

# CHAPTER 2-4

## BRYOPHYTA – TAKAKIOPSIDA

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## BRYOPHYTA – TAKAKIOPSIDA



Figure 1. Mt. Daisetsu from Kogan Spa, Hokkaido, Japan. The foggy peak of Mt. Daisetsu is the home of *Takakia lepidozioides*. Photo by Janice Glime.



Figure 2. Hunting for *Takakia* in its typical damp, high elevation or foggy habitat. Photo with permission from <<http://www.botany.ubc.ca/bryophyte/LAB8.htm>>.

### Phylum Bryophyta

**Bryophyta**, *sensu stricto* (in their narrowest sense), are the mosses. These comprise, roughly, 13,000 species worldwide (Crum 2001), but with many tropical taxa likely to be as yet undiscovered, the number could be much higher. Three classes have been recognized traditionally,

the **Bryopsida**, **Andreaeopsida**, and **Sphagnopsida** (Crum 1991). However, as more evidence from genetic and biochemical relationships have become available, and the interesting genus *Takakia* has produced sporophytes in our presence, further division seems justified. Buck and Goffinet (2000) define six classes: **Takakiopsida**, **Sphagnopsida**, **Andreaeopsida**, **Andreaebryopsida**, **Polytrichopsida**, and **Bryopsida**. Recent cladistic analyses using morphological, developmental, anatomical, ultrastructural, and nucleotide sequencing data supports placement of these classes into a single phylum (Newton *et al.* 2000).

### Class Takakiopsida

*Takakia* seems to be among the most primitive of mosses, possessing many characters similar to those of the liverworts, and is the only known genus of its class, having two species [*T. ceratophylla* (Figure 6-Figure 23), *T. lepidozioides* (Figure 24-Figure 35)]. Its leaves in groups of fours, often fused at the base (Figure 5, left), made it immediately stand out as unique. *Takakia* was actually discovered in the Himalayas in 1861 by Mitten (Renzaglia *et al.* 1997), but it was described as a species of liverwort in the genus *Lepidozia*, *L. ceratophylla*. Then it was forgotten for nearly a century. When it was again discovered high in the mountains of Japan, Sinske Hattori sent it to specialists around the world. The phycologists looked and decided it was not one of theirs, and eventually it produced multicellular archegonia, supporting their claim. The pteridologists concluded it was not a reduced fern, nor a lycopod or other tracheophyte cryptogam. It seemed the more likely choices were mosses and



liverworts. Although its 3-dimensional structure seemed a bit out of place, it seemed most like a liverwort, and there it stayed for several decades (Hattori & Inoue 1998; Hattori & Mizutani 1958). But eventually, its **slime papillae** (Figure 4), its **leaves in 3 rows** (Figure 5), its **simple oil bodies** – not granular as in liverworts, its **archegonia** (Figure 3) sometimes on a **pedestal**, and its archegonial **neck cells in 6 vertical rows** began to raise questions. Its chromosome number was 4 or 5, unlike the typical 10 in liverworts and even higher numbers in most mosses.

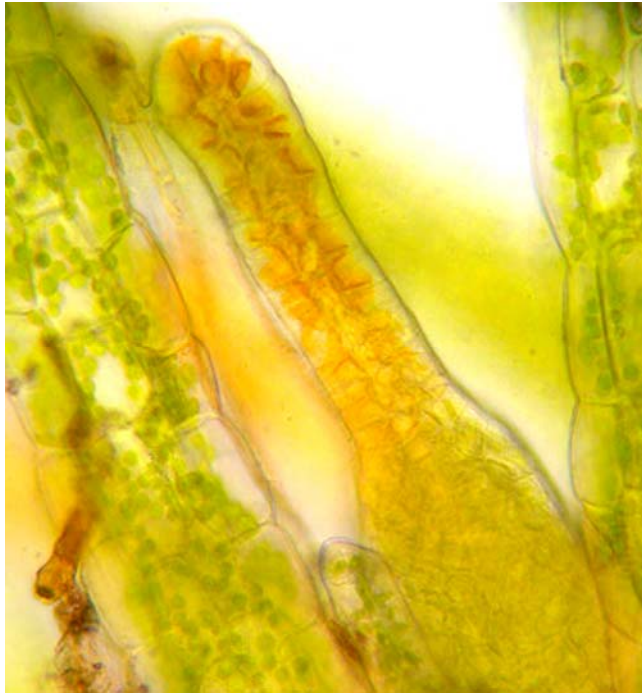


Figure 3. Archegonium of *Takakia lepidozoides*. Photo with permission from <[www.botany.ubc.ca/bryophyte/LAB8.htm](http://www.botany.ubc.ca/bryophyte/LAB8.htm)>.

Then, at one of its former collection sites, it produced capsules (Smith 1990; Smith & Davison 1993)! And there

was the proof. Although not too distant from a liverwort capsule, it **dehiscid spirally** in a single valve (Figure 5, right), and **no elaters** emerged. Indeed, aside from its **filamentous, divided leaves**, it had much in common with *Andreaea*, a moss. The spiral line of dehiscence splits and twists, creating a more efficient spore dispersal (Renzaglia *et al.* 1997; Higuchi & Zhang 1998).



Figure 4. Slime papilla of *Takakia lepidozoides*. Photo with permission from <<http://www.botany.ubc.ca/bryophyte/LAB8.htm>>.

In trying to resolve the phylogenetic position of *Takakia*, Schuster (1997) referred to it as "one of a handful of isolated and unique plants." It is like the Monocleales of the liverworts in its longitudinal suture of the capsule and its "feeble conducting strand" of the sporophyte. Its lobed leaves are like those in the Jungermanniales of the liverworts. The leafless horizontal stolons, slime papillae, massive secretions of mucilage, orange antheridia nestled among leaves of all three rows (Figure 5, middle), and absence of rhizoids are characters like those of the Calobryales among the liverworts. Its capsule with 3-4-5 layers and thickened epidermal cells with thin inner cells and its absence of stomata and air spaces resemble *Symphogyna* in the Metzgeriales, also a liverwort.



Figure 5. *Takakia*. **Left:** vegetative plant of *Takakia lepidozoides* showing filamentous leaves. **Middle:** leafy plant of *Takakia ceratophyllum* with young capsule. **Right:** dehiscing capsule of *Takakia ceratophyllum* showing spiral split and exposed spores. Note single suture that splits, hence a single valve. Photo permissions on left from [www.botany.ubc.ca/bryophyte/LAB8.htm](http://www.botany.ubc.ca/bryophyte/LAB8.htm); photo in middle from website of the Hattori Botanical Laboratory; photo on right from Ken McFarland, Mosses website, through fair use.



Some of its characters are unlike those of either mosses or liverworts. The antheridia of *Takakia* lack perigonia or any structure to surround them, and likewise the archegonia lack perichaetial leaves or any modified surrounding structures.

But it clearly has moss characters as well. The calyptra ruptures distally and is carried by the sporophyte on an elevated capsule. The capsule differentiates and sporogenesis occurs after the seta elongates. The sporophyte is persistent, and the capsule lacks elaters and operculum, but it has a "feeble" **columella** (mass of sterile tissue in center of capsule). Hence, as is often the case in the bryophytes, the gametophyte and the sporophyte tell different stories. In this case, the gametophyte is most like the Marchantiophyta, but the sporophyte is clearly more like members of the Bryophyta. Looking so much like a liverwort, yet also much like a moss, this apparently primitive plant seems an appropriate link between these two major groups.

The genus is distributed in western North America (Queen Charlotte Islands) and central and eastern Asia (Himalayas and mountains of China and northern Japan). The known locations all have cool climates where fog is often present to keep this strange moss moist.

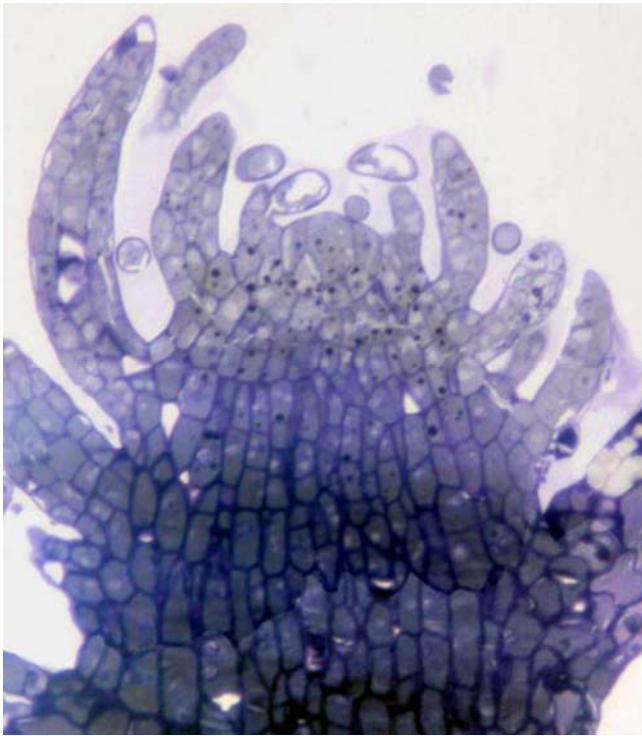


Figure 6. *Takakia ceratophylla* longitudinal section of stem tip. Photo by Karen Renzaglia, with permission.



Figure 7. *Takakia ceratophylla* leaf. Photo by Karen Renzaglia, with permission.



Figure 8. *Takakia ceratophylla* stem stripped of leaves to reveal the antheridia. Photo by Karen Renzaglia, with permission.

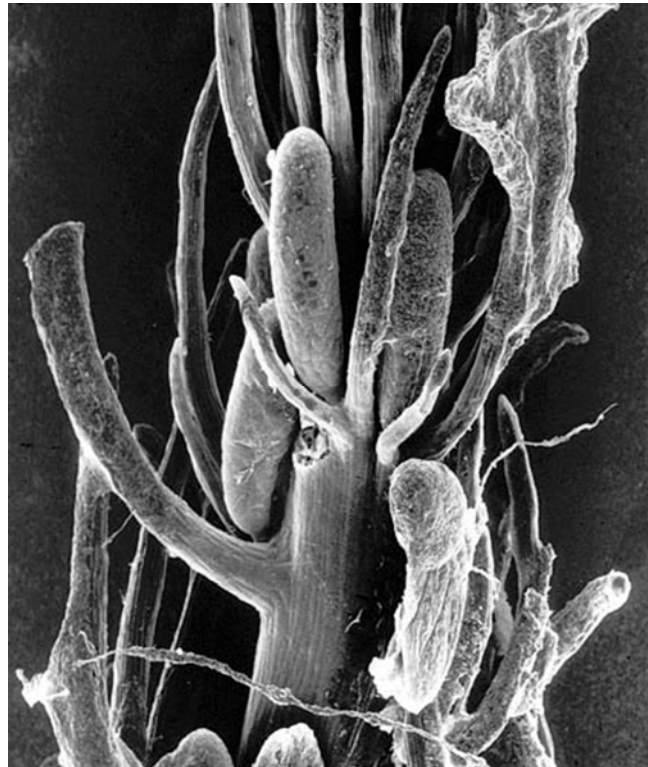


Figure 9. SEM of *Takakia ceratophylla* stem stripped of leaves to reveal the antheridia. Photo by Karen Renzaglia, with permission.





Figure 10. *Takakia ceratophylla* antheridium. Photo by Karen Renzaglia, with permission, and modified by Janice Glime.



Figure 11. *Takakia ceratophylla* seta and aborted archegonia. Photo by Karen Renzaglia, with permission.



Figure 12. *Takakia ceratophylla* longitudinal section of immature capsule and calyptra with glimpses of the columella. Photo by Karen Renzaglia, with permission.

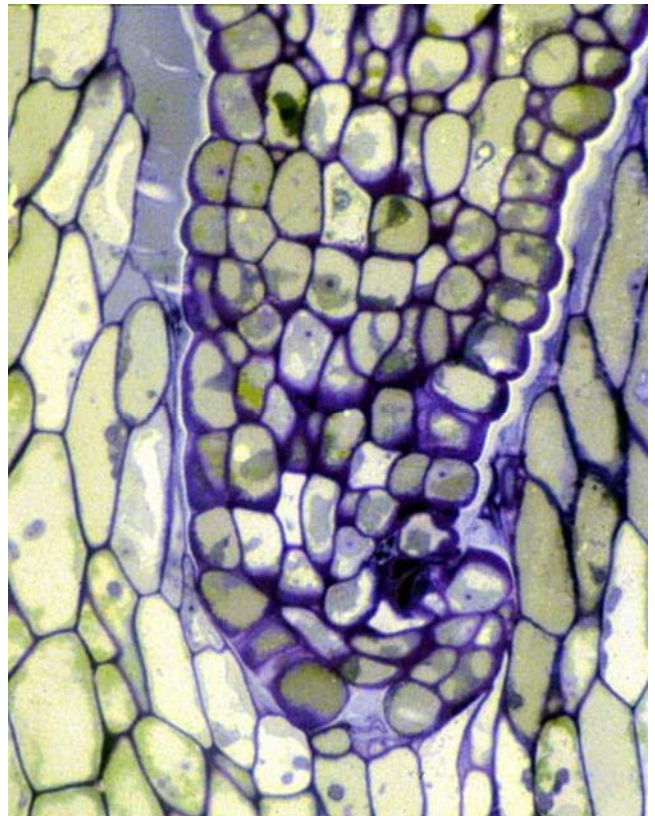


Figure 13. *Takakia ceratophylla* sporophyte with hooked foot. Photo by Karen Renzaglia, with permission.



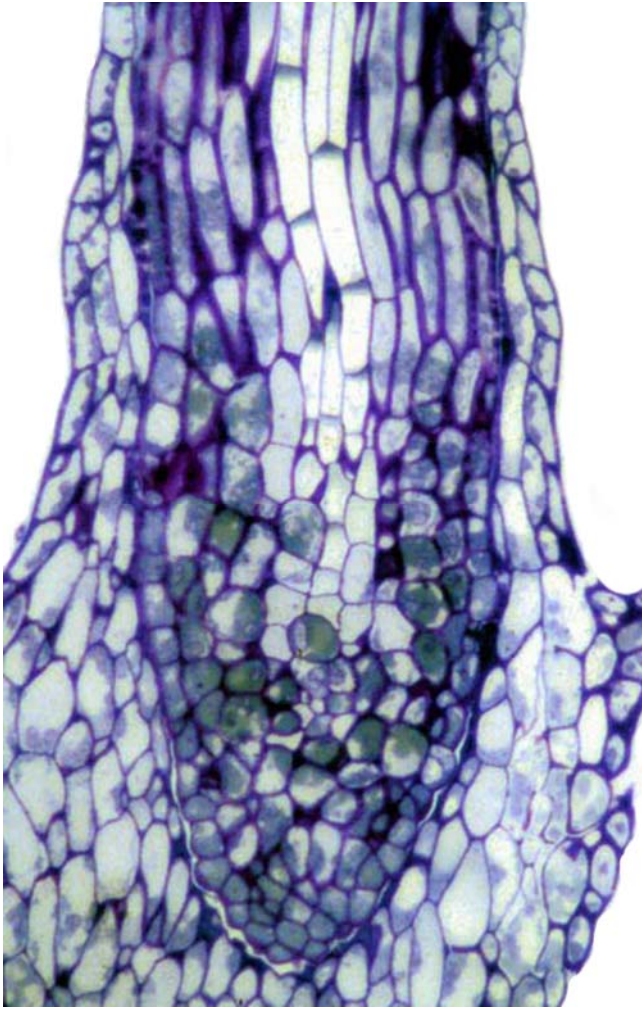


Figure 14. *Takakia ceratophylla* sporophyte foot. Photo by Karen Renzaglia, with permission.



Figure 15. *Takakia ceratophylla* epidermal cell of foot with wall ingrowths. Photo by Karen Renzaglia, with permission.



Figure 16. *Takakia ceratophylla* with immature capsule. Photo by Ken McFarland, through fair use.

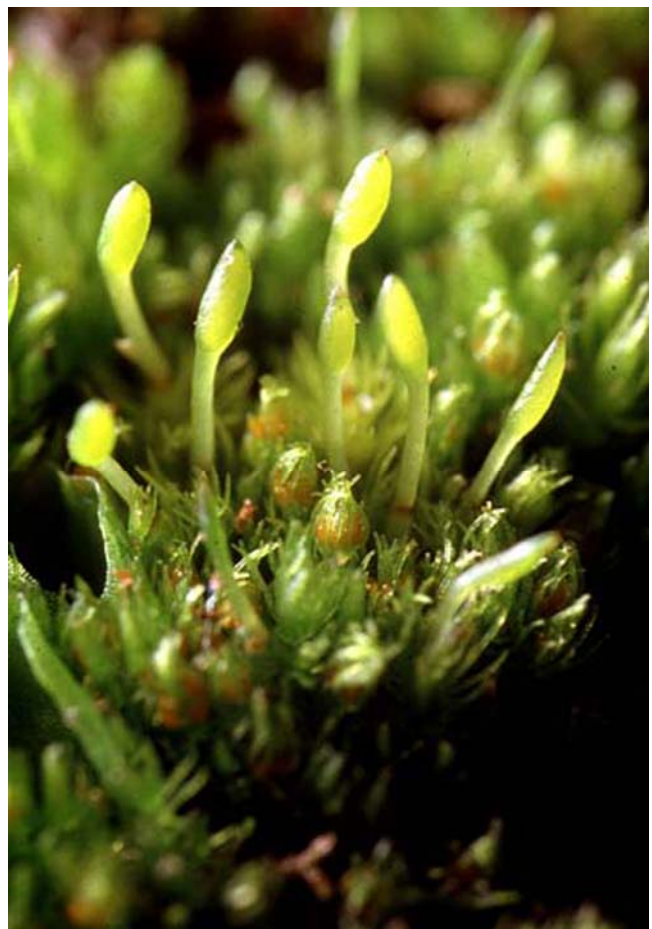


Figure 17. *Takakia ceratophylla* with capsules. Photo by Ken McFarland, with permission.



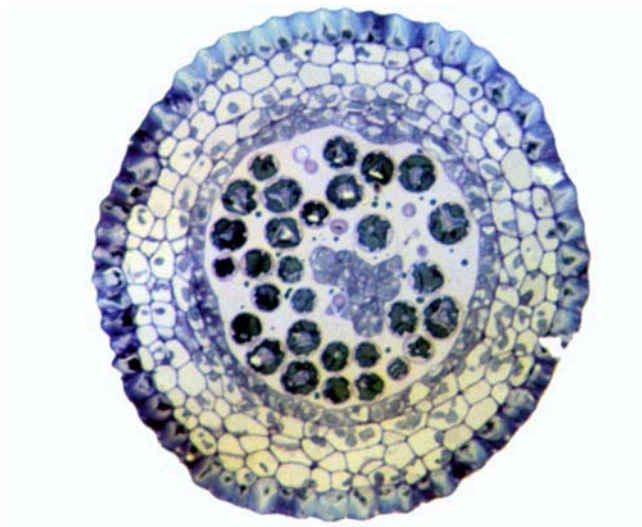


Figure 18. *Takakia ceratophylla* sporophyte cross section showing columella and tetrads of spores. Photo by Karen Renzaglia, with permission.

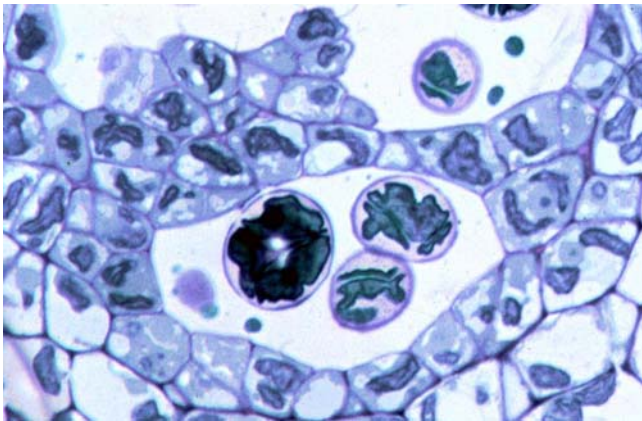


Figure 19. *Takakia ceratophylla* sporophyte cross section showing chambers with tetrads of spores. Photo by Karen Renzaglia, with permission, and modified by Janice Glime.

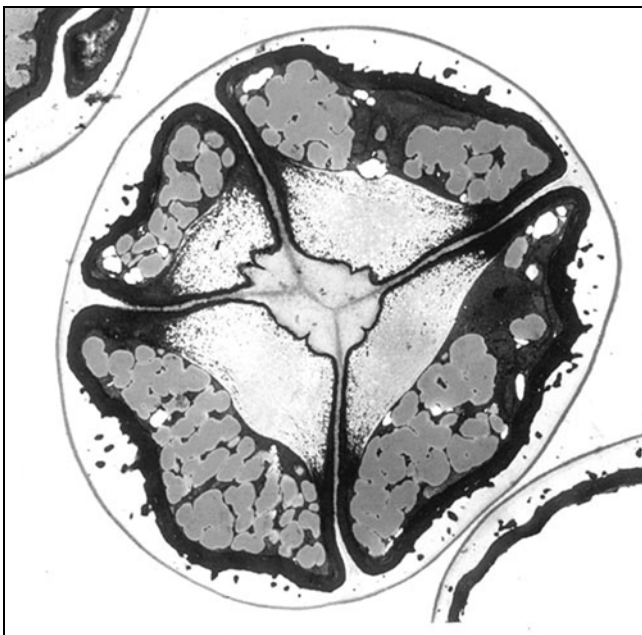


Figure 20. *Takakia ceratophylla* TEM of tetrad of spores. Photo by Karen Renzaglia, with permission.

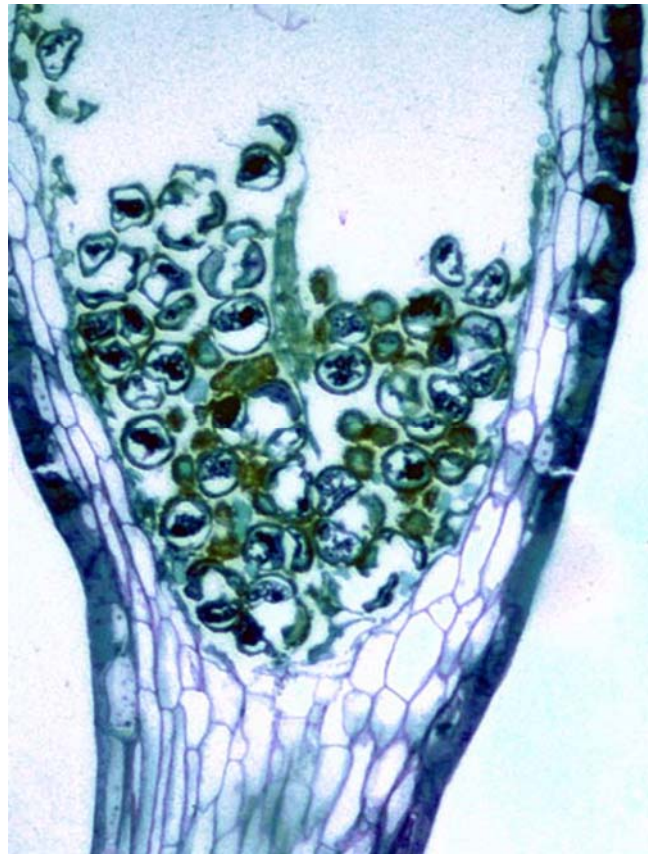


Figure 21. *Takakia ceratophylla* sporophyte longitudinal section showing spores. Photo by Karen Renzaglia, with permission.



Figure 22. *Takakia ceratophylla* with dehiscent capsules. Photo by Karen Renzaglia, with permission.



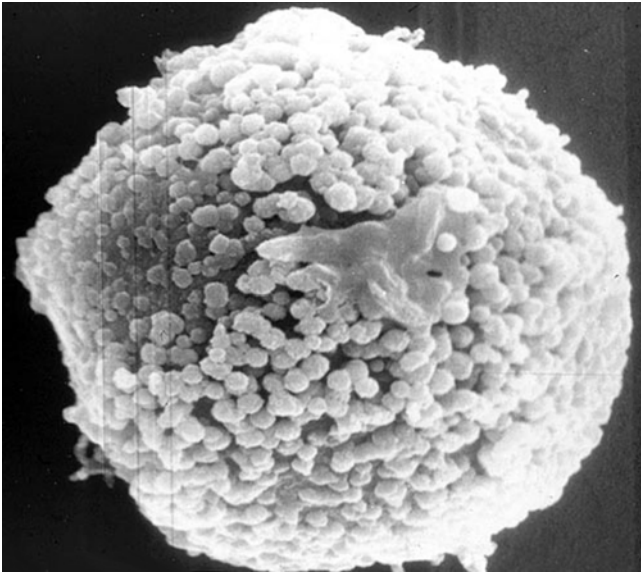


Figure 23. *Takakia ceratophylla* spore SEM. Photo by Karen Renzaglia, with permission.



Figure 26. *Takakia lepidozoioides* growing on rock in Japan. Photo from website of the Herbarium of Hiroshima University, with permission.



Figure 24. *Takakia lepidozoioides* habitat in Hokkaido, Japan, where this species can be found on Mt. Daisetsu. Photo from website of the Herbarium of the University of Hiroshima, with permission.



Figure 25. *Takakia lepidozoioides* cave in Hokkaido, Japan, where this species can be found on Mt. Daisetsu. Photo from website of the Herbarium of the University of Hiroshima, with permission.



Figure 27. *Takakia lepidozoioides* showing connecting rhizomes. Photo from the Herbarium of Hiroshima University, with permission.



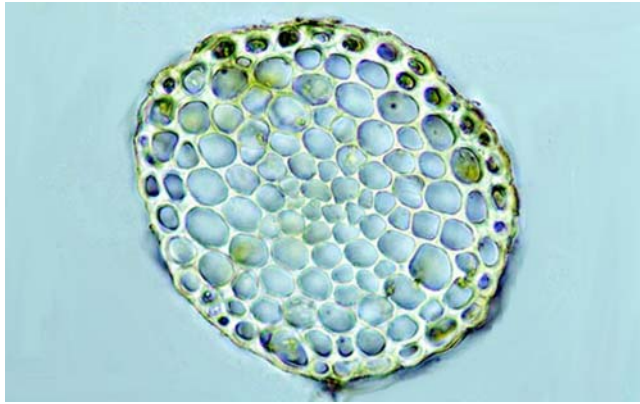


Figure 28. *Takakia lepidozioides* stem cross section. Photo from the website of the Herbarium of Hiroshima University, with permission.



Figure 29. *Takakia lepidozioides* leaf cross section. Photo from the website of the Herbarium of Hiroshima University, with permission.



Figure 30. *Takakia lepidozioides* rhizome tip with mucous cells. Photo from the website of the Herbarium of Hiroshima University, with permission.



Figure 31. *Takakia lepidozioides* tip of young rhizome. Photo from the website of the Herbarium of Hiroshima University, with permission.



Figure 32. *Takakia lepidozioides* mucous cells on stem. Photo from the website of the Herbarium of Hiroshima University, with permission.

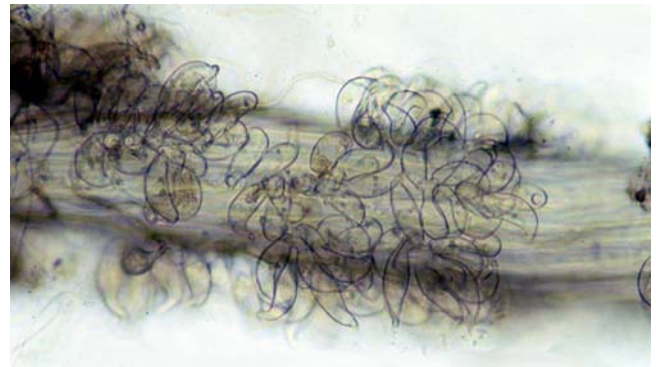


Figure 33. *Takakia lepidozioides* slime papillae. Photo from the website of the Herbarium of Hiroshima University, with permission.

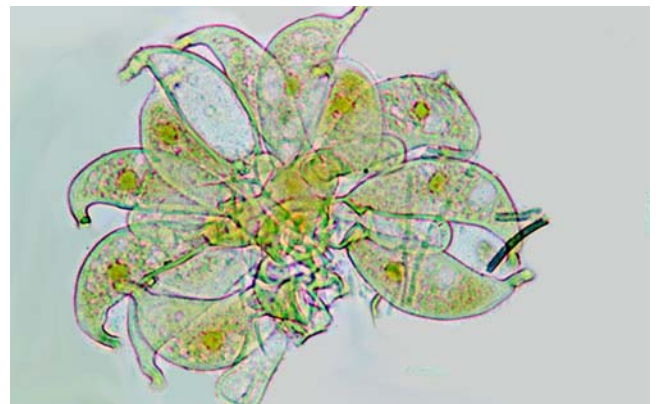


Figure 34. *Takakia lepidozioides* mucous cells on stem. Photo from the website of the Herbarium of Hiroshima University, with permission.



Figure 35. *Takakia lepidozioides* mucous cells on stem. Photo from the website of the Herbarium of Hiroshima University, with permission.

## Summary

Bryophyta can be considered to have six classes: **Takakiopsida**, **Sphagnopsida**, **Andreaeopsida**, **Andreaobryopsida**, **Polytrichopsida**, and **Bryopsida**. **Gametophores** of Bryophyta, including Takakiopsida, produce **archegonia** and/or **antheridia** and the **embryo** develops within the archegonium.

In **Takakiopsida**, as in all Bryophyta, **sporophytes** remain **attached** to the gametophyte and produce **spores** by **meiosis**. Bryophyta, hence **Takakiopsida**, produce spores from the sporophyte only once. Takakiopsida have **capsules** that split spirally into valves.

## Acknowledgments

I appreciate the comments and suggestions of Karla Werner, who offered a beginner's perspective. Noris Salazar Allen offered constructive criticisms on the taxonomic descriptions and helped with the proof reading of an early version. Karen Renzaglia and Hironori Deguchi kindly gave me permission to use their many web images. Llo Stark helped me improve the clarity.

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