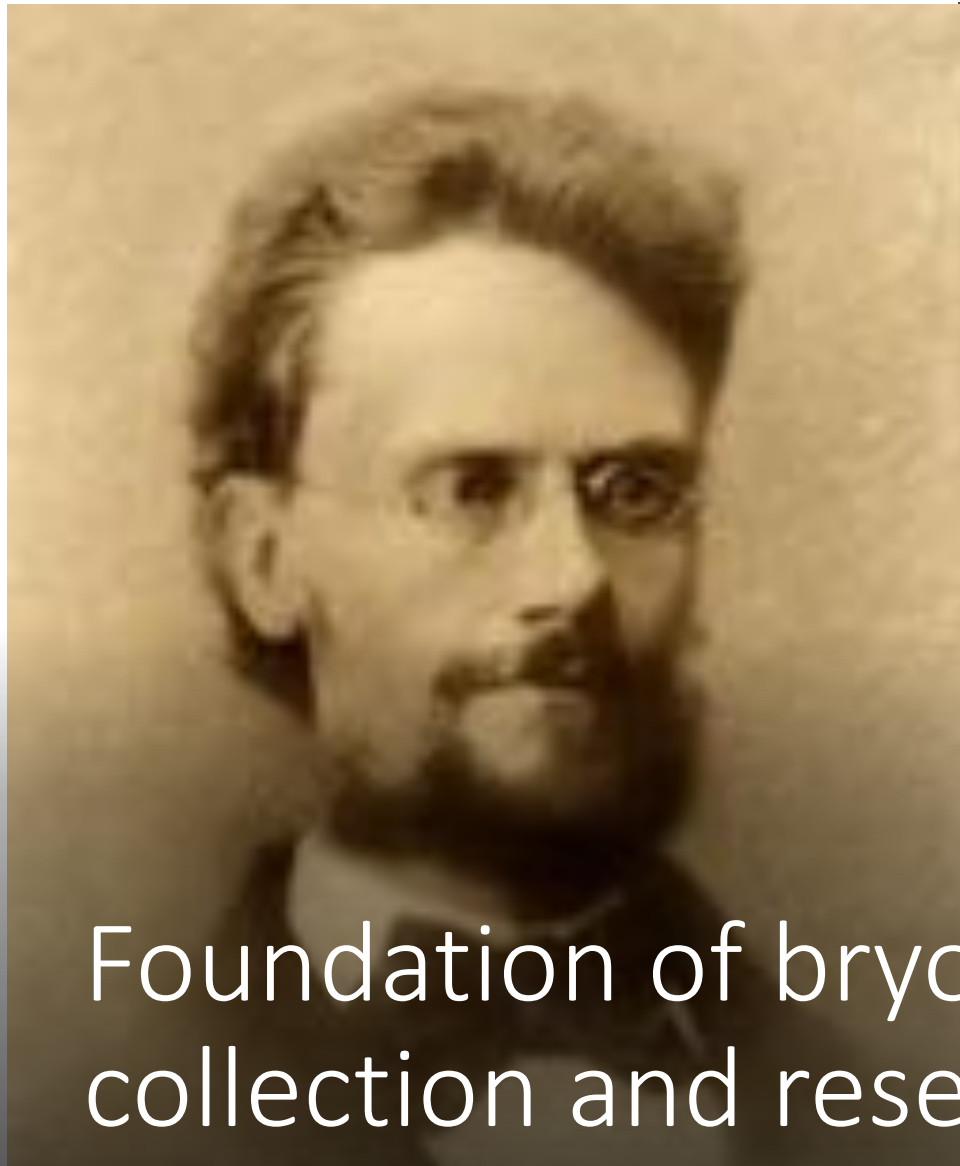
## Bryophytes



Xiaolan He, 03.09.2020

# Content

- Bryophyte collection and research at H
- Bryophyte specimen
- Bryophyte diversity
- Species description
- Herbarium specimens in other research



# Foundation of bryophyte collection and research at H

Herb. S. O. Lindberg

47 758 specimens

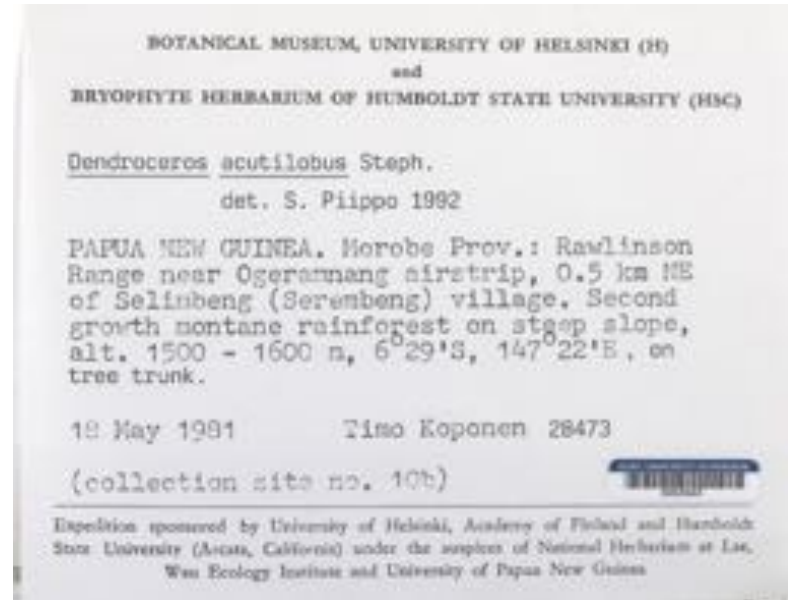
ca. 5000 species

Herb. Brotherus

111 100 specimens

ca. 16 000 species

# A bryophyte specimen





# Specimen arrangement and storing



Packets not glued on sheets !



# Bryophyte specimens

- Easy to collect.
- Normally no worries to get immediately dried.
- One gets easily whole plant, or even many.
- Easy to get enough material, also for duplicates.
- Storing specimens does not take much space.



Sri Lanka 2005



Drying  
specimens in  
limited  
space!  
Sri Lanka 2005

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Setting up the drying system on boat  
Chile 2012





Recording each specimen after collecting



Drying specimens in engine room  
Chile 2012



Mesh bags





Further drying specimens when possible  
Chile 2012





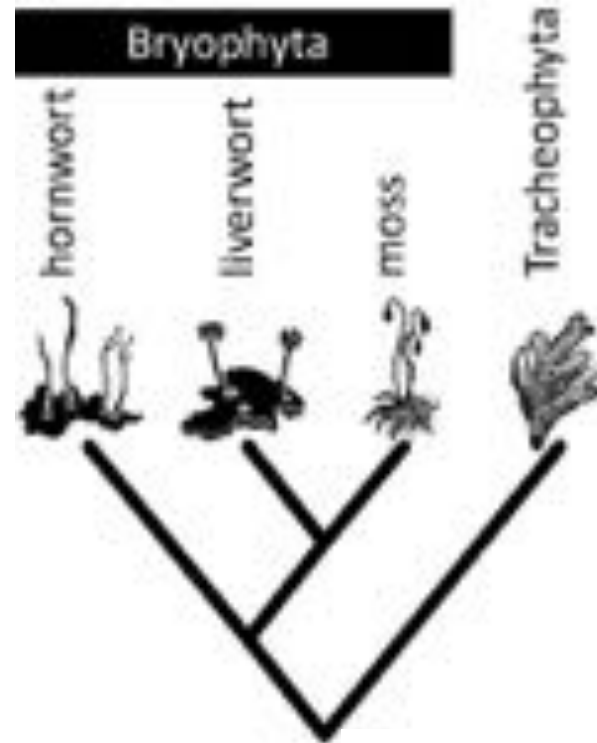
# Bryophyte diversity

ca. 20,000 species

Marchantiophyta 8000 spp.

Bryophyta 12,000 spp.

Hornworts ca. 236 spp.



Finland: 951 bryophytes:

709 mosses, 239 liverwort, 3 hornworts

**50%** of the European bryophyte flora





New Zealand: 595 liverworts  
523 mosses



*Petalophyllum preissii*

<http://www.endangeredspecies.org.nz/store/images/Petalophyllum-preissei07%20-%20Copy.jpg>



*Schistochila appendiculata*

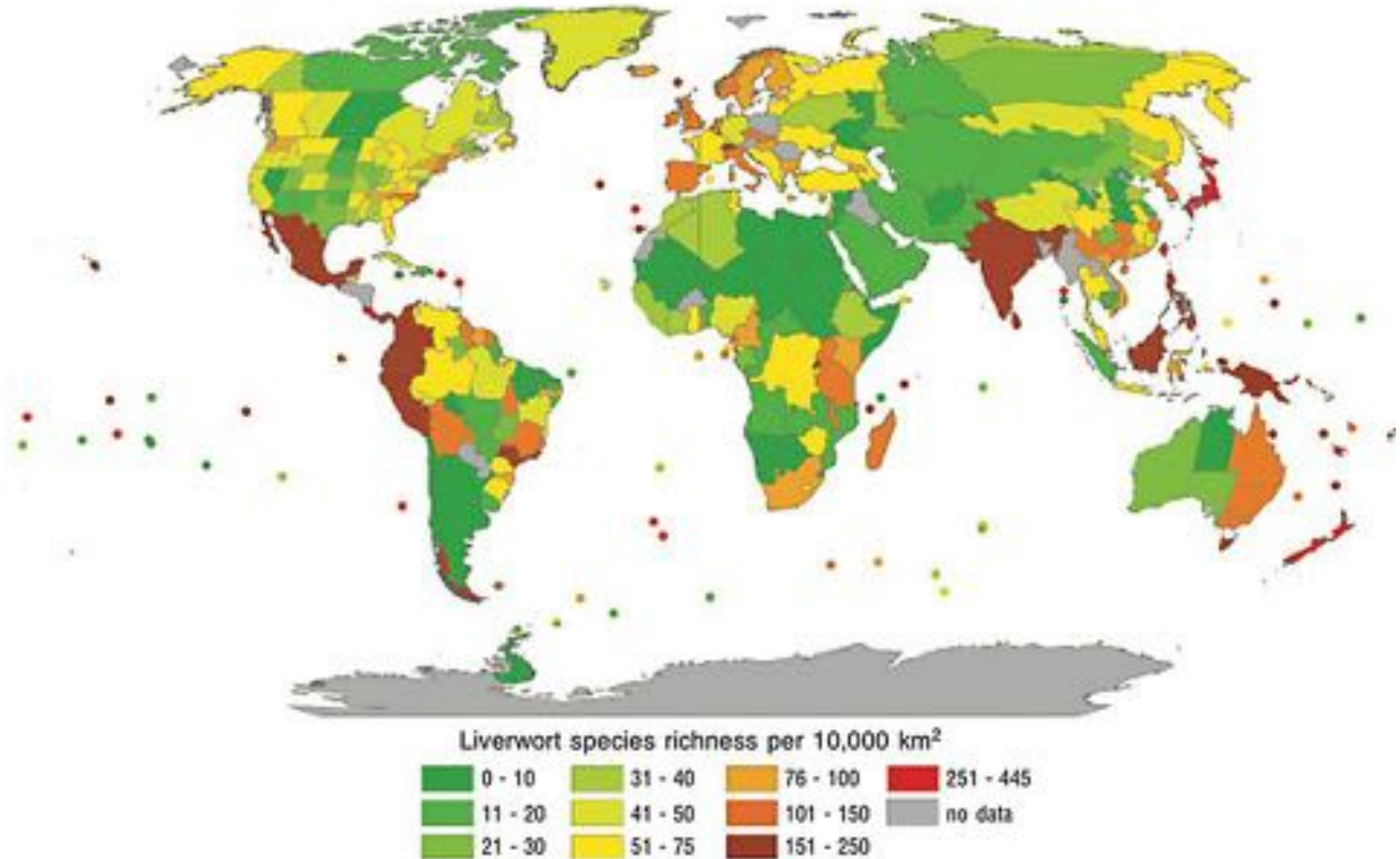




# Bryophyte diversity in different regions

	liverwort	Moss
Finland	239	709
Britain and Ireland	~300	763
New Zealand	595	523
China	1050	1945
North America north of Mexico	582	1320

# Global liverwort diversity and distribution patterns



## World checklist of hornworts and liverworts

Lars Söderström<sup>1,\*</sup>, Anders Hagborg<sup>2,\*</sup>, Matt von Konrat<sup>2,\*</sup>,  
Sharon Bartholomew-Began<sup>3</sup>, David Bell<sup>4</sup>, Laura Briscoe<sup>2</sup>, Elizabeth Brown<sup>5,†</sup>,  
D. Christine Cargill<sup>6</sup>, Denise P. Costa<sup>7</sup>, Barbara J. Crandall-Stotler<sup>8</sup>,  
Endymion D. Cooper<sup>9</sup>, Gregorio Dauphin<sup>10</sup>, John J. Engel<sup>2</sup>, Kathrin Feldberg<sup>11</sup>,  
David Glenny<sup>12</sup>, S. Robbert Gradstein<sup>13</sup>, Xiaolan He<sup>14</sup>, Jochen Heinrichs<sup>11</sup>,  
Jörn Hentschel<sup>15</sup>, Anna Luiza Ilkiu-Borges<sup>16</sup>, Tomoyuki Katagiri<sup>17</sup>,  
Nadezhda A. Konstantinova<sup>18</sup>, Juan Larrain<sup>2</sup>, David G. Long<sup>19</sup>, Martin Nebel<sup>20</sup>,  
Tamás Pócs<sup>21</sup>, Felisa Puche<sup>22</sup>, Elena Reiner-Drehwald<sup>23</sup>, Matt A.M. Renner<sup>5</sup>,  
Andrea Sass-Gyarmati<sup>21</sup>, Alfons Schäfer-Verwimp<sup>24</sup>, José Gabriel Segarra Moragues<sup>25</sup>,  
Raymond E. Stotler<sup>8,†</sup>, Phiangphak Sukkharak<sup>26</sup>, Barbara M. Thiers<sup>27</sup>,  
Jaime Uribe<sup>28</sup>, Jiří Váňa<sup>29</sup>, Juan Carlos Villarreal<sup>30</sup>, Martin Wigginton<sup>31</sup>,  
Li Zhang<sup>32</sup>, Rui-Liang Zhu<sup>33</sup>



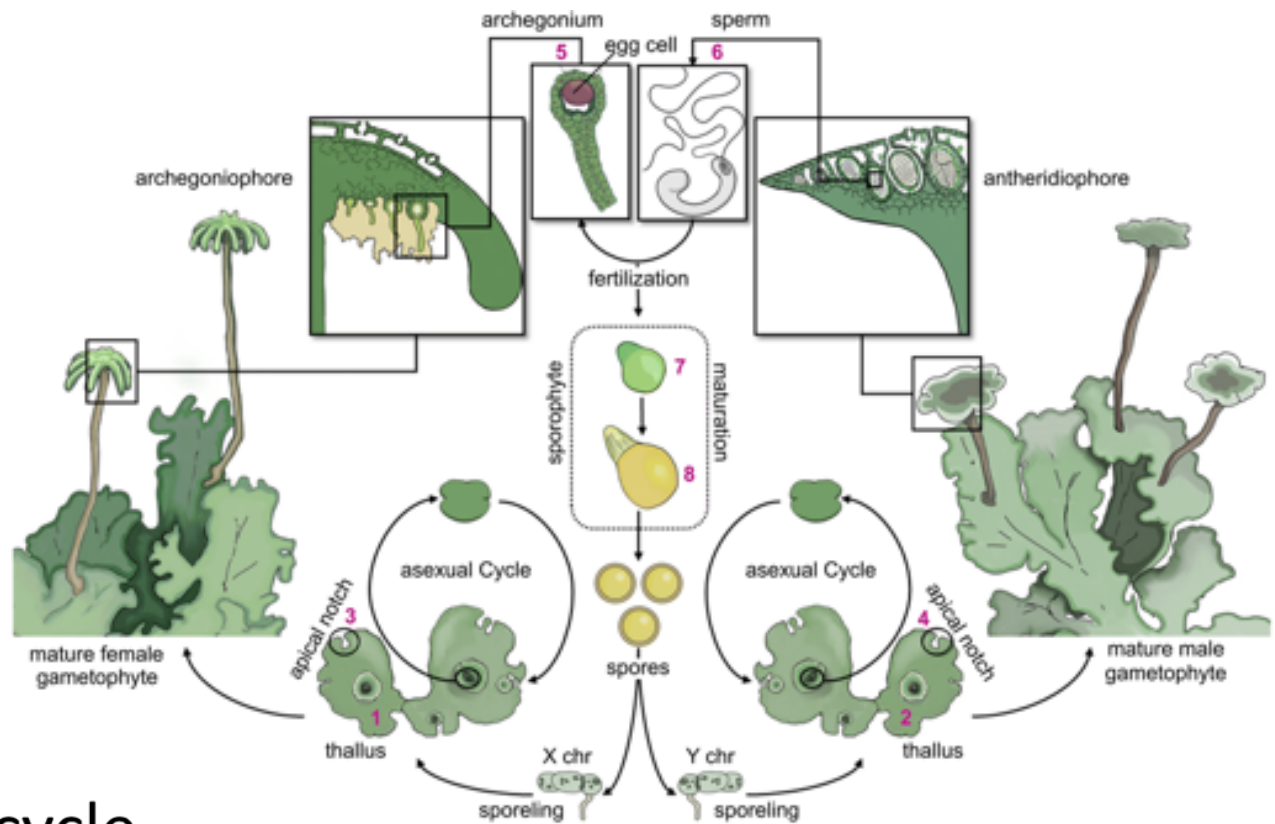
## Summary statistics

We here present the first-ever worldwide checklist for liverworts (Marchantiophyta) and hornworts (Anthocerotophyta) that includes 8,078 taxa (species and below) in 7,486 species representing 398 genera, 92 families, 20 orders and 7 classes from the two phyla. The list includes 3,533 species with three stars, 2,988 species with two stars and 915 species with one star. The checklist also has extra utility in that it contains 3,106 references in the bibliography that serve as a powerful bibliographic resource for liverwort and hornwort systematic and taxonomic research.

Hornwort: 236 species, 14 genera, 5 families, 5 orders, 2 classes

# How the diversity has evolved

Gametophyte  
Sporophyte  
Reproduction  
Dispersal

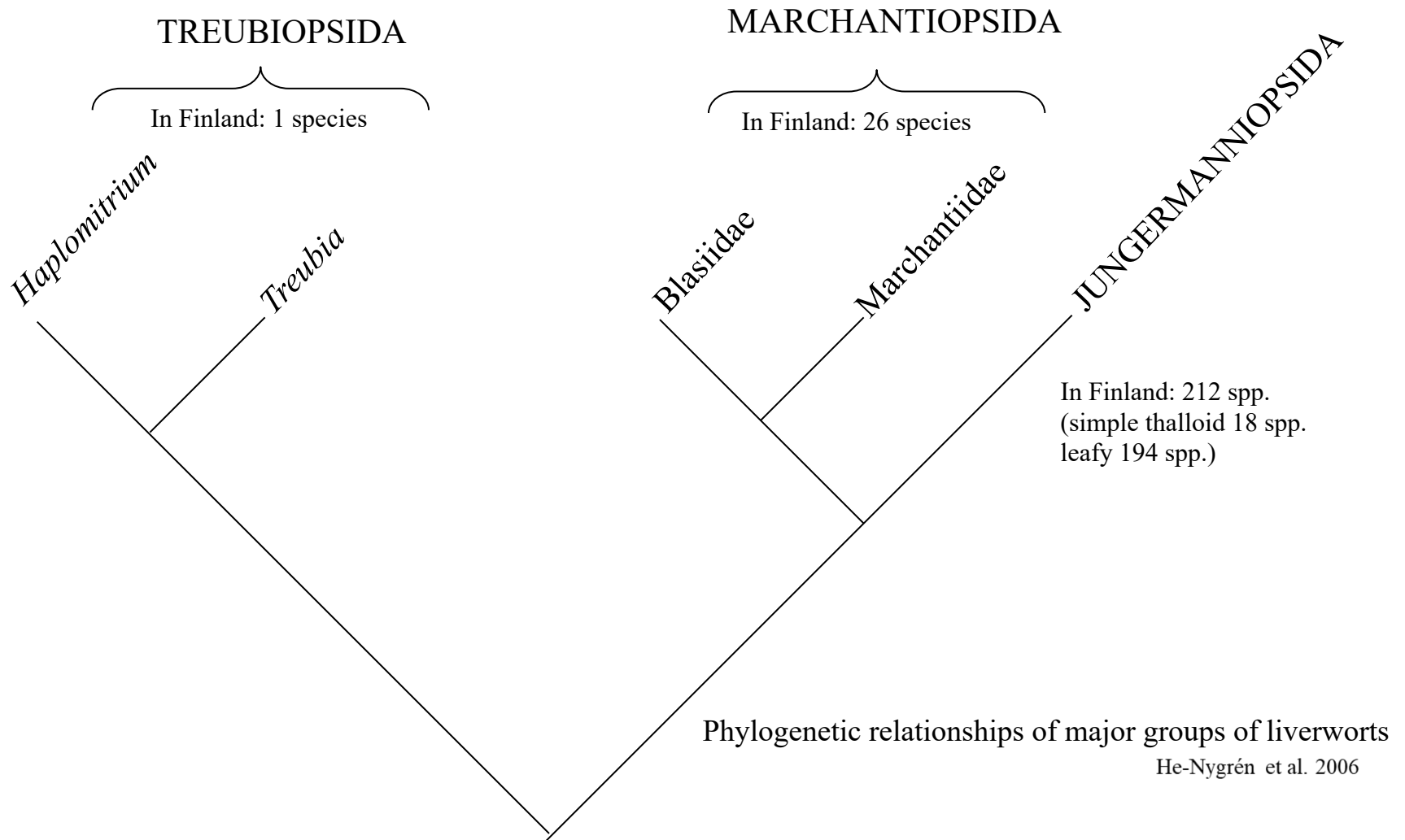


The Life cycle

Schmid et al. 2018



# Marchantiophyta



# Liverworts: in brief

Gametophytic morphology highly diverse. Both sexual and asexual reproduction.

Sporophytic morphology less variable compared with gametophyte.

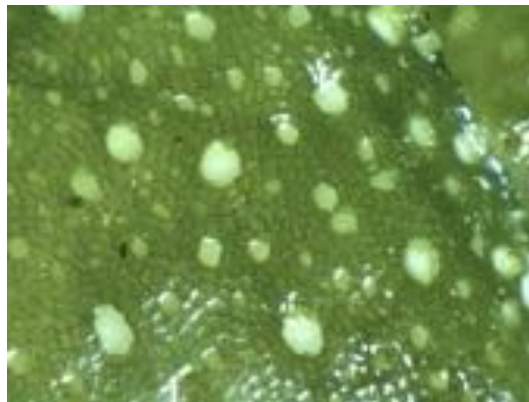
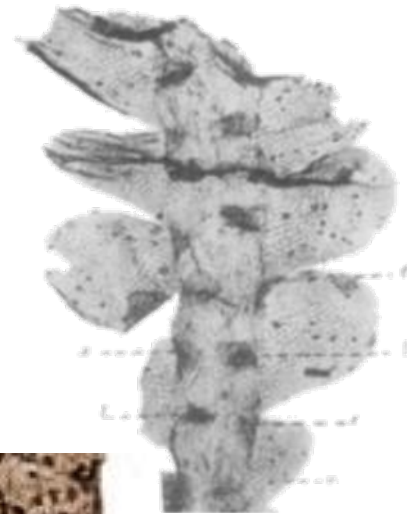
Spore dehiscence in a short time. Capable of long-distance dispersal.

Variable ecology – from dry to aquatic environment (except sea), high diversity in tropical mountain rainforests and temperate rainforests with oceanic climate.



# Treubia

- *Treubia* (6-7 species) and *Haplomitrium* (7 species) are sister to the rest of the liverworts.
- *Treubiites kidstoni*, a Carboniferous fossil, and *Metzgeriothallus sharonae*, seem to have single oil-bodies in some cells.
- Special features:
  - Semi-leafy form, dorsal scales
  - Cells with single large oil-body filling the cell
  - Copious mucilage on lower stem surface
  - Fungi of Mucoromycotina type infecting the cells of the stem (rather than usual Glomeromycota)



*Treubia lacunosa*



<http://tasmanianplants.com/>

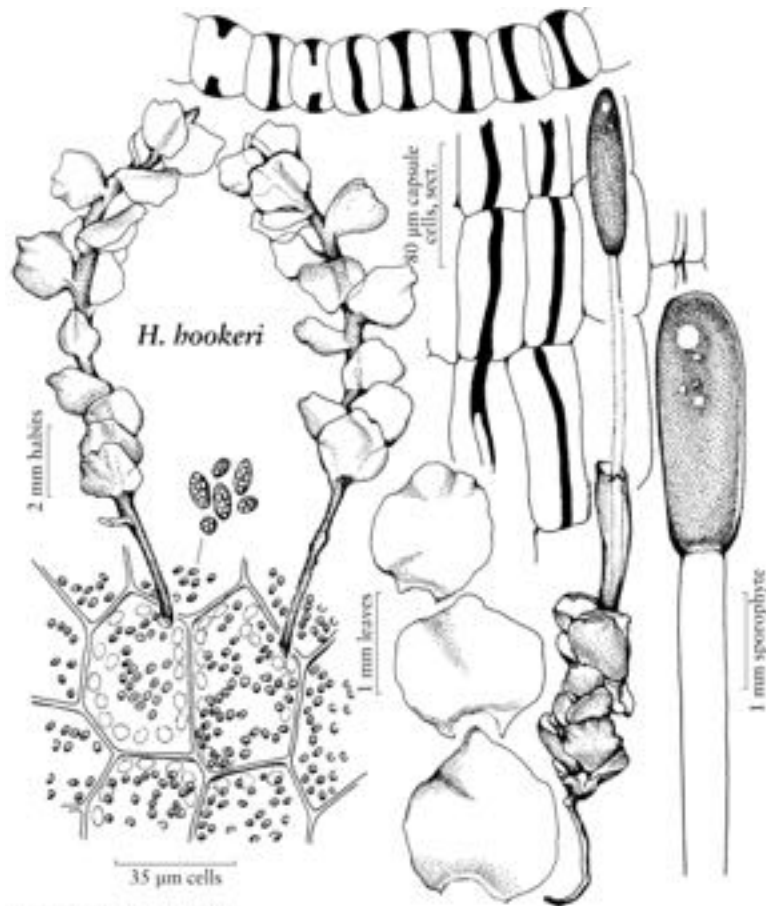


*Treubia tasmanica*



# Haplomitrium

- Erect leafy shoots, leaves in 3 rows
- Leafless, subterranean stolons
- The small leaf on the dorsal side of the stem
- Leaves mostly 1-celled layers, but at base multistratose
- Rhizoids absent
- Antheridia and archegonia in leaf axils



## HAPLOMITRIUM

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*Haplomitrium mnioides*

[http://fungi.sakura.ne.jp/moss\\_memo/moss\\_101109.htm](http://fungi.sakura.ne.jp/moss_memo/moss_101109.htm)

# Marchantiopsida

Majority are relatively drought-resistant. Spores are large, may retain viability for decades.

Ability to become adapted to man-made sites and become weedy.

~30 genera, ~250 spp.

*Riccia* ~150 spp.



# Marchantiopsida

## Synapomorphies:



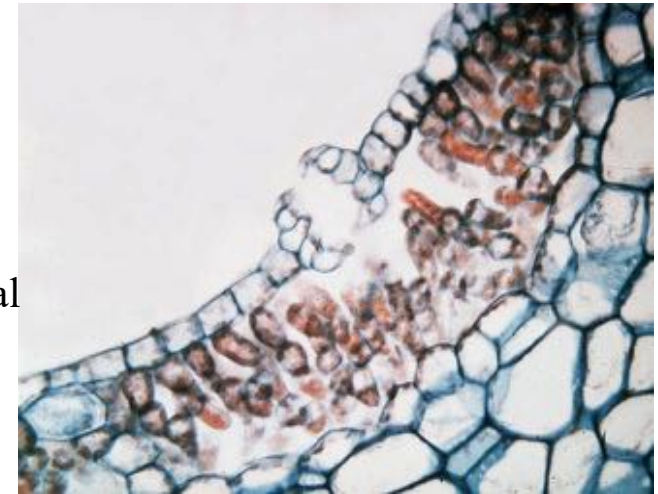
**█** - ventral scales

**█** - dimorphic cells  
 - 1-stratose capsule wall  
 - spore dehiscence irregular  
 - reduced seta

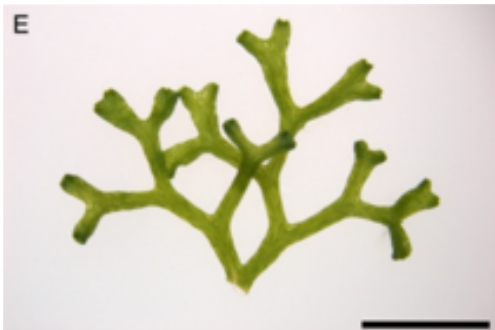
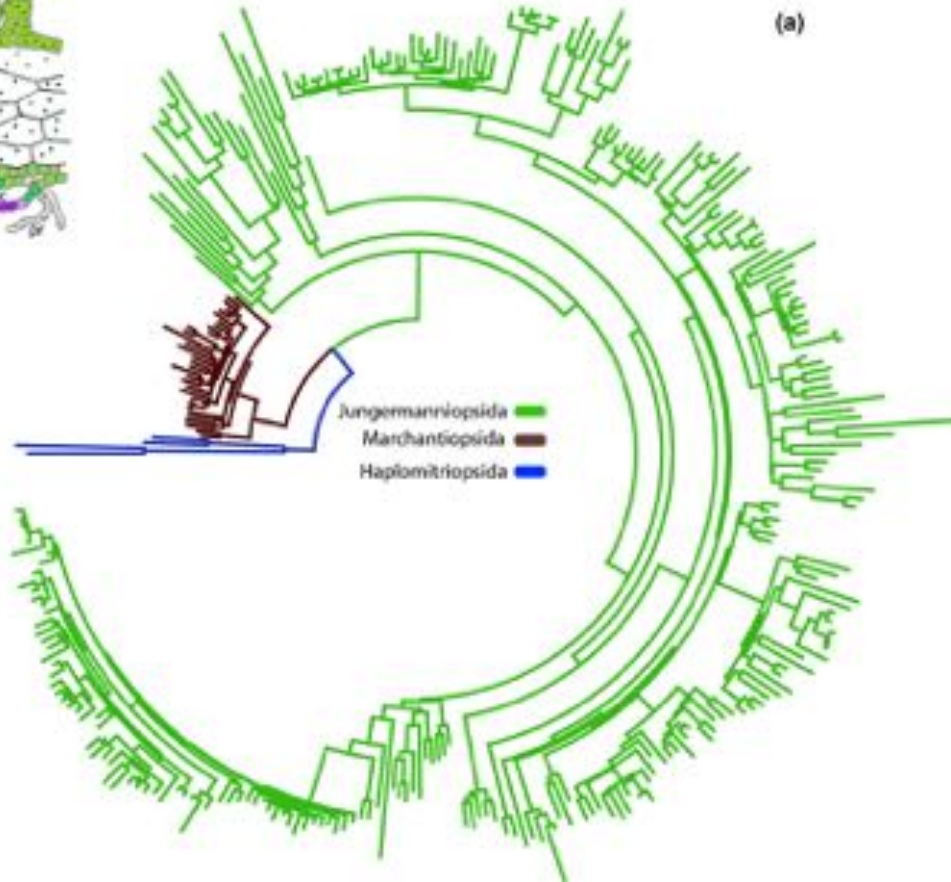
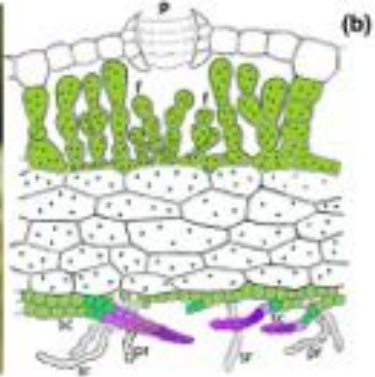
**█** - dimorphic rhizoids  
 - pores, air chambers on dorsal  
 - storage tissue on ventral  
 - gametangiophores



*Marchantia*



# Marchantiopsida

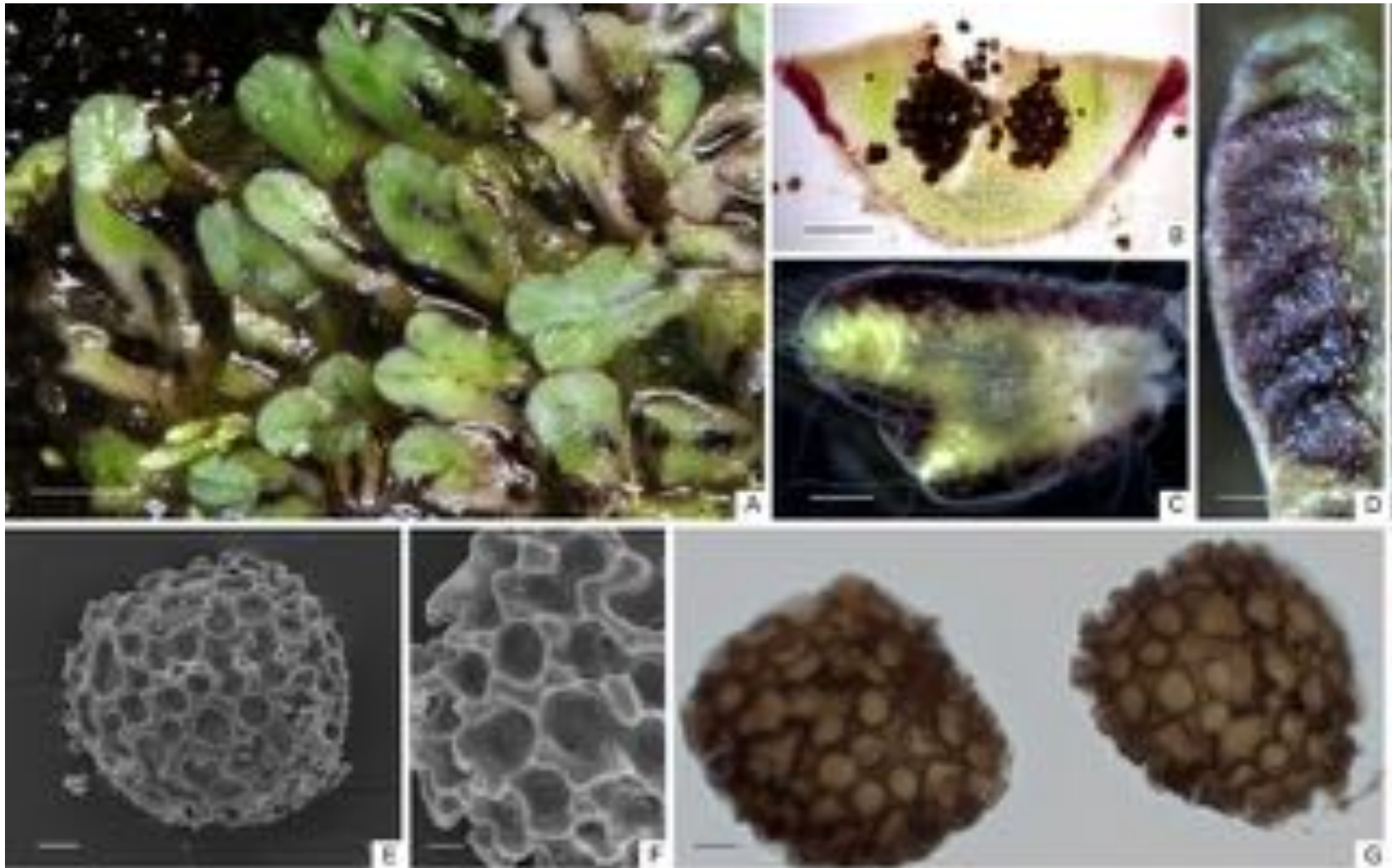


*Riccia fluitans*  
Althoff & Zachgo 2020

Villarreal et al. 2015



*Riccia subplana* A. Habit; B. Transverse section of segment showing the dark area where the sporophyte is located; C. Ventral pink scales; D. Enlarged ventral area of scales; E–F. SEM micrographs of spores. E. Proximal face; F. Detail of small ridges; G. Light microscopy micrographs of spores in distal and proximal views with detail of areoles and small ridges. Ayub et al. 2014





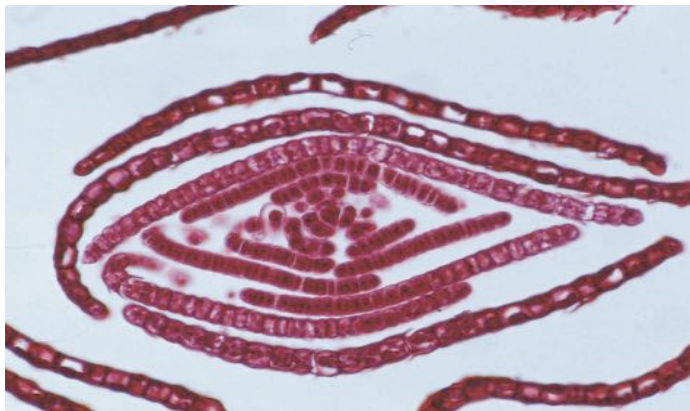
# Jungermannniopsida

Both thalloid and leafy

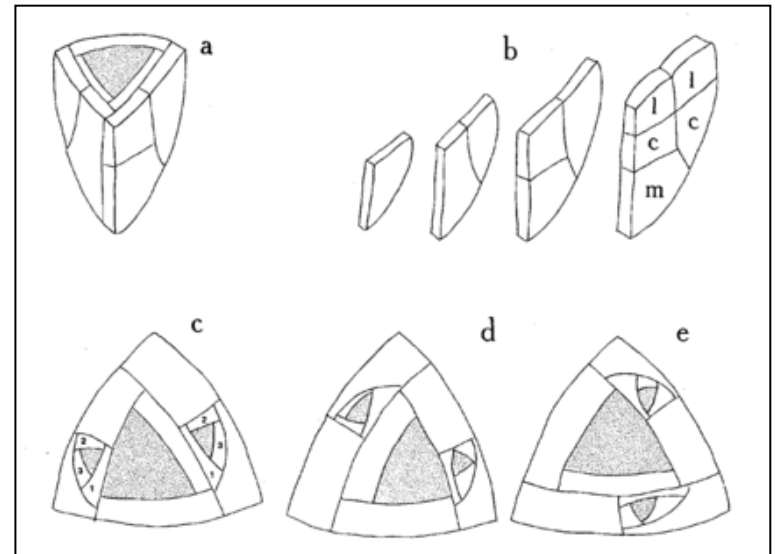
Pelliidae: mostly thalloid, apical cell cuneate, lenticular or tetrahedral anacrogynous.

Metzgeriidae: thalloid or leafy, apical cell lenticular, gynoecia acrogynous.

Jungermannniidae: apical cell tetrahedral, leafy, leaves in two to three rows, developing from 2 leaf initials, trigones in cells, archegonia surrounded by a perianth. > 5000 species!

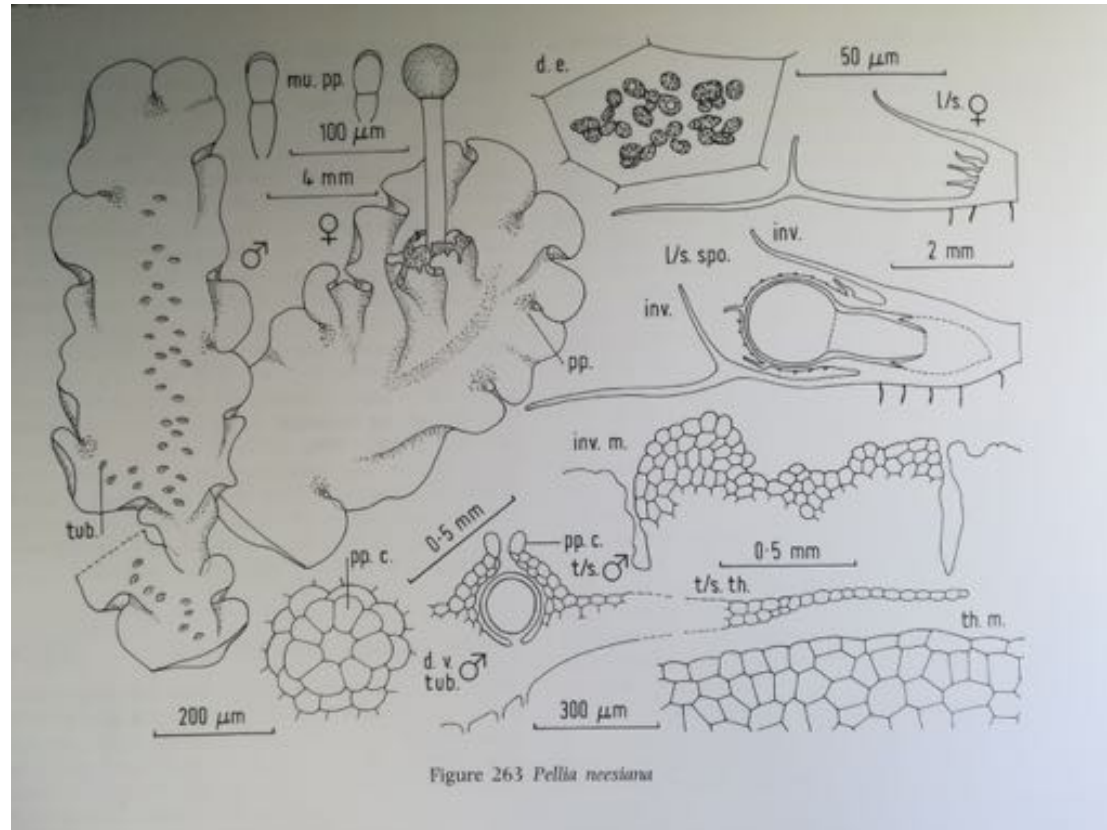
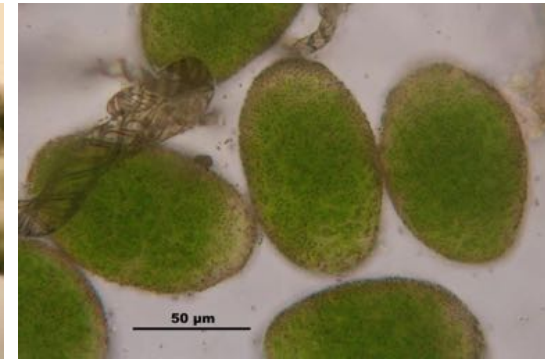


Tetrahedral apical cell of *Nipponolejeunea*



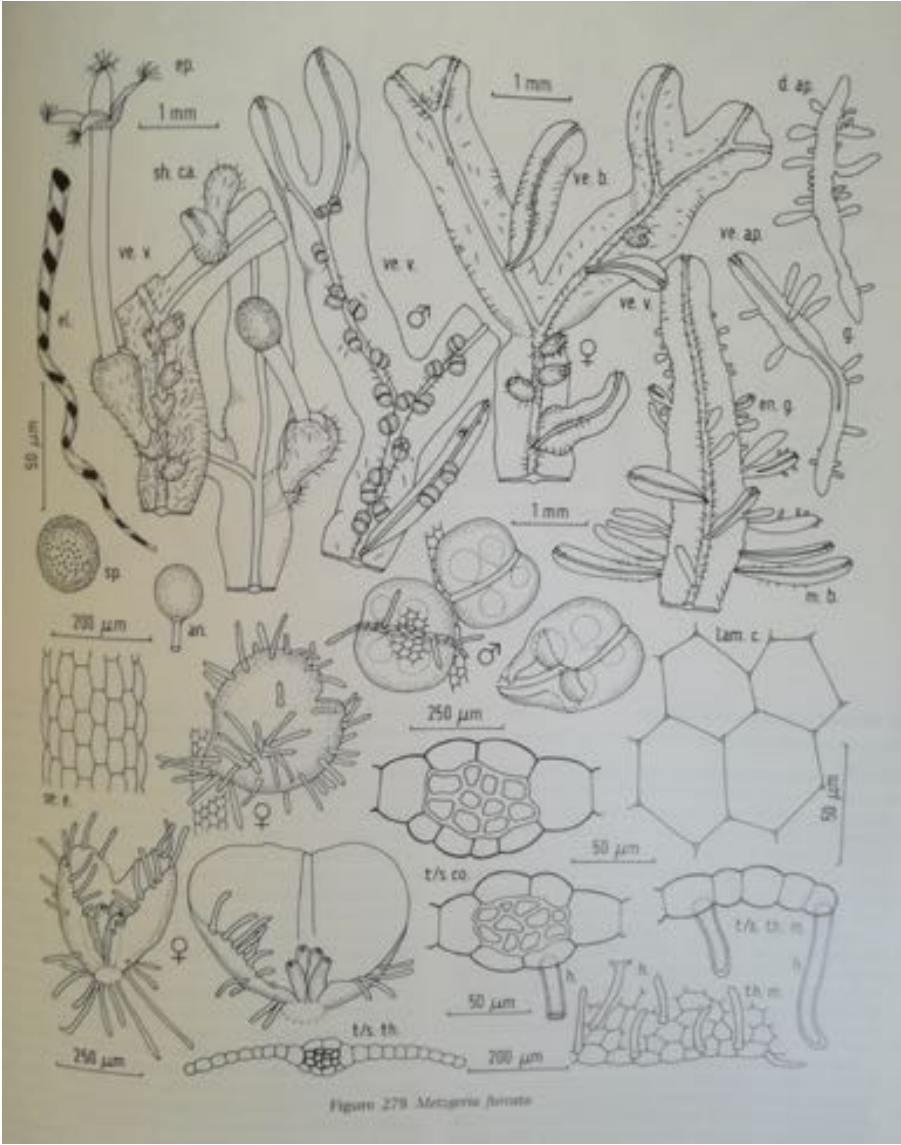
# Jungermannniopsida

## Pelliidae: *Pellia neesiana*



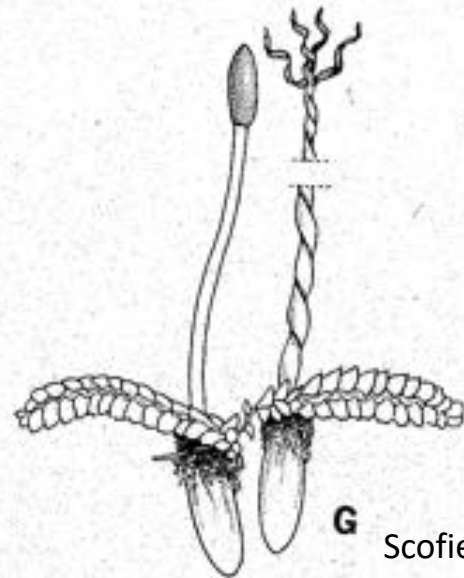
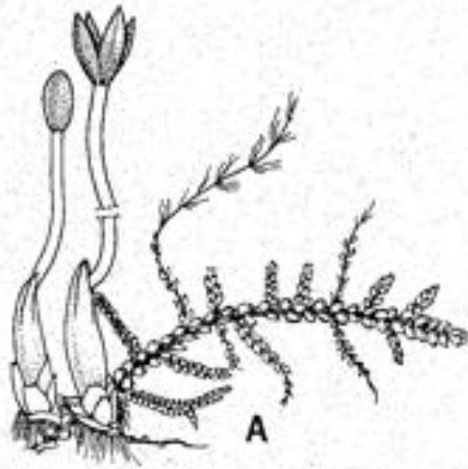


# Metzgeriidae: *Metzgeria furcata*



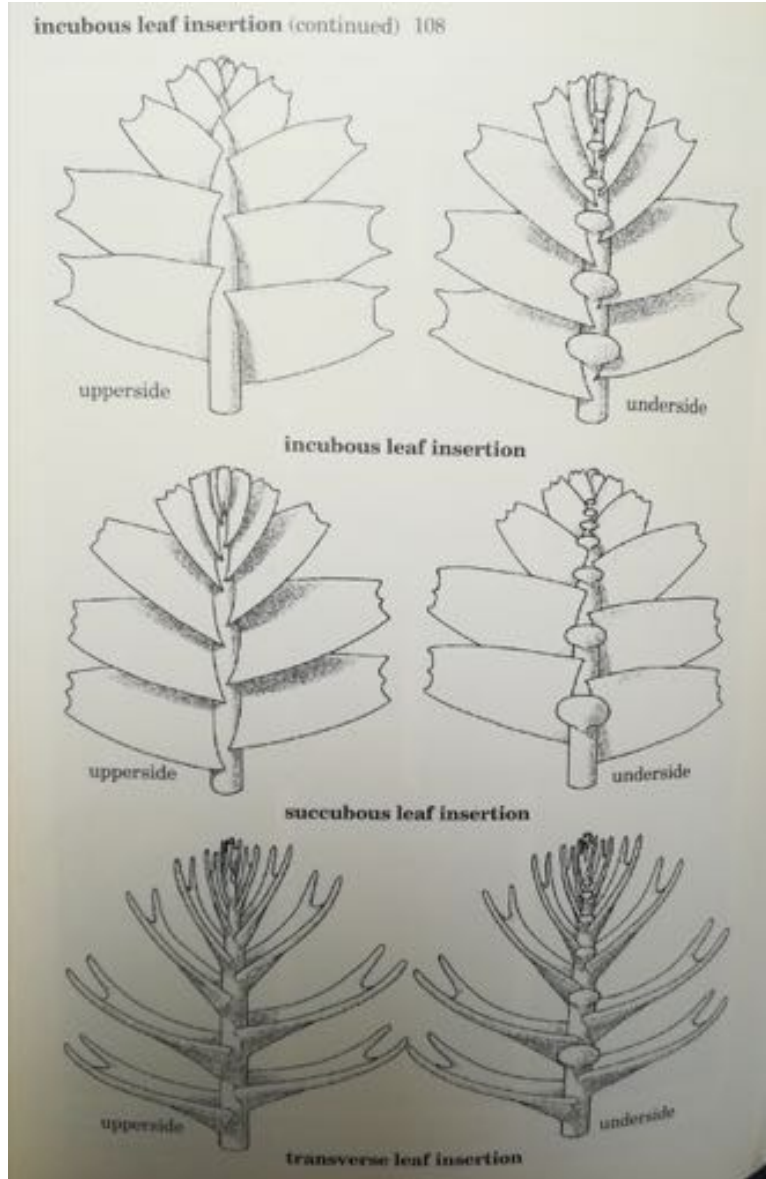


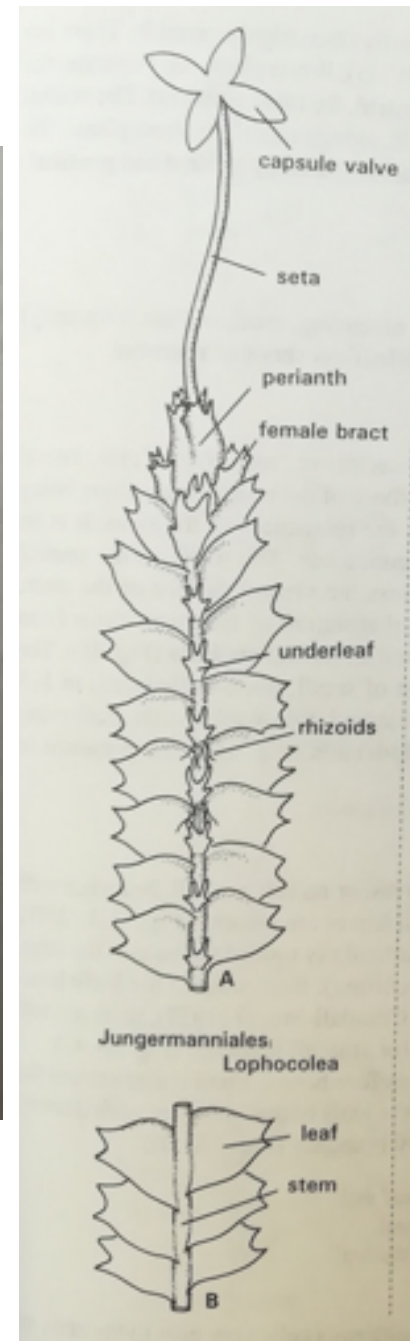
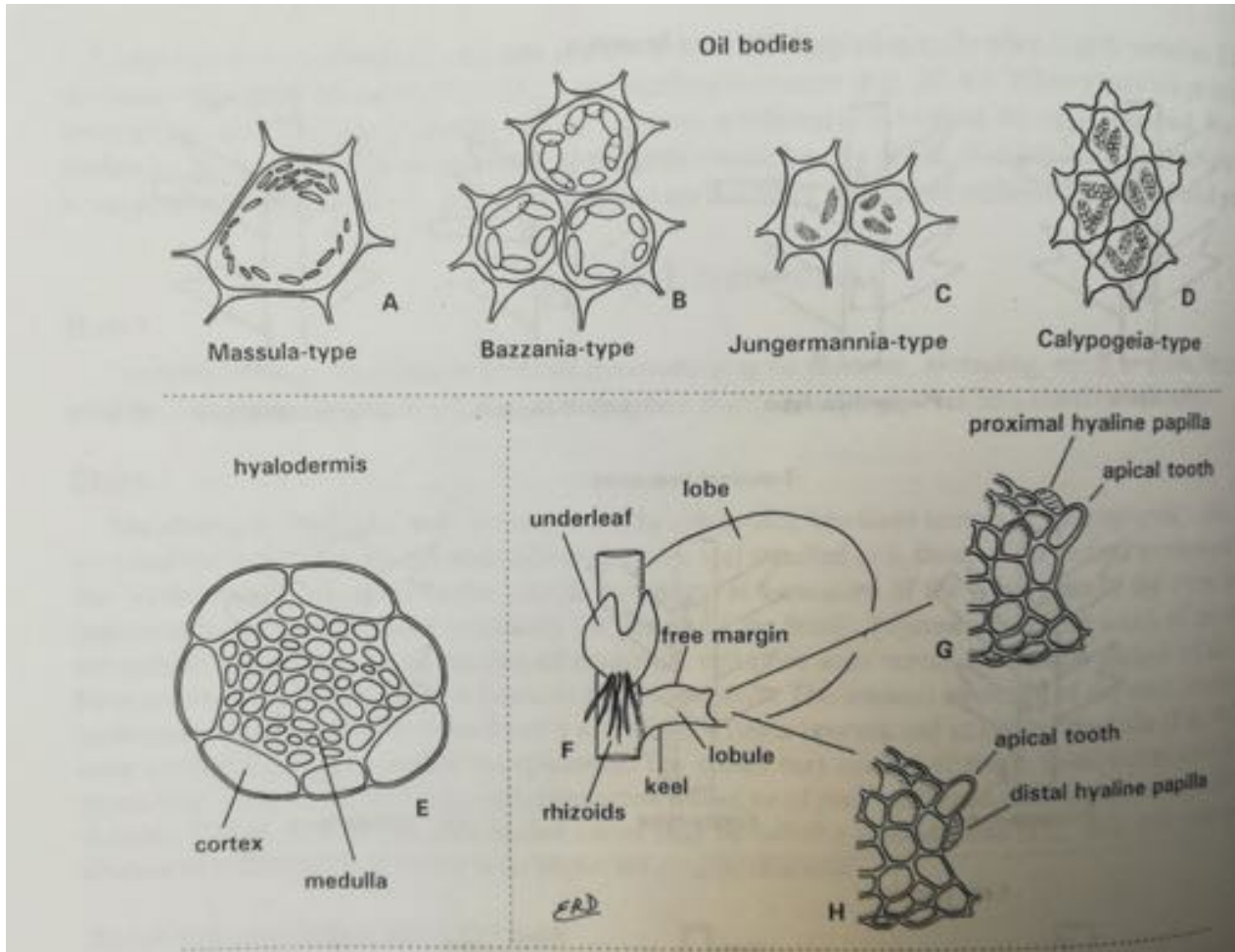
# Jungermannniidae



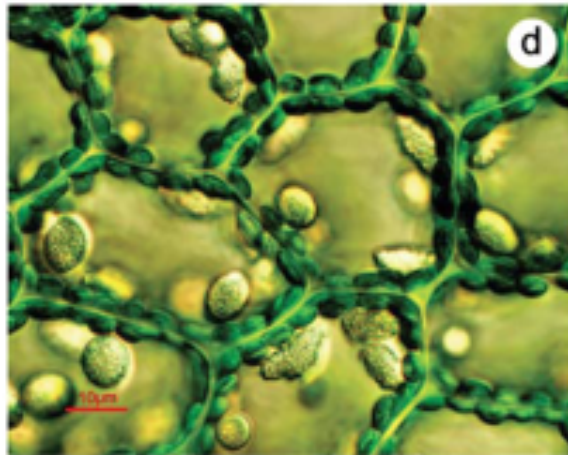
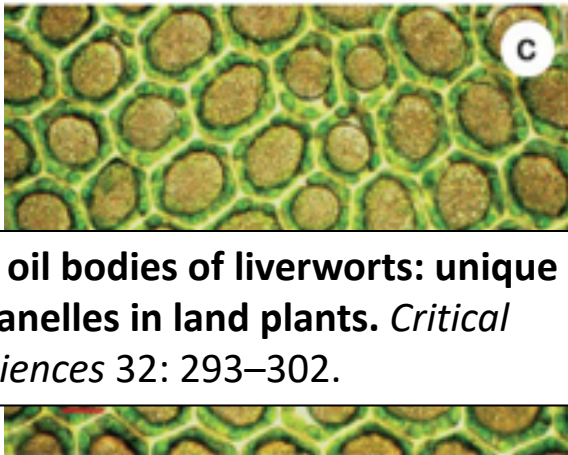
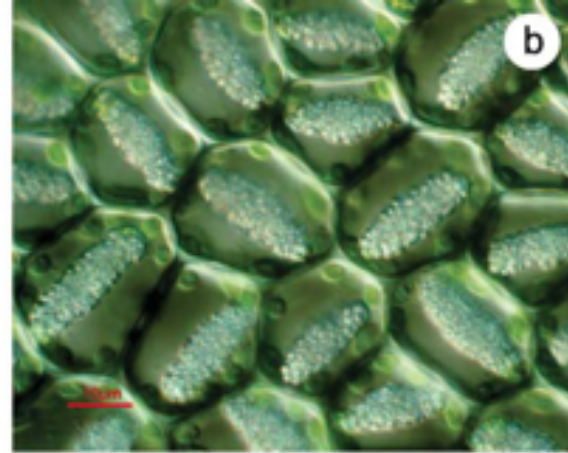
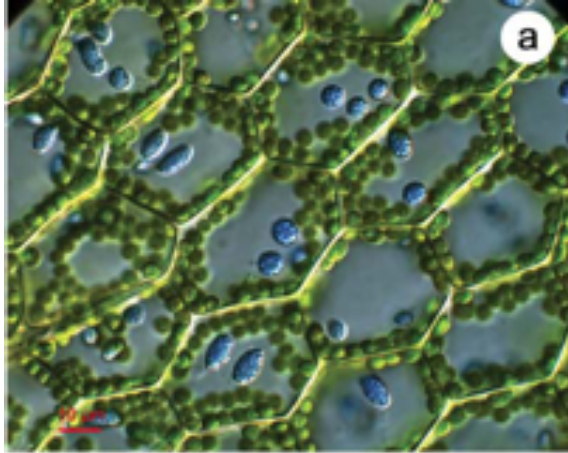
Scofield, W.B. 1985.  
Introduction to bryology.

# Leaf insertion

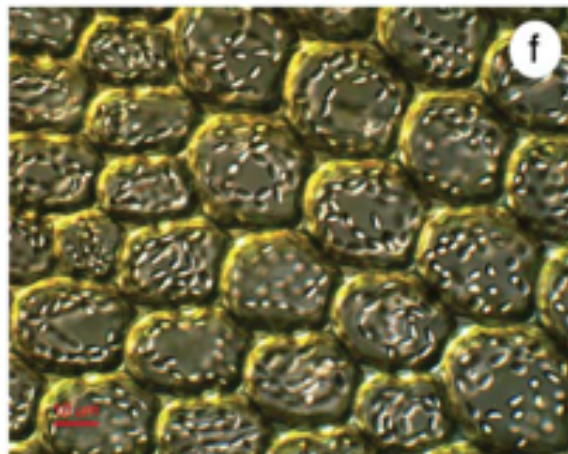
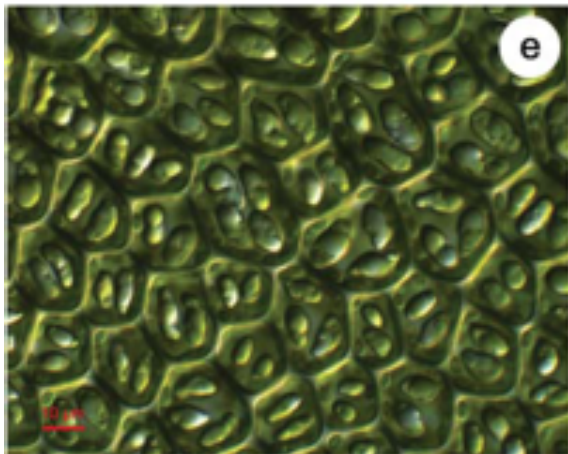




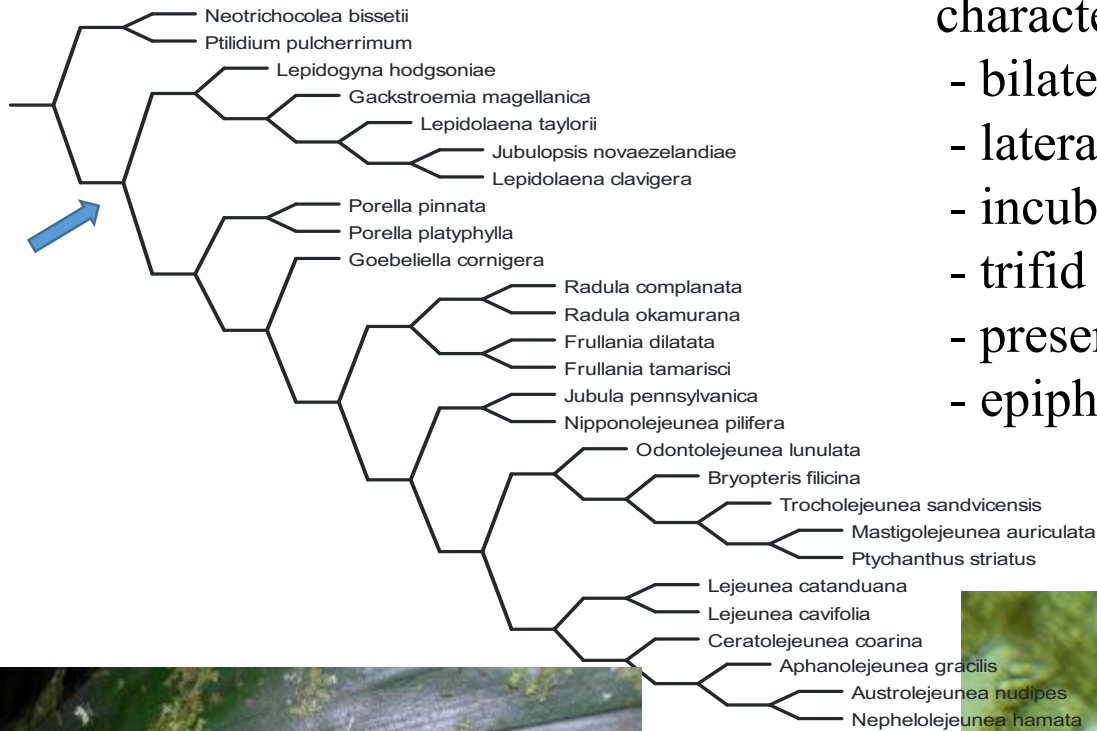




He et al. 2013 **The oil bodies of liverworts: unique and important organelles in land plants.** *Critical Reviews in Plant Sciences* 32: 293–302.



# Porellales



characters:

- bilateral, anisophyllous gametophyte
- lateral branching
- incubous leaf insertion
- trifid leaves
- presence of lobule
- epiphytism



*Xylolejeunea*

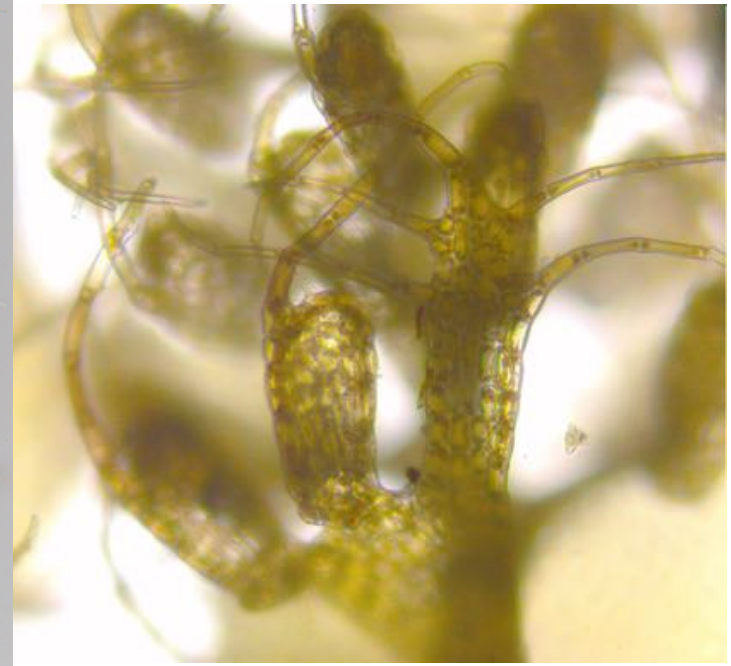


# Lepidolaenaceae

Lepidolaenineae of Porellales  
(He-Nygrén et al.2006)

Porellineae (Crandall-Stotler et al. 2009)  
together with Porellaceae and Goebeliellaceae

- Pinnate growth
- Lateral branching
- trifid leaf lobes
- formation of water-sacs
- rhizoids restricted to underleaf base



*Lepidolaena clavigera*

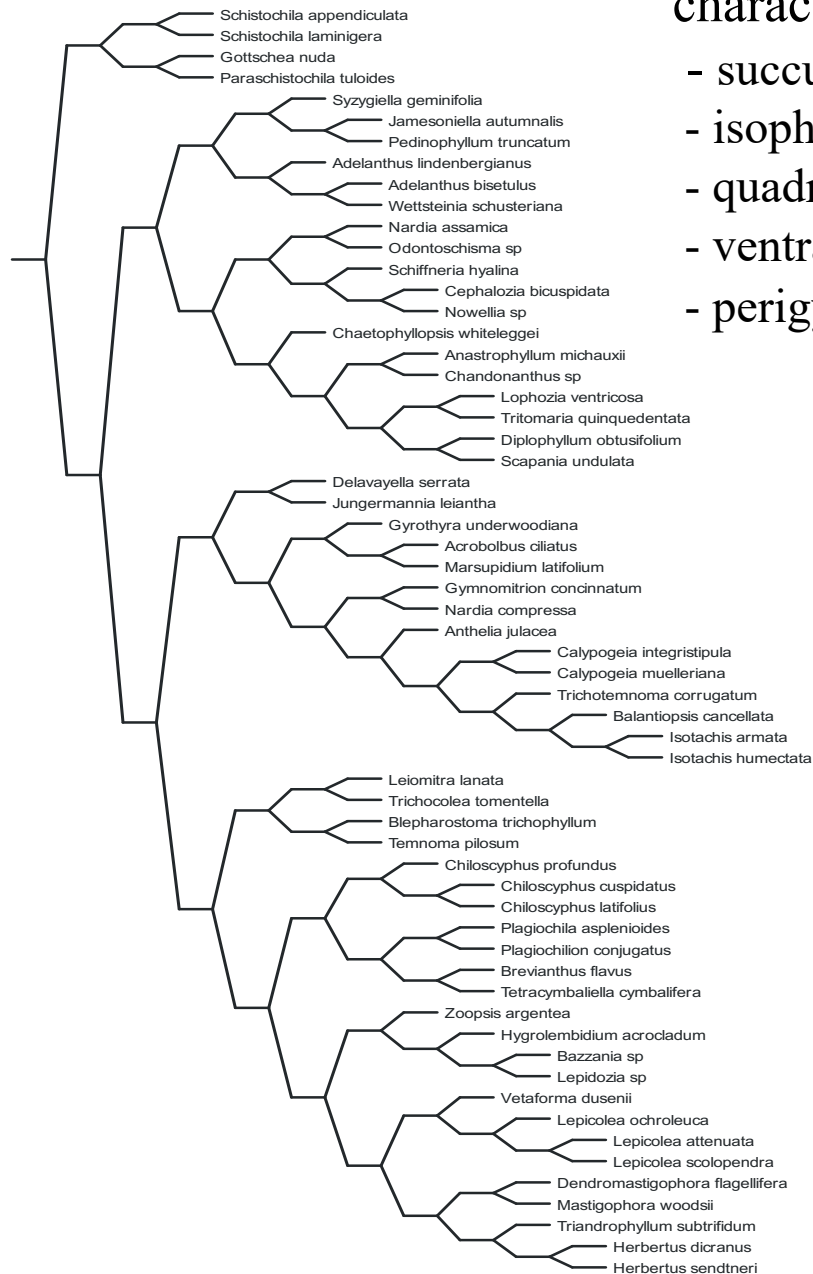


*Lepidolaena menziesii*





# Jungermanniales



## characters:

- succubous leaf insertion
- isophyllous, radial gametophyte
- quadrifid leaves
- ventral branching
- perigynium, in addition to shoot-calyptra and perianth

*Goebelobryum unguicularis*



*Gyrothra underwoodiana*

*Cephalozia lunulifolia*



Crandall-Stotler, B. ym. 2009. Phylogeny and classification of the Marchantiophyta. *Edinburgh Journal of Botany* 66: 155-198.

# Species description



# For taxonomist, it may take years of work to make a species description!

Description to be clear and brief. Verbs and most definite and indefinite articles to be omitted.

Gametophyte characters (shoot size, stem, rhizoid, branching, leaf, cell, sexuality, gametangia)

Sporophyte characters (spore, foot, seta, elater, capsule wall, etc.)

Habit

Ecology

Associated plants

Distribution

Discussion/differentiation

Illustration/photo

Map



Franz Stephani (1842-1927): **Species Hepaticarum**, Volume 1-6, 1898-1925

a worldwide treatment of the species of liverworts and hornworts

Nearly 10 000 species of liverworts and hornworts were treated, including more than 4000 *sp. nov.*

Unfortunately, ca 85% of the new species have been synonymized, due to lack of knowledge on extra European species, and species were described based on narrow distributional ranges, among others.

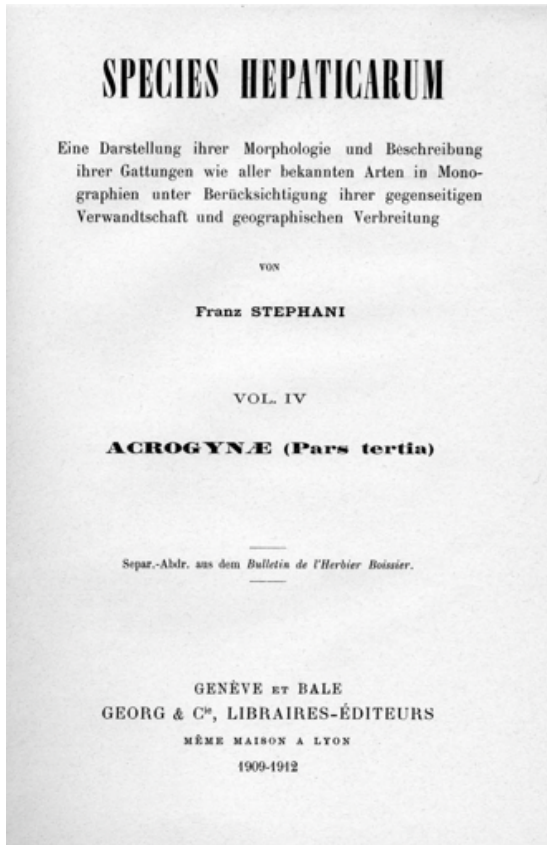
**But, still highly valuable!**

Stephani Herbarium, Geneva

Type specimens

Stephani's original drawings, total more than 12 000 plates

Icones Hepaticarum



## An example

### *Lophozia longidens* (Lindb.) Konstant. et Vilnet

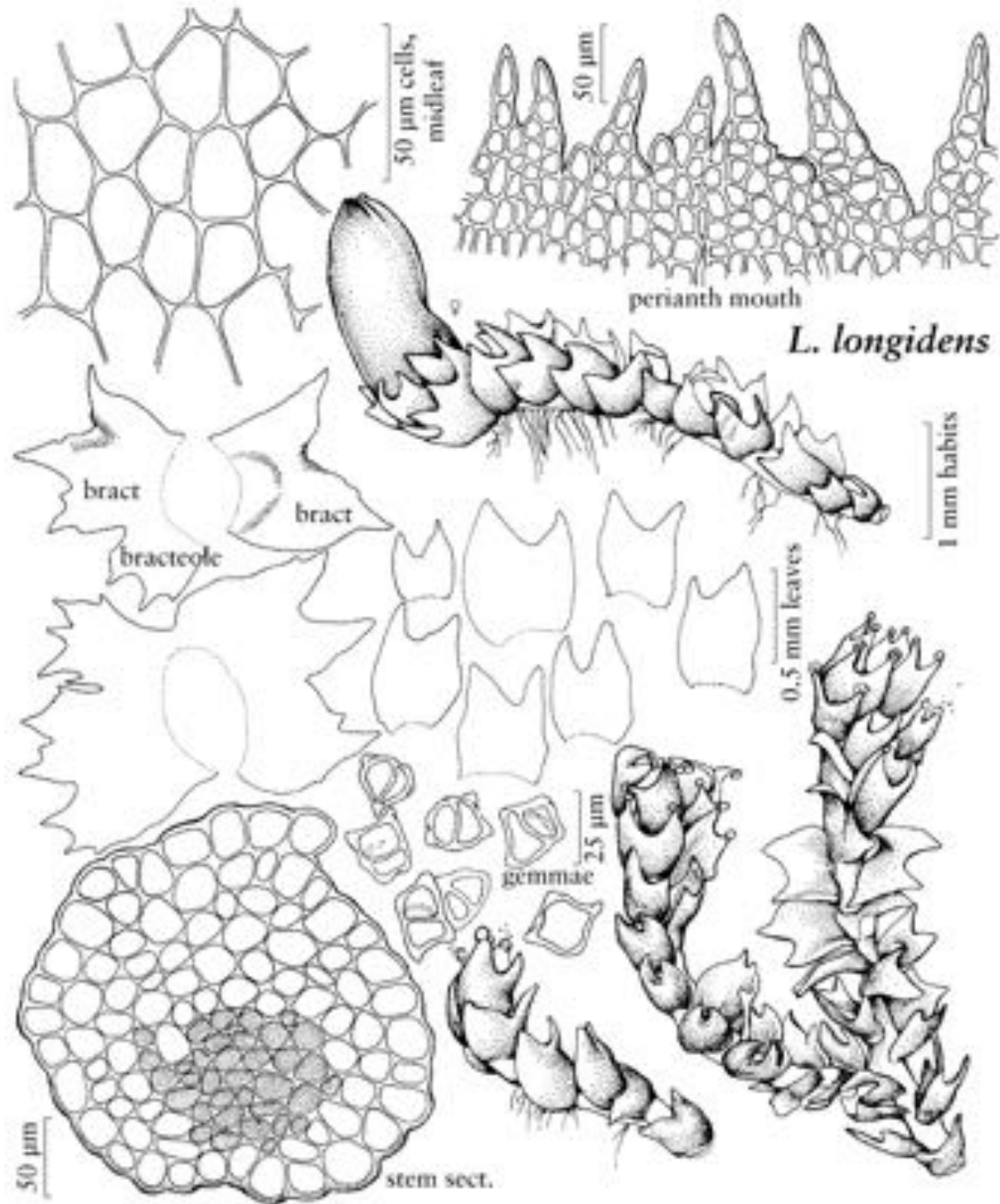
*Lophozia longidens* (Lindberg) Macoun, Geol. Survey Canada: Cat. Canad. Pl. 7: 18. 1902

*Jungermannia longidens* Lindberg, Bot. Not., 27. 1877



**Plants** ca. 5--15 x 0.6--1 mm, ascending, rarely prostrate, green to bright green, rarely brownish. **Stems** 0.17--0.35 mm in diameter, sparsely branching, transverse section with microcellous layer to  $1/3$ -- $1/2$  x stem thickness, sometimes absent in attenuate tips; rhizoids sparse to common, in indistinct fascicles, colorless to pale brownish near origin. **Leaves** transversely or (rarely, in shady forms) oblique inserted, distant, spreading, erect-spreading at the ends of lobes, deflected away from the stem, flattened, rectangular to ovate, 0.4--0.8 x 0.3--0.55 mm, 2(--3)-lobed, equal lobes divided by U-shaped to semilunate sinus descending to  $1/3$ -- $1/4$  x leaf length; lobes entire, angulate to horn-like; cells of midleaf rectangular to rarely pentagonal, 23--27 x 22--26  $\mu$ m, in base to 30  $\mu$ m; cuticle smooth, walls thin, trigones small, concave to triangular; oil bodies 3--12(--17) per cell, spheric, 3--7  $\mu$ m in diameter to ovoid, 3--5 x 4--9  $\mu$ m, finely granular, nearly colorless to grayish, non-biconcentric; underleaves absent. **Specialized asexual reproduction** by gemmae in masses at apices of leaf-lobes, red-brown to brownish and chestnut, rarely greenish in shade forms, commonly 3--4(--5)-angular in outline, 20--30(--40) x 13--24(--36)  $\mu$ m, (1--2)-celled, with slightly thickened angles. **Sexual condition** dioicous. **Androecia** intercalary, often with gemmae at tips, male bracts 3 pairs, similar to leaves but inflated in the base, 1-androus, antheridial stalk 1-seriate. **Gynoecia** terminal with subfloral innovations, female bracts in 1 pair, rectangular to trapezoidal, sometimes dentate, but commonly entire, ca. 0.6 x 0.35--0.7 mm, divided to  $1/3$  x length into 2--4 lobes, connate; bracteole present, lanceolate, sometimes shortly 2-lobed to  $1/3$  x length, ca. 0.5 x 0.2--0.3 mm, connate with one of bracts to  $2/3$  x length. **Perianth** exerted to  $3/4$  x length, ca. 2--2.5 x 0.7 mm, cylindrical, complicated at mouth, mouth ciliate to lobulate with lobules and cilia to 5--7 cells in length, generally 1-stratose. **Seta** 5 mm, capsule oval, walls 3-stratose, exterior walls with nodular thickenings, interior walls with annular thickenings, reddish brown. **Elaters** ca. 100--120 x 7.5  $\mu$ m. **Spores** spheric, 11--13  $\mu$ m.

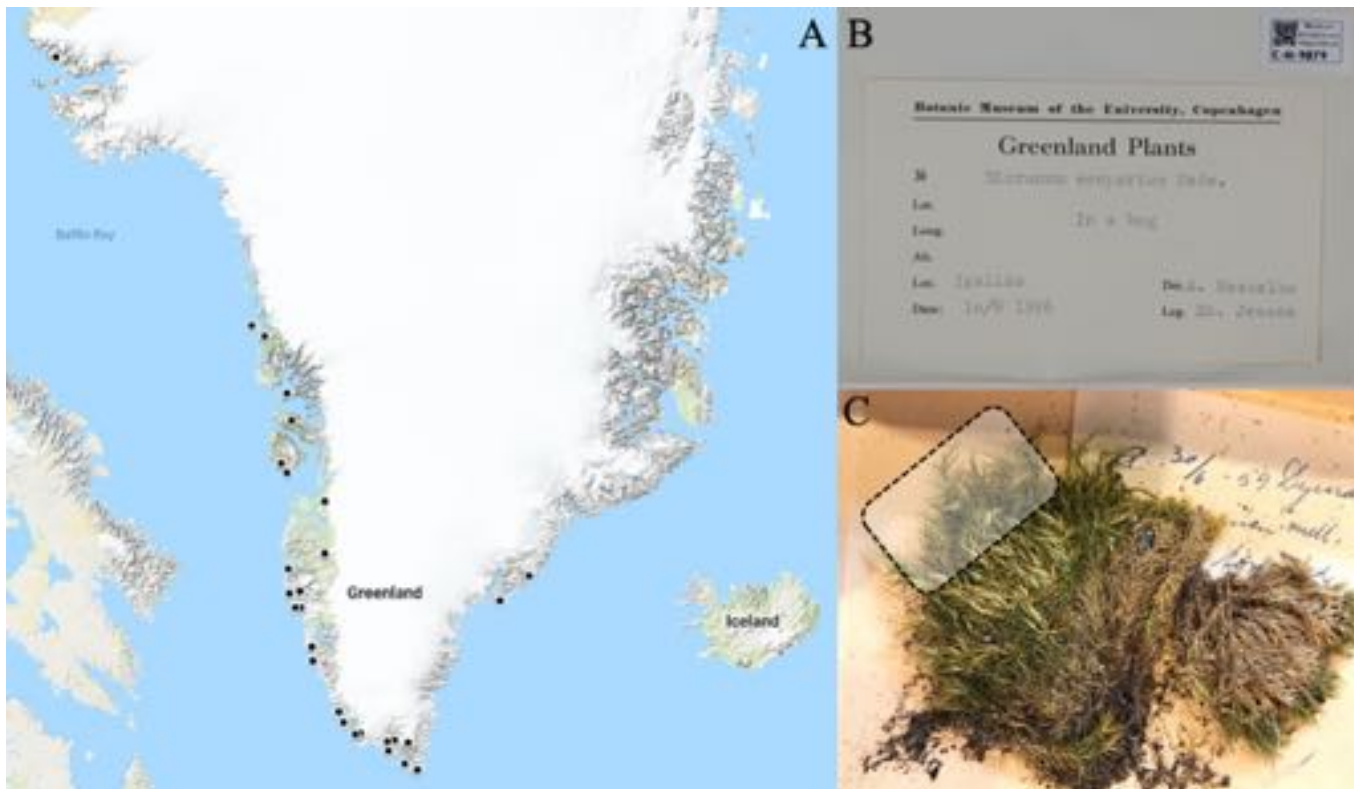




# Herbarium specimens in other research

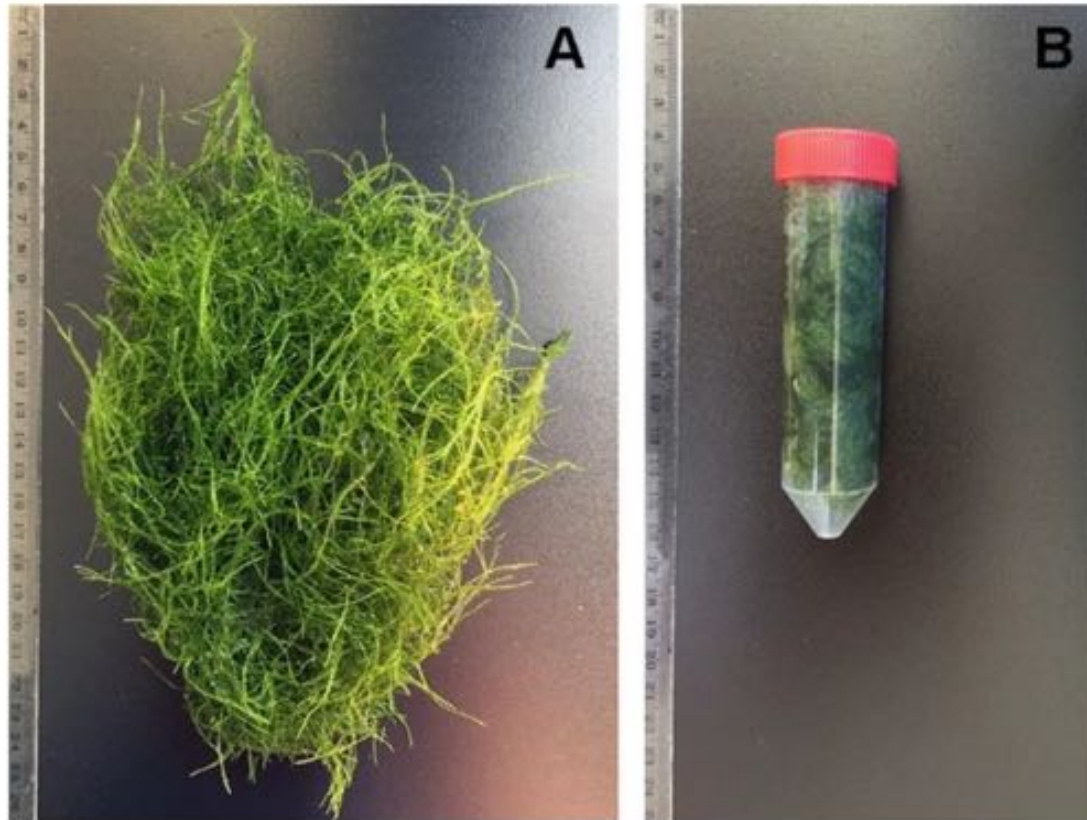
# Bryophytes as bioindicators

Martinez-Swatson et al. 2020: Biomonitoring of Polycyclic Aromatic Hydrocarbon Deposition in Greenland Using Historical Moss Herbarium Specimens Shows a Decrease in Pollution During the 20<sup>th</sup> Century





Papadia et al. 2020: Aquatic Mosses as Adaptable Bio-Filters for Heavy Metal Removal from Contaminated Water.



*Taxiphyllum barbieri*