2. SPHAGNACEAE Dumortier

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Plants with branches in fascicles, branches usually of spreading and pendent types but rarely spreading only. **Protonemata** thallose. **Leaves** usually of two distinctly different types; branch leaves that are normally inrolled and broadest ca. 1/4–1/3 the distance from the base, more or less tapered to a cucullate to involute apex; stem leaves more or less flat and usually broadest at the base; both leaf types of a network of hyaline, dead cells and green chlorophyllose cells; pores and reinforcing fibrils frequent in branch leaf hyaline cells and uncommon in stem leaf hyaline cells. **Rhizoids** lacking. **Sporophytes** consisting of a spherical capsule with pseudostomata on capsule surface, a very short seta, and a foot, exserted on a pseudopodium of gametophyte tissue. **Spores** released by explosive opening of operculum.

The sphagnum mosses, or peat mosses, are unique not only morphologically but also ecologically. With their abundant clear cells they can retain up to 25 times their dry weight in water, and a uniquely strong acidifying power permits sphagnum to direct succession wherever conditions are suitable for them to flourish. Much of the earth's surface with a cool humid climate is dominated, thus, by sphagnum peatlands.

Genus 1, species ca. 285 (89 species in the flora): nearly worldwide.

1. SPHAGNUM Linnaeus, Sp. Pl. 2: 1106. 1753; Gen. Pl. ed. 5, 487. 1754 • [Greek *sphagnos*, an unknown plant]

Plants typically with upright stems, young branches arranged spirally around stem at growing apex into a capitulum, branches clustered into fascicles along stem, stem and branch leaves of alternating inflated, S-shaped to rhomboid hyaline cells and narrow linear chlorophyllous cells, hyaline cells typically fibrillose and porose on branch leaves. **Protonema** typically 1-stratose, gametophyte developing from lateral margin. **Stems** differentiated into a central cylinder of thin-walled parenchymatous cells, merging into a cylinder of thick-walled cortical cells surrounded by 0–4 layers of thin-walled inflated cells, superficial layer of cells usually aporose, but may be porose. **Stem leaves** may be less fibrillose or efibrillose and less porose or aporose

than the branch leaves, often septate, a distinct border of narrow linear chlorophyllous cells often along margins and at base, and with a greater width:length ratio than branch leaves in anisophyllous forms, partly differentiated in hemiisophyllous forms, and identical in isophyllous forms. **Branches** typically dimorphic as spreading and pendent branches, but some species lack branches or branches are not clearly differentiated, pendent branches typically more slender than spreading branches and with a tendency to adhere to and cover the stem. **Branch fascicles** typically with 2 spreading and 1–2 pendent branches, but there may be up to 12(–14) per fascicle. **Branch stems** typically green, with a superficial layer of inflated retort cells; these grouped or solitary, usually porose at the distal end with a conspicuous or inconspicuous neck. **Branch leaves** with $^2/_5$ phyllotaxy, of a 1-stratose network of alternating chlorophyllous and hyaline cells; hyaline cells usually S-shaped, rarely rhomboid, nearly always strengthened with conspicuous spiral fibrils, small to large, round to elliptic and sometimes ringed pores occur along commissures or rarely on cell lumen, convex surface typically with more pores per cell than concave surface; chlorophyllous cells may be enclosed on both surfaces, more broadly exposed on one surface or equally exposed on both surfaces as viewed in transverse section, adjacent cell walls typically smooth, but various types of cell wall projections may be clearly visible in transverse section. **Sexual condition** dioicous or monoicous; stalked globose antheridia borne at the tips of branches usually with swollen colored tips of branches near capitulum; long-necked archegonia borne on short branches singly surrounded by perichaetial leaves that are typically longer than branch leaves. **Capsule** spherical, brown to black, lacking an annulus or peristome with a operculum convex; spore sac amphithecial in origin, over-arching columella. **Calyptra** membranous. **Spores** tetrahedral, with prominent trilete mark, fine to coarse superficial surface, distal surface may have raised Y-mark, bifurcated Y-mark sculpture, or none.

Species 285 (89 in the flora): worldwide except Antarctica, primarily in boreal regions but also in cool, moist montane and oceanic habitats such as nutrient-poor and acidic wetlands and mires.

The concept of species in *Sphagnum* is controversial. We have followed P. Isoviita (1966) and K. I. Flatberg (1994) in the recognition of species. H. A. Crum (1984) and others (R. E. Daniels and A. Eddy 1985; A. L. Andrews 1958, 1959) have adopted more conservative taxonomic concepts for species in the Northern Hemisphere. Description of the spores above is from Cao T. and D. H. Vitt (1986); for additional discussion of the protonema see C. B. McQueen (1988).

Microscopic features can be observed by using a concentrated aqueous or alcohol solution of Crystal Violet. A 50% solution of alcohol and Methylene Blue or Safranin Red can be used, but these usually do not stain features such as minute pores, fibrils, wall thinnings, and surface sculpture on the chlorophyllous cells. The number and kinds of branches should be determined, individual stem and branch leaves (from the middle of a spreading branch) should be examined from the distal 2 cm of the plant, and the superficial surface of stem cortical cells as well as cross sections of branch leaves and stems may need examination.

SELECTED REFERENCES Crum, H. A. 1984. Sphagnaceae. In: N. L. Britton et al., eds. 1905+. North American Flora.... 47+ vols. New York. Ser. 2, part 11. Crum, H. A. 1986. Sphagnaceae. In: G. S. Mogensen, ed. Illustrated moss flora of arctic North America and Greenland. 2. Meddel. Grønland, Biosci. 18: 1–61. Daniels, R. E. and A. Eddy. 1985. Handbook of European *Sphagna*. Huntingdon. Flatberg, K. I. 2002. The Norwegian *Sphagna*: A Field Colour Guide. Trondheim. Isoviita, P. 1966. Studies on *Sphagnum* L. 1. Nomenclatural revision of the European taxa. Ann. Bot. Fenn. 3: 199–264. McQueen, C. B. 1990. Field Guide to the Peat Mosses of Boreal North America. London. Nyholm, E. 1954–1969. Illustrated Moss Flora of Fennoscandia II: Musci. Lund. Pp. 647–799.

1. Outer stem cortical cell walls reinforced with spiral fibrils . . . . . 1a. *Sphagnum* sect. *Sphagnum*, p. 48
1. Outer stem cortical cell walls smooth.
   2. Outer cortical cells of branches nearly all porose at distal end; branch leaves with denticulate margins and bordered with resorption furrow . . . . . 1b. *Sphagnum* sect. *Rigida*, p. 55
   2. Outer cortical cells of branches of two kinds, smaller aporose cells and larger retort-shaped cells with pore at apical end; branch leaf margins usually entire.
      3. Fascicles of 7 or more branches . . . . . 1h. *Sphagnum* sect. *Polyclada*, p. 85
      3. Fascicles of 6 or fewer branches.
         4. Branch leaf hyaline cells efibrillose, but see 46. *S. splendens* in sect. *Cuspidata* . . . . . 1e. *Sphagnum* sect. *Isocladus*, p. 60
         4. Branch leaf hyaline cells fibrillose.
            5. Branch and stem leaves isophyllous; branches in fascicles of 2–3, spreading and pendent branches similar, or plants may have single or no branches; hyaline cells of branch leaves usually with numerous pores along the commissures, giving a bead-like appearance; chlorophyllous cells of branch leaves in transverse section barrel-shaped, truncate-elliptic to trapezoidal, exposed equally on both surfaces or slightly broader on the convex surface . . . . . 1g. *Sphagnum* sect. *Subsecunda* (in part), p. 78
            5. Branch and stem leaves usually anisophyllous; 3–6 branches per fascicle, spreading branches clearly differentiated from pendent branches; hyaline cells of branch leaves with scattered pores along the commissures or free; chlorophyllous cells of branch leaves in transverse section triangular, truncate-trapezoidal to elliptical and may be more broadly exposed on either surface.
               6. Branch leaf chlorophyllous cells triangular to trapezoidal, exposed much more broadly on concave or convex surface.
                  7. Chlorophyllous cells of branch leaves triangular to trapezoidal in transverse section, more broadly exposed on the convex surface; in plants with stellate capitula, the branches between the rays of the capitulum occur in pairs; stem leaves often hanging downward on the stem . . . . . 1f. *Sphagnum* sect. *Cuspidata*, p. 61
                  7. Chlorophyllous cells of branch leaves triangular to trapezoidal in transverse section, more broadly exposed on the concave surface; in plants with stellate capitula, the branches between the rays of the capitulum single; stem leaves upright on the stem . . . . . 1i. *Sphagnum* sect. *Acutifolia*, p. 85
               6. Branch leaf chlorophyllous cells lenticular, truncate-elliptic to trapezoidal; exposed more or less equally on both surfaces or slightly more broadly on convex surface.
                  8. Stem leaves with apex broad and fimbriate; branch leaves often squarrose from an enlarged clasping base; interior surface of chlorophyllous cells often finely papillose . . . . 1d. *Sphagnum* sect. *Squarrosa*, p. 58
                  8. Stem leaves with apex obtuse and entire to erose; branch leaves straight, slightly subsecund, or slightly recurved; interior surface of chlorophyllous cells always smooth.
                     9. Branch leaves with broad truncate toothed apex, hyaline cells with pores in cell ends and angles . . . . . 1c. *Sphagnum* sect. *Insulosa*, p. 57
                     9. Branch leaves with rounded, untoothed or weakly toothed apex, hyaline cells on convex surface with numerous pores along commissures or free . . . . 1g. *Sphagnum* sect. *Subsecunda* (in part), p. 78

1a. Sphagnum Linnaeus sect. Sphagnum

Plants typically large, with distinct capitulum; green, pale green, yellowish, red, tan, brown to dark brown. **Stems** green, brown or reddish, outer cortex of 3–4 layers of inflated, thin-walled cells, superficial cells with conspicuous to faint spiral fibrils, no or strong ornamention on interior wall, and 1–6 round to ovate pores per cell. **Stem leaves** typically as large as or larger than branch leaves, lingulate to ovate-lingulate with broad rounded apex, border fringed; hyaline cells rhomboid, efibrillose or fibrillose, sometimes ornamented, aporose, 0–2-septate, and often resorbed on exterior surface. **Branches** dimorphic, spreading branches tumid, pendent branches usually shorter and more slender. **Branch fascicles** with 2–3 spreading branches and 1–3 pendent branches. **Branch stems** green, surrounded by 1 layer of enlarged thin-walled cells, typically porose and fibrillose, in some species ornamented on interior wall; retort cells absent. **Branch leaves** ovate to broadly ovate, apex cucullate and roughened on convex surface; margin toothed; hyaline cells fibrillose; convex surface pores round to elliptic, usually with 1 at each corner of three adjacent hyaline cells; chlorophyllous cells lenticular to triangular, sometimes with wall ornamentation visible in transverse section; chlorophyllous cells enclosed, equally exposed, or more broadly exposed on concave surface, end walls thickened or unthickened. **Sexual condition** usually dioicous. **Capsule** 2 mm or more. **Spores** typically 22–30 µm, distal surface sculpture may be present; proximal laesura usually more than 0.5 spore radius.

Species 54 (12 in the flora): worldwide except Antarctica.

1. Branch leaf chlorophyllous cells in transverse section ± equilateral-triangular, often with conspicuous vertically oriented comb-fibrils on the hyaline cells where overlying chlorophyllous cells.
   2. Branch cortical cells with funnel-like projections often extending halfway or more into the next cell; branches strongly clavate and blunt . . . . . 11. *Sphagnum portoricense*
   2. Branch cortical cells with flat end walls or with weak funnel-like projections extending less than halfway into the next cell; branches not clavate or if clavate, with pointed ends.
      3. Interior layer of stem cortical cells with distinct comb-lamellae; branch leaves with or without comb-lamellae; stem leaves without comb-lamellae . . . . . 1. *Sphagnum affine*
      3. Interior layer of stem cortical cells without comb-lamellae or at least not visible with a light microscope; branch leaves with comb-lamellae; stem leaves with or without comb-lamellae.
         4. Stem leaf hyaline cells with distinct comb-lamellae; branches clavate and pointed; branches leaves strongly imbricate . . . . . 3. *Sphagnum austinii*
         4. Stem leaf hyaline cells without distinct comb-lamellae; branches not clavate; branch leaves more or less spreading.
            5. Stem leaves short (ca. 0.8–1.1 mm); branch leaves broad (breadth:length ca. 0.7–0.8), branch leaf comb-lamellae usually distinct only in lower half of leaf; branch cortical comb-lamellae present; plants yellow to golden brown . . . . . 6. *Sphagnum imbricatum*
            5. Stem leaves long (ca. 1.1–1.5 mm.); branch leaves narrow (breadth:length ca. 0.6–0.68), branch leaf comb-lamellae distinct throughout most of leaf; branch cortical cell comb-lamellae usually absent; plants dark brown . . . . . 12. *Sphagnum steerei*

1. Branch leaf chlorophyllous cells in transverse section narrowly triangular, trapezoidal, truncate-elliptic, elliptic or lenticular; comb-fibrils if present horizontally oriented.
   6. Branch leaf chlorophyllous cells in transverse section short-elliptic, elliptic to lenticular, and enclosed on both surfaces.

7. Branch leaf chlorophyllous cells in transverse section short-elliptic and well enclosed; plants purplish red when pigmented . . . . . 7. *Sphagnum magellanicum*
7. Branch leaf chlorophyllous cells in transverse section narrowly elliptic and slightly enclosed on both surfaces; plants brown when pigmented.
   8. Branch leaf chlorphyllous cells in transverse section without thickened ends walls; superficial stem cortical cells with reinforcing fibrils weak or absent; branch leaf hyaline cells where overlying chlorophyll cells often with comb-fibrils . . . . . 2. *Sphagnum alaskense*
   8. Branch leaf chlorphyllous cells in transverse section with thickened end walls; superficial stem cortical cells with strong reinforcing fibrils; branch leaf hyaline cells where overlying chlorophyllous cells smooth . . . . . 4. *Sphagnum centrale*

[6. Shifted to left margin.—Ed.]

6. Branch leaf chlorophyllous cells in transverse section narrowly triangular, rectangular to truncate-elliptic, exposed equally on both surfaces or more broadly on the convex surface.
   9. Branch leaf hyaline cells papillose where overlying chlorophyllous cells . . . . . 9. *Sphagnum papillosum*
   9. Branch leaf hyaline cells epapillose where overlying chlorophyllous cells.
      10. Superficial stem cortical cells with fibrils weak or lacking; chlorophyllous cells rectangular to truncate-elliptic, exposed equally on both surfaces . . . . . 10. *Sphagnum perichaetiale*
      10. Superficial stem cortical cells with strong fibrils; chlorophyllous cells triangular, exposed more broadly on concave surface.
         11. Branch leaf hyaline cells where overlying chlorophyllous cells often with irregular worm-like ridges, especially at the leaf base; pores on the convex surface numerous, small and round to elliptic . . . . . 5. *Sphagnum henryense*
         11. Branch leaf hyaline cells smooth throughout; pores on the convex surface elliptic to flattened-elliptic, not numerous . . . . . 8. *Sphagnum palustre*

1. Sphagnum affine Renauld & Cardot, Rev. Bryol. 12: 44. 1885

Sphagnum imbricatum subsp. *affine* (Renauld & Cardot) Flatberg; *S. imbricatum* var. *affine* (Renauld & Cardot) Warnstorf; *S. imbricatum* var. *laeve* Warnstorf

Plants moderate-sized and lax to somewhat compact, ± stiff-stemmed; moderate-sized to large, forming lawns or low, loose hummocks; green, yellow-brown to golden brown and often tinged with brown to purplish brown; capitulum ± flat in lax open-grown forms to ± rounded and compact in open-grown forms. **Stems** brown, superficial cortical layer with spiral reinforcing fibrils clearly visible, usually 2 or more pores per cell, comb-fibrils visible on interior wall. **Stem leaves** to 1.3–1.9 × 0.6–1.2 mm; rarely hemiisophyllous; hyaline cells non-ornamented, nonseptate or sometimes septate. **Branches** ± tapering, leaves loosely imbricate to spreading and often squarrose in shade forms. **Branch fascicles** with 2 spreading and 2–3 pendent branches. **Branch stems** with cortical cell comb-lamellae weakly differentiated on interior wall, no or weak funnel-like projections on the interior end walls, pores in superficial wall mostly restricted to leaf attachments. **Branch leaves** ovate to ovate elliptical, 1.5–2 × 0.9–1.6 mm; hyaline cells on convex surface with elliptic to more often round pores along the commissures, comb-lamellae can be present, but often absent or restricted to leaf bases; chlorophyllous cells broadly triangular in transverse section and well-enclosed on the convex surface; end wall not thickened. **Sexual condition** dioicous. **Capsule** with scattered pseudostomata . **Spores** 27–31 µm; granulate on both surfaces; laesura on proximal surface less than 0.5 the spore radius.

Capsules fairly common, mature early to late summer. Widespread and often ruderal, wide variety of minerotrophic wetlands, especially abundant in forested mires; low to moderate elevations; Nfld. and Labr. (Nfld.), N.S., P.E.I.; Ala., Ark., Conn., Del., D.C., Fla., Ga., Ill., Ind., Ky., La., Maine, Md., Mass., Miss., Mo., N.H., N.J., N.Y., N.C., Ohio., Okla., Pa., R.I., S.C., Tenn., Tex., Vt., Va., W.Va.; Europe.

Sphagnum affine may occur elsewhere but the taxonomy is unclear (K. I. Flatberg 1984). Although species of sect. *Sphagnum* are notoriously difficult to tell apart in the field, *S. affine* is typically smaller than *S. centrale, S. palustre*, and *S. papillosum*, the other brown species of this section with which it may occur. It is also much more likely to have somewhat squarrose branch leaves, especially in shade forms.