New York City EcoFlora

Bryophytes are diminutive plants related by a common ancestor to Algae and forming three distinct evolutionary lineages: Liverworts (Division Marchantiophyta), Mosses (Division Bryophyta), and Hornworts (Division Anthocerotophyta). Like other plants, they make their own food from water and carbon dioxide via photosynthesis, but unlike flowering plants, they lack complex vascular tissue and reproduce by spores, not seeds. The dominant phase of the life-cycle of Bryophytes is the gametophyte phase. This is the result of meiosis in which the genome is halved (haploid) analogous to the production of sperm and egg cells in higher plants and animals. In Bryophytes, the diploid phase (sporophyte) with a double complement of chromosomes is tiny and dependent on the gametophyte. It's as if human sperm and eggs were the dominant phase of our life-cycle, conspicuous and free-living and the diploid baby (sporophyte) spent its entire short life in the womb.

Bryophytes are ecologically important as pioneers of barren surfaces. They are often the first to appear after volcanic eruptions, tree falls, floods and ice scour. They can absorb and retain many times their weight in water and help mitigate sudden downpours. They retain water and release it slowly into the environment where it can be used by other organisms. They contribute to nutrient cycling by trapping and absorbing minerals from water and air. They can form crusts with Lichens on old dunes, helping to stabilize the sand and build soil leading to succession by other plants. They provide niches for other organisms, especially tiny invertebrates such as Snow Fleas who are in turn consumed by larger invertebrates and so on up the food chain. Fallen logs first become encrusted with Bryophytes and in time the moist, nutrient-rich carpet may become an incubator for fern spores and seeds of flowering plants. Bryophytes are highly sensitive to small differences in humidity, UV radiation, pollution and characteristics of the underlying surface (substrate). Whether in the city or a primeval forest, dozens of microhabitats may occur in just a few steps. Bryophytes were on earth long before flowering plants and mammals and have evolved survival strategies that will ensure they remain long after.

The first catalog of New York State Mosses was published in 1957 by Edwin Ketchledge and revised most recently in 1980 (Ketchledge, 1980). The first distributional checklist of the Liverworts of New York was produced in 2015 by Bob Duncan and Nancy Slack (Duncan & Slack, 2015). Natalie Cleavitt estimates that there are 617–637 Bryophyte species in the state (Cleavitt, 2021). There has never been a complete catalog or inventory of the Bryophytes of New York City.

Confident identification of some Bryophytes requires a microscope and fresh or rehydrated samples. Species distinctions are sometimes made on the basis of cell shape and their arrangement and other microscopic features. But a 10x hand lens and good light are often enough to identify many Bryophytes. A good field guide for our region is *Mosses, Liverworts and Hornworts, a Field Guide to Common Bryophytes of the Northeast*, by Ralph Pope (Comstock Publishing Associates, a division of Cornell University Press, 368 pp. 2016).

References: Cleavitt, N. 2021. How many bryophytes are there in New York and are any of them rare? Finger Lakes Native Plant Society <https://flnps.org/how-many-bryophytes-are-there-new-york-and-are-any-them-rare> accessed February 29, 2021.
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Duncan, B. and N. Slack. 2017. New York State Liverworts and Hornworts: A Distributional Checklist by Counties. Evansia 34: 114–133.

New York City EcoFlora

Marchantiophyta
Liverworts, Hepatics

Description: Small, terrestrial plants less than 4 inches long and one inch wide (10 cm × 2–20 mm), anchored to the substrate by single-celled root-like structures called rhizoids; body prostrate, either fleshy, flattened and ribbon like (thallose Liverworts) or differentiated into flattened stem-like structures with rows of overlapping leaf-like scales (foliose Liverworts); leaf-like scales overlapping in two or three ranks (the central rank often markedly different), without central vein (costa) and often with marginal hairs, true stomata absent; asexual reproductive structures called gammae cups (pictured at left) produce genetically identical spores dispersed by water droplets; sexual reproduction by separate sperm-producing structures called antheridia and egg-producing structures called archegonia (pictured at left), the sperm requiring water to reach the eggs in the archegonia.

Where Found: Liverworts occur globally on all continents including Antarctica. Their ability to tolerate wetting and drying has enabled them to occupy deserts as well as leaves and branches in the forest canopy. They can be found on rocks, logs and trees in natural landscapes and in disturbed soil along stream banks, road cuts and trails. In New York City, Liverworts can be found on tree trunks, rocks, soil of tipped trees, even buildings and sidewalks.

Natural History: Fossil and molecular phylogenetic analysis suggest that Liverwort-like organisms were the first plants to colonize the land, some 470 million years ago (Kenrick and Crane, 1997). The metabolic pathways and physical adaptations enabling them to survive harsh and dramatically changing conditions on land are the key to their success and literally paved the way for life on land by other organisms. The cells of most Liverworts are unique in the plant kingdom in containing oil bodies wrapped in a protein membrane (He et al., 2013). The possible functions of liverwort oil bodies are protection from herbivores, pathogens, cold temperatures, excessive light, UV radiation and desiccation (He et al., 2013). However, Liverworts are so little studied compared to flowering plants, experimental and comparative studies are needed to fully understand the role of Liverwort lipid bodies. Many Liverworts have Fungi living inside their tissue (endosymbiosis) and at least one Liverwort (*Cryptothallus*) lacks chlorophyll and is completely dependent on a fungus for its food. In addition to oil bodies, Liverworts produce mucilage, a viscous fluid that helps protect from desiccation. Liverwort spore capsules contain elongate structures called elatiors that aid in dispersal. Spirally arranged thickenings in the cells walls create tension. As the cells dry, the tension is released and the elatiors are propelled into motion, flinging out spores.

Cultural History: Liverworts contain terpenes and other bioactive compounds and are often aromatic. The thallose Liverwort *Marchantia polymorpha* has long been used Chinese traditional medicine to treat liver disease and inflammation. Other medicinal applications of Liverworts include cytotoxicity, anti-HIV inhibitory, antimicrobial, insect antifeedant and mortality, nematocidal activity, neurotrophic and piscicidal activity, anti-obesity, anti-influenza activity, allergenic contact dermatitis, cardiotonic and vasopressin antagonist, muscle relaxing and others (Asakawa, 2012).

Name Notes: The Division Marchantiophyta is named for the Liverwort genus *Marchantia*, thallose Liverworts that occur worldwide. The ending "Phyta" means plant. "Wort" is an English term meaning small plant, often used as food and medicine, such as Birthwort (*Aristolochia*). The amorphous shapes of some thallose Liverworts such as Marchantia somewhat resemble livers, hence the appellation. Another name given to Liverworts is Hepatic, also derived from their resemblance to livers. The scientific names of Liverworts and all Bryophytes follows the same conventions as flowering plants and is governed by the International Code of Nomenclature for Algae, Fungi and Plants promulgated in a rule book updated every six years.

Species Notes: Liverworts comprise 5000–8000 species in about 390 genera (Crandall-Stotler et al., 2009). They are most diverse in montane rainforests of the southern hemisphere. The Liverwort oil bodies have diverse chemistry and morphology and are used in classification. They are visible under magnification and appear as shiny globules, but they can only be observed in the living tissue. Liverworts can be divided into two groups based on their morphology: thallose and foliose. Thallose Liverworts consist of a ribbon-like sheet, often lobed and wrinkled. The thallus may be one or several cells thick. Foliose Liverworts are far more common and often resemble mosses with pseudo stems and leaves.

Links: observations.

References: He, X., Y. Sun, R-L Zhu. 2013. The oil bodies of liverworts: unique and important organelles in land plants. Critical Reviews in Plant Sciences 32(5): 293–302. **Asawaka, Y. 2012.** Liverworts-potential source of medicinal compounds. Medicinal and Aromatic Plants 1(3): 1–2. **Kenrick, P. and P.R. Crane. 1997.** The origin and early evolution of land plants. Nature 389: 33–39. **Crandall-Stotler, B., R.E. Stotler and D.G. Long. 2009.** Phylogeny and classification of the Marchantiophyta. Edinburgh Journal of Botany 66: 155–198. **Duncan, B. and N. Slack. 2015.** New York State Liverworts Distributional Checklist. unpublished. New York Botanical Garden library catalog number QK 556.5.N7 D86 2015. **Lincoln, M.S.G. 2008.** Liverworts of New England, A Guide for the Amateur Naturalist. Memoirs of the New York Botanical Garden 99: 1–161.

Bryophyta
Mosses

Description: Small plants often forming dense colonies or mats from multicellular root-like rhizoids; stems upright or prostrate, weak or firm, branching none, simple or verticillate; leaves small, attached directly to the stem, ranging from 1/2 to 3 mm long, usually 1 cell thick, thickened down the middle (costa), the margins usually smooth, sometimes toothed, the apex tapering to a point or elongate and hair-like; sperm producing antheridia and egg-producing archegonia produced among the leaves or at the apex of the stem; sporophytes developing from fertilized archegonia either on a stalk (seta) or directly atop the stem; spore capsules usually releasing spores by an opening at the tip, initially covered by tissue called an operculum, the rim smooth or with hairs or teeth (peristome teeth).

Where Found: Like Liverworts, Mosses are distributed from pole to pole and occupy diverse habitats.

Natural History: The rhizoids of Mosses are more developed than Liverworts, but lack internal conducting tissue. They can sometime be more of the plant's biomass than the above ground part. Rhizoids help anchor the plant and conduct water by capillary action on the outside of the rhizoid. Seta of moss sporophytes are usually straight but in the Bonfire Moss, *Funaria hygrometrica* (pictured), they are contorted and hold the capsule down but gyrate upwards as the capsules reach maturity. Most Bryophyte spores are very small (5–50 microns or 1/1000 of a meter), but *Archidium ohioense* has spores up to 320 microns or much wider than a human hair. Spores may be dispersed by wind, vapor-wind, water, decay, insects, earthworms, mollusks, spiders, birds and even mammals (Glime, 2017). Heavy spores such as those of *Archidium* may be dispersed by water or even the feet of animals. Approximately half the species in the family Splachnaceae are known as Dung Mosses because they grow on dung and dead flesh (coprophilous). Many have evolved species-specific relationships with flies who disperse the spores. The flies are attracted by bright colors and aromatic compounds produced by the sporophyte (Marino et al., 2009). Liverworts have elatiors to help disperse the spores. Mosses have peristome teeth. These are teeth-like structures around the rim of Moss capsule openings. They are respond to ambient moisture levels. Some Mosses, such as Sphagnum have explosively dehiscent capsules. The capsules shrink as they dry and eventually the internal pressure blows the capsule covering (operculum) off and exhales a puff of spores. Asexual reproduction occurs via gemmae, propagules and detached rhizoids, leaves, stems and rhizoids. Researchers at the Antarctic research station on Macquarie Island found that gemmae, deciduous shoots, leaves, leaf fragments and stem fragments with attached leaves could be made to grow in the laboratory (Selkirk, 1984).

Cultural History: Not everything we think of as Moss is actually a Moss. Spanish Moss of the Louisiana bayous is actually a flowering plant related to Pineapple. Other small green things seen on rocks or other surfaces are actually Algae, Lichens, Filmy Ferns, *Selaginella* or Liverworts and Hornworts. Clubmosses (*Lycopodium*) are not Mosses, but allied to Ferns. Peat derived from Peat Mosses (real Mosses in the genus *Sphagnum*) and other incompletely decayed plants is an important fuel for cooking and heating for some traditional cultures. Mosses can be used as bioindicators of soil conditions, pollution levels, mineral content and past climatic conditions. Mosses are used horticulturally as soil conditioners, packing material, decoration and substrate for other plants. In her book, Gathering Moss, Dr. Robin Kimmerer writes "Since 1990, this luxuriant moss growth has come under attack from commercial moss harvesters, who strip branches completely bare and sell the moss to the horticulture industry. Legal moss harvest in the Coastal Range of Oregon has been estimated to exceed 230,000 kilograms per year. The Forest Service regulates moss harvest on National Forests by a system of permits, but enforcement is minimal. Illegal harvest is thought to be as much as thirty times higher than the legal quota." Growing Moss can be as easy as keeping a shady site moist and letting the ambient spores find you. Mosses are photosynthetic and don't decline when covered by leaves or other debris, so gently rake fallen leaves off your Moss garden in winter.

Name Notes: The term "bryophyte" comes from the Greek *bryon*, meaning moss and *phyton* meaning plant.

Species Notes: With over 12,000 species, Mosses are largest group of the Bryophytes. The most recent checklist of Mosses of New York State reports 461 species (Ketchledge, 1980).

Links: observations.

References: **Ketchledge, E.H. 1980.** Revised checklist of the mosses of New York State. New York State Museum Bulletin. 440, Albany, NY. **Marino, P., R. Raguso and B. Goffinet. 2009.** The ecology and evolution of fly dispersed dung mosses (Family Splachnaceae): Manipulating insect behavior through odour and visual cues. Symbiosis 47: 61–67. **Glime, J. M. 2017.** Adaptive Strategies: Spore Dispersal Vectors. Chapt. 4–9. In: Glime, J. M. Bryophyte Ecology. Volume 1. 4-9-1. Physiological Ecology. Ebook sponsored by Michigan Technological University and the International Association of Bryologists. <http://digitalcommons.mtu.edu/bryophyte-ecology/>. **Selkirk, P.M. 1984.** Vegetative reproduction and dispersal of bryophytes on sub-Antarctic Macquarie Island and in Antarctica. Journal of the Hattori Botanical Laboratory, 55, 105–111. **Goffinet, B. and W.R. Buck. 2004**. Systematics of the Bryophyta (Mosses): From molecules to a revised classification. Monographs in Systematic Botany. Molecular Systematics of Bryophytes. 98. Missouri Botanical Garden Press. pp. 205–239.

Anthocerotophyta
Hornworts

Description: Small plants; gametophyte body (thallus) a lobed or wrinkled green sheet; underside of thallus producing smooth rhizoids; sperm-producing antheridia and egg-producing archegonia produced on upper surface; sporophytes developing from fertilized eggs, stalkless, growing from a basal meristem, the spore capsule needle-like, splitting by slits to release the spores; spores maturing sequentially from the top of the sporangium to the base.

Where Found: Hornworts occur worldwide but are most abundant and diverse in tropical and subtropical regions, especially southern and southeastern Asia. They grow best in constantly moist, humid environments. Hornworts are found in forests, fields, ponds, streams, riverbanks and on tree trunks.

Natural History: Hornworts have slime-pores on the thallus underside that become colonized by Blue Green Algae (Cyanobacteria in the genus *Nostoc*). Outgrowths of the Hornwort thallus penetrate the Cyanobacterium, forming a symbiotic association between the two organisms. The *Nostoc* provide the Hornwort with nitrogen and receives carbohydrates from its photosynthesizing host. These are best seen in the genus *Dendroceros*, in which they are visible to the naked eye as blackish dots. A handlens may be necessary to see them clearly. Unique among the land plants, Hornworts have specialized carbon capture and concentrating structures within the chloroplast, a feature they share with Algae. The Hornwort sporophyte is unique in the Bryophytes in having pores for gas exchange (stomata) that are similar to those of vascular plants.

Cultural History: Because of their soft tissues, Liverworts and Hornworts are poorly represented in the fossil record. But phylogenetic reconstructions suggest that major extinctions have occurred several times. It is not known whether the few remaining species are ancient relicts or are the result of more recent speciation (Villarreal et al. 2010). Hornworts and at least one species of Liverwort are among the very few plants with symbiotic associations with Blue Green Algae (Cyanobacteria). The Hornwort, *Anthoceros punctatus*, has been used as a model system to study plant–cyanobacteria interactions.

Name Notes: The English word "wort" means small plant, thus Hornworts are small plants with horns, so named for the horn-like sporophyte. The Latin "antho" means flower. The element "cerato" is a prefix applied to something that is horn-like. Therefore the Anthocerotophyta are "flowering horn plants". The aquatic plant *Ceratophyllum demersum* is sometimes called Hornwort.

Species Notes: The hornworts are the smallest group of the Bryophytes. There are thirteen accepted genera and 200–250 species (Villarreal et al., 2010). No worldwide monograph of the Hornworts has ever been produced and Hornwort floras are few in both temperate and tropical regions. Species are distinguished on the basis of the number and anatomy of chloroplasts inside the cells, the presence pyrenoids (carbon dioxide concentrating structures within the chloroplast), the numbers of antheridia within the androecia, and the cell arrangement of antheridia jacket cells. There are five genera of Hornworts in North America north of Mexico (Stotler and Crandall-Stotler, 2005): *Anthoceros* (6 spp.), *Megaceros* (1 sp.), *Notothylas* (2 spp.), *Phaeoceros* (7 spp.), *Phaerosporoceros* (1 sp.)

Links: observations.

References: Renzaglia , K.S. and K.C. Vaughn. 2000. Anatomy, development and classification of hornworts. Chapter 1 (pp 1–20) *in* A.J. Shaw & B. Goffinet (eds) Bryophyte Biology, Cambridge University Press. **Schuster, R.M. 1992.** The Hepaticae and Anthocerotae of North America, East of the Hundredth Meridian. Vols. 1–6. Field Museum of Natural History: Chicago. **Stotler, R.E. and B. Crandall-Stotler. 2005.** A Revised classification of the Anthocerotophyta and a checklist of the hornworts of North America, north of Mexico. The Bryologist 108: 16–26.

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