

Illustration 1. *Tetraxis pellucida*.

Bryophytes of UBC Botanical Garden

Bryophytes are often overlooked in gardens where the showy flowers are admired and appreciated. The UBC Botanical Garden is a wonderful place to explore; most of the year something is flowering, but in the midst of winter when most plants are dormant, the miniature world of bryophytes is thriving, revelling in the wetness of our Northwest Coast climate. As will become apparent, water is very important for their reproduction. Bryophytes are a large group of plants that includes the mosses, liverworts and hornworts. Mosses are the most common and probably familiar to most people. They have very small, simple leaves arranged spirally on short stems. Bryophytes lack the structural complexity of much of the rest of the plant kingdom.

This paper is part of an ongoing inventory project to examine bryophyte diversity in UBC Botanical Garden. Three of the authors (Haddad, Stewart and Webb) were UBC students in the Introduction to Bryology course given in January - April 2002. So far, we have found 77 species of bryophytes, including 62 mosses, 14 liverworts, and 1 hornwort. We hope that this paper will inspire readers to take a closer look at the bryological inhabitants of the Botanical Garden on their next visit.

To identify a moss you need to think small and carry a hand-lens. Bryophytes live in a variety of different habitats. You will find them in lawns, on rocks, on living trees, on decaying wood, on soil, and near or in streams and ponds.

In the lawns at the UBC Botanical Garden, the presence of mosses among the grasses and at lawn edges is controlled by moisture availability and by the particular care given to the lawn to encourage grass growth. Frequent low mowing can place the grass at a disadvantage, especially late in the autumn and through the winter. During these seasons, mosses are favoured by ample moisture and light, and they grow luxuriantly in the absence of competition from the dormant grasses. Even in healthy lawns, shaded margins, or sites where grasses have not spread, mosses can thrive. In the Bo-

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tanical Garden lawns, *Rhytidiadelphus squarrosus* can form turfs of loosely growing shoots. The apex of the leafy shoots is star-like in appearance, with the leaves diverging outward and curving down at the tips (described as squarrose). The spirally arranged leaves are in five rows, and form a star-like apex. Occasionally, we found the moss *Pseudoscleropodium purum*, a moss which was unintentionally introduced from Europe, probably as packing material in nursery stock. This somewhat feathery-looking moss has regular branching, overlapping leaves with the points upward, and both shoots and branches that are swollen and somewhat worm-like in appearance. Although it is a very attractive moss, it can become a severe pest in lawns. *Calliergonella cuspidata* is another branched lawn moss, but one in which the apical leaves are sharply pointed and tightly packed giving the shoot tip a very sharp appearance (*cuspidata* = like a tooth).

Boulders, scattered in open areas, have a number of mosses confined to them, including (in the garden), *Grimmia pulvinata*, *G. trichophylla*, *Racomitrium elongatum*, *R. heterostichum*, *R. varium* and *Schistidium papillosum*. The leaves of many of the rock mosses are tipped with fine hairs, which give them a grayish appearance. Also on boulders are mosses that occur in other habitats: *Claopodium crispifolium*, *Dicranoweisia cirrata*, *Dicranum scoparium*, *Eurhynchium oregonum*, *E. praelongum*, *Homalothecium fulgescens*, *H. nuttallii*, *Hypnum subimponens*, *Isoetecium stoloniferum*, *Metaneckera menzeisii*, *Pseudotaxiphyllum elegans* and the liverwort *Porella cordaena*.

Living trees in the garden also have their suite of bryophytes. Many of the same species also persist on decaying logs. The richest diversity of bryophytes in the region tend to be on broad-leafed maples (*Acer macrophyllum*) but in the garden this is surprisingly not the case, with only *Claopodium crispifolium* and *Isoetecium stoloniferum* surviving on that species. Other deciduous trees have *Orthotrichum consimile*, *O. lyellii*, *Homalothecium fulgescens*, and *H. nuttallii*. The following mosses are present on coniferous trees: *Anulocomnium androgynum*, *Buckiella undulata* (= *Plagiothecium undulatum*), *Dicranum fuscescens*, *D. scoparium*, *D. tauricum*, *Hypnum circinale*, *Isoetecium stoloniferum*, *Plagiothecium laetum*, *Pseudotaxiphyllum elegans*, and *Rhizomnium glabrescens*. *Rhizomnium glabrescens* can be recognized by its large elliptical leaves. Each unbranched shoot is up to 2.5 cm tall. The male shoots are terminated by a flower-like structure composed of a ring of leaves surrounding a dark central disc. This central region is where antheridia (male sex organs) are found. When water

splashes in, it propels sperm close to the female reproductive structures (archegonia) where they can swim to the egg. This is called a splash-cup mechanism. *Plagiomnium insigne* is a very similar species, although much larger (up to 7 cm tall). It is rarer in the garden.

Rotten logs and stumps, especially those sufficiently decomposed to retain moisture for extended periods, harbour several mosses, including *Buckiella undulata*, *Claopodium crispifolium*, *Dicranum fuscescens*, *D. scoparium* (front cover), *D. tauricum*, *Eurhynchium oreganum*, *E. praelongum*, *Hypnum circinale*, *Isoetecium stoloniferum*, *Plagiothecium laetum*, *Pseudotaxiphyllum elegans*, *Rhizomnium glabrescens*, *Rhytidadelphus loreus*, and *Tetraphis pellucida* (Illustration 1). *Tetraphis pellucida* is one of our favourites. One has to look very closely to see the small shoots topped with a gemma cup. Each cup is made up of leaves and contains a number of gemmae (small, asexual reproductive structures). When a raindrop lands in the cup, the gemmae are splashed out (another splash-cup mechanism). Each gemma will grow into a clone of the original plant. Sporophytes, the product of sexual reproduction, can be observed on other shoots. They are about 1.5 cm in length, and unlike most mosses, have many teeth surrounding the opening of the spore capsule. *Tetraphis* species have only four teeth. The sporophyte must be fully mature for this to be seen.

An array of leafy liverworts thrive on humid rotten logs. Unlike the spirally arranged leaves of mosses, the leaves of liverworts are arranged in rows of two or three. They are generally less tolerant of drying than the mosses. *Blepharostoma trichophyllum*, *Calypogeia azurea*, *Calypogeia muelleriana*, *Cephalozia bicuspidata*, *Cephalozia lunulifolia*, *Geocalyx graveolens*, *Lepidozia reptans*, *Lophocolea bidentata*, *Lophocolea heterophylla*, and *Scapania bolanderi* are all common in the garden. Many of these have intricately lobed leaves that can only be appreciated by looking at them with a hand-lens. *Lepidozia reptans* has 3 – 4 lobed leaves that resemble tiny hands. This liverwort is especially abundant on rotten stumps.

Isoetecium stoloniferum (Illustration 2) is an extremely variable moss species that exhibits some highly distinctive forms that may prove, upon more detailed study, to be justifiably classified as one or more new species. All of these variants are present in the garden. On boulders in sunny sites a glossy, golden green variant forms local colonies. It has worm-like branches and the whole plant curls downward when dry. On some trees the regularly branched large feathery plants form masses, especially above the tree bases.

The leaves of this variant are 2 - 4 mm long; the plants are not notably shiny and are generally a dull green colour. By far the most frequent variant commonly festoons tree branches and tree trunks, and often produces tinsel-like shoots with tiny leaves. It is essentially a “beard” moss, and from a distance seems hair-like. However, it does not reach its best development in the garden.

Disturbed sites, including shaded path margins, as well as garden plots in which the soil is infrequently cultivated, and gravel or bare earth patches, favour bryophytes that can tolerate periods of drying. Mosses in these sites include *Atrichum undulatum*, *Barbula unguiculata*, *Brachythecium frigidum*, *Bryum capillare*, *Calliergonella cuspidata*, *Claopodium crispifolium*, *Didymodon vinealis*, *Eurhynchium oreganum*, *E. praelongum*, *Funaria hygrometrica*, *Polytrichum juniperinum*, *Pseudocrossidium hornschuchianum* and *Rhizomnium glabrescens*. Many of these cannot be recognized in the field without both a hand-lens and considerable experience. If they possess capsules, determination can be made with more confidence, even without a hand-lens. *Atrichum undulatum* is a relatively large moss, with leaves often 2 - 3 cm long. The erect plants are unbranched and form vivid green turfs. When moist, the narrow leaves radiate outward and, under a hand-lens, show diagonal undulations that angle outward from the midrib. The upper surface of the midrib has parallel flaps of tissue that form longitudinal lines. When dried, the leaves curl and are somewhat corkscrew twisted. The cap (calyptra), which surmounts the capsule, is smooth, even though this genus belongs to a group known as the hair-cap mosses (*Atrichum* = without hairs). Capsules, when present, are elongate and somewhat curved. When mature, and the lid has fallen from the capsule tip, one can view with a hand-lens the peristome teeth around the capsule opening. These teeth curve inward over a membrane. Spores can be shed only through tiny slits between the teeth, and are puffed out only with pressure on the capsule. *Polytrichum juniperinum*, another hair-cap moss, is found in patches along trails and does have a hairy calyptra. It is drought-tolerant and when dry the leaves fold upward to reduce water loss.

The streams that pass through the garden provide humid banks and moistened boulders where a number of bryophytes thrive, particularly those that can tolerate fluctuating water levels. *Dichodontium pellucidum* is a common moss on rocks and banks where it forms yellow-green to dark green turfs with quite large (to 5 cm) individual shoots. You can also find *Fissidens*

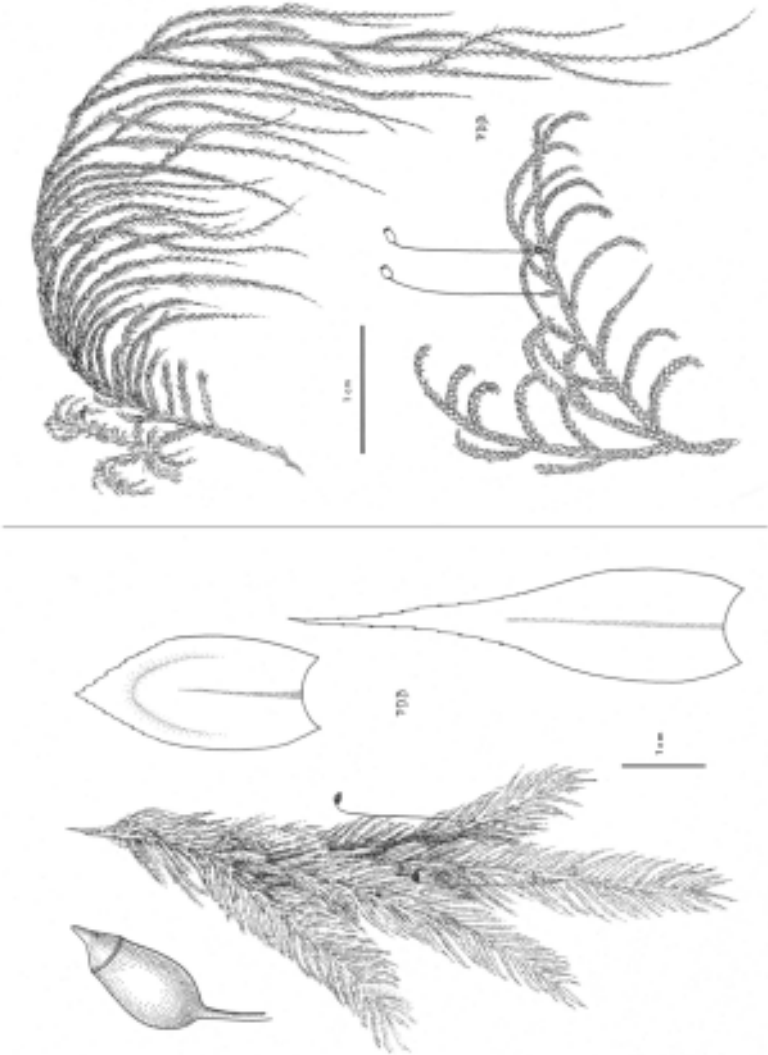


Illustration 2. The extremely variable *Isoethecium stoloniferum*.

limbatus (Illustration 3) in similar habitats. The leaves of *Fissidens* species are unique among the mosses in having leaves with pocket-like flaps. Other mosses found on rocks in the streams are *Heterocladium macounii*, *Hygrohypnum ochraceum*, *Hypnum subimponens* and *Porotrichum biglovii*. Inhabiting places higher on the banks are *Atrichum undulatum*, and the liverwort *Jungermannia*. *Jungermannia* can also be found on dampish soil in other parts of the garden.

A survey of the ponds in the BC Native Garden revealed that *Sphagnum* was the main type of moss growing at the edge and in the ponds. Five species have been collected and identified so far: *Sphagnum capillifolium*, *S. girgensobnii*, *S. magellanicum*, *S. pacificum*, and *S. squarossum*. Members of this water-loving genus have a characteristic tuft of branches at the top of their main stems; lower down the stem the branches are in clusters. Some of the branches in a cluster stick out more or less perpendicular to the main stem, while others hang down along the stem. Microscopically, *Sphagnum* is a very interesting and beautiful moss. The leaves are made up of large, dead, porous cells surrounded by smaller, living green ones. The nature of the cells coupled with the overall branching form of the plant make this a very efficient sponge system. *Sphagnum girgensobnii* by the Native Pond was producing sporophytes at the time of the survey. Spore dispersal is by the “shot-gun method”, whereby pressure builds up inside the spore capsule until it blows its lid, sending the spores flying through the air. *Sphagnum capillifolium* also grows in the hummock at the E.H. Lohbrunner Alpine Garden, where *Polytrichum strictum* is also found. This is commonly called bog haircap moss because it is found mainly in peatlands.

The Alpine Pond is the location of the only hornwort in the Garden, *Phaeoceros laevis*. It grows on gravelly soil beside a bench. Hornworts do not have defined stems and leaves, but a flattened, green, and ribbon-like thallus. It adheres to the ground by small unicellular projections. In the late fall, horn-shaped sporophytes are present, which are shaped like horns. Behind the bench grows *Marchantia polymorpha*, a thalloid liverwort. It is considered a pest by gardeners and horticulturists, but in the early spring it is at its most interesting, in reproductive mode. The plants are either male or female. On male plants you will find erect stalks, which have a roundish plate-like structure on top that houses the antheridia (sperm producing structures). The female plant has similar stalks, but instead of a plate, there is an umbrella-like disc with many downward pointing lobes. This is where eggs are housed

and where sporophytes develop (the sporophyte is the product of a fertilized egg). Asexual reproduction is a very common way for this plant to reproduce too. You can find gemma cups on the upper surface, which, as previously mentioned, act as splash cups.

The best time of year for experiencing bryophytes is from fall to early spring, when the foliage of the deciduous plants is not obscuring them from view and wet weather allows them to flourish and expand their branches and leaves. Of course, any time is a good time to admire bryophytes. So, next time you visit the UBC Botanical Garden be dazzled by the *Cardiocrinum giganteum* (giant Himalayan lily), but take a closer look around; there are many smaller wonders to explore.

Useful References

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- Schofield, W.B. 1992. Some Common Mosses of British Columbia. Royal British Columbia Museum, Victoria.
- Schofield, W.B. 2002. Field Guide to Liverwort Genera Of Pacific North America. University of Washington Press, Seattle.

Appendix 1: Bryophytes of UBC Botanical Garden

Mosses

- Atrichum undulatum* (Hedw.) P. Beauv.
Aulacomnium androgynum (Hedw.) Schwaegr.
Barbula unguiculata Hedw.
Brachythecium albicans (Hedw.) Schimp.
Brachythecium frigidum (C.Mull.) Besch
Brachythecium salebrosum (Web. & Mohr) Schimp
Bryum argenteum Hedw.
Bryum capillare Hedw.
Bryum pallescens Schleich. ex Schwaegr..
Buckiella undulata (Hedw.) Irel.
Calliergonella cuspidata (Hedw.) Loeske.
Ceratodon purpureus (Hedw.) Brid.
Claopodium crispifolium (Hook.) Ren. & Card.
Climacium dendroides (Hedw.) Web. & Mohr.
Dichodontium pellucidum (Hedw.) Schimp.
Dicranella heteromalla (Hedw.) Schimp.
Dicranoweisia cirrata (Hedw.) Lindb. ex. Milde
Dicranum fuscescens Turn.
Dicranum scoparium Hedw.

Dicranum tauricum Sapeh.
Didymodon vinealis (Brid.) Zand.
Eurhynchium oreganum (Sull.) Jaeg.
Eurhynchium praelongum (Hedw.) Schimp.
Fissidens limbatus Sull.
Funaria hygrometrica Hedw.
Grimmia pulvinata (Hedw.) Sm. ex Sm. & Sowerby
Grimmia trichophylla Grev.
Heterocladium macounii Best.
Homalothecium fulgescens (Mitt. ex C. Mull.) Lawt.
Homalothecium nuttallii (Wils.) Jaeg.
Hygrohypnum ochraceum (Turn. ex Wils.) Loeske.
Hypnum circinale Hook.
Hypnum subimponens Lesq.
Isothecium stoloniferum Brid.
Metaneckera menziesii (Hook. in Drumm.) Steere.
Orthotrichum consimile Mitt.
Orthotrichum lyellii Hook. & Tayl.
Philonotis fontana (Hedw.) Brid.
Plagiomnium insigne (Mitt.) T. Kop.
Plagiothecium laetum Schimp. in B.S.G.
Polytrichum commune Hedw.
Polytrichum formosum Hedw.
Polytrichum juniperinum Hedw.
Polytrichum strictum Brid.
Poro-trichum bigelovii (Sull.) Kindb.
Pseudocrossidium horns-chuchianum (Schultz) Zand.
Pseudoscleropodium puruum (Hedw.) Fleisch.
Pseudotaxiphyllum elegans (Brid.) Iwats.
Racomitrium elongatum Ehrh. ex Frisv.
Racomitrium heterostichum (Hedw.) Brid.
Racomitrium varium (Mitt.) Jaeg.
Rhizomnium glabrescens (Kindb.) T. Kop.
Rhytidiadelphus loreus (Hedw.) Warnst.
Rhytidiadelphus squarrosus (Hedw.) Warnst.
Schistidium papillosum (Hedw.) Bruch & Schimp.
Sphagnum capillifolium (Ehrh.) Hedw.
Sphagnum girgensohnii Russ.
Sphagnum magellanicum Brid.
Sphagnum pacificum Flatb.
Sphagnum squarrosum Crome.
Tetraphis pellucida Hedw.
Tortula muralis Hedw.

Liverworts

Blepharostoma trichophyllum (L.) Dum.
Calyptogeia muelleriana (Schiffn.) K.Mull.
Calyptogeia azurea Stotler & Crotz.
Cephalozia bicuspidata (L.) Dum.
Cephalozia lunulifolia (Dum.) Dum.

- Chiloscyphus polyanthos* (L.) Corda.
- Geocalyx graveolensi* (Schrad.) Nees.
- Jungermannia* sp. L. emend. Dum.
- Lepidozia reptans* (L.) Dum.
- Lophocolea bidentata* (L.) Dum.
- Lophocolea heterophylla* (Schrad.) Dum.
- Marchantia polymorpha* L.
- Porella cordaeana* (Hub.) Moore.
- Scapania bolanderi* Aust.

Hornworts

- Phaeoceros laevis* (L.) Prosk.

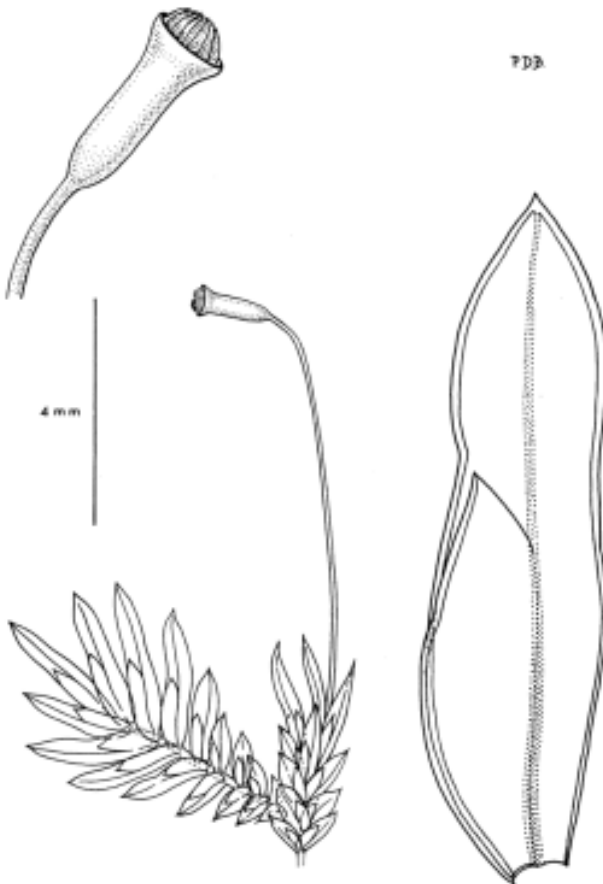


Illustration 3. *Fissidens limbatus*.