Bryology for the High School

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The study of mosses and liverworts has been relegated to a very minor role in much of the "new biology." That these organisms may offer unusual fields of investigation is the author's contention.

Introduction

The bryophytes are among the most neglected organisms in the plant kingdom. This is probably due to the lack of professional bryologists. Actually the mosses and liverworts are extremely important and should receive far more attention because of their evolutionary implications. You can place the mosses directly between the nonvascular and vascular plants as a living representative of the old world flora. The mosses, of course, experience an alternation of their generations (sporophyte and gametophyte), but equally significant are their asexual reproduction processes with gemmae and paraphyllia.

Ecologically, the mosses and liverworts have world-wide distribution that can indicate the characteristics of a particular geographical area. These cryptogams are quite adaptable in their environmental situations, and can vary in their life cycle, size, color, and microclimate according to where they are found. From the tundra to the tropical rain forests and to the desert, the mosses are generally specific for each of these areas. There are mosses that typically accumulate in greenhouses that are normally not found in other habitats. Species variations can change from niche to niche, but the genera can often be world-wide. To illustrate the varying ecological niche of the mosses, they can be found growing on trees, rocks, loose sand, forest floor, open fields, and completely submerged in fresh water streams.

This, then, should indicate that the bryophytes can be interesting and challenging if you would take the time to notice them, to collect them, and to study them.

Difference Between a Moss and a Liverwort

In general, it can be said that the difference between a moss and a liverwort is morphological. This difference is obvious when comparing a moss with a thallus liverwort. However, not all liverworts are the thallus type; some are leafy and resemble a moss most remarkably. One characteristic that would distinguish a moss from a leafy liverwort is the presence of a nerve (midrib); present only in the leaf of the moss. This is not totally dependable, however, because not all mosses have a nerve present in their "leaves."[1] As far as sterile (not fruiting) material is concerned, diagnostically you can observe the cellular structure of the phylloids called *areolation*, and also the arrangement of the phylloids on the "stem."[2] The cells of the liverwort leaf are usually cuboid, whereas in the moss, cellular elongation is most common. Furthermore, leaf arrangement in the liverwort is three-ranked with two of the leaves usually opposite, while the third leaf is small and underneath the larger ones. Leaf arrangement in the mosses varies from a two-ranked appearance to an appressed sheathing characteristic.

Reproductively the mosses produce a conspicuous capsule usually borne at the terminal end of the seta, with or without a calyptra, and always showing a cap or lid. If a capsule is produced in the liverwort, it will split lengthwise forming four valves for the release of the spores.

In summary, then, the bryophytes can be divided into three groups: (1) mosses, (2)

[1]In bryology, the term "phylloid" is more commonly used in place of leaf.
[2]The term "cauloid" is often substituted for stem.

leafy liverworts, and (3) thallus liverworts. For identificaton of the bryophytes, a closer look at all of the diagnostic characters in the laboratory is imperative, and only after this close examination can you begin to apply a taxonomic key to the specimen.

Field Identification

Equipped with a 10x triplet hand lens, genera identification in the field can come to you only after you have repeatedly recognized the outstanding characteristics of the genera. This of course takes practice, time, and patience. If you are conscientious and return to the field frequently, it should take a relative short time before you become intimately familiar with the local flora.

Collection and Preservation

An army surplus bag such as a gas mask bag, a 10x triplet hand lens, a few dozen small paper bags–size No. 2, and a small field notebook is all the equipment a bryologist needs for field work. The rest is not easy! You have to look for the bryophyte. Many times they are in the open, forming a carpet; other times they will be found in crevasses of rocks and on the trunks of trees. If a creek or other water areas are present, then you must look along the banks and in the stream itself. Look on rocks, around rocks, and under rocks. The bryophytes grow *everywhere*.

When you collect, be sure to obtain as much of the growth as practical–at least a handful. If it is fruiting, be sure to include this in the specimen. If you can make a field identification, write this name on the paper bag, place the moss in the bag and record the location, date, and niche particulars either on the bag or in your field notebook.

Upon returning to the lab, confirm your identification by running the specimen through a taxonomic key. Here, I would like to recommend: H. S. Conard, *How to Know the Mosses and Liverworts*, W. C. Brown Co.: Dubuque, Iowa, 1956. This book is a good key, easily understood, and fairly well illustrated.

To preserve and store your collection, small packets made with a good grade of rag content typing paper 8½″ x 11″ is used. To make these packets, fold the bottom up to within 3 inches of the top, fold each side in 1½ inch, finally fold the top down until you have an envelope with dimensions of 5½″ x 4″. The identification label can then be attached to this top flap. This label should include: genus and species, date collected, brief description of the habitat, location of collection station, your name (or collector's name), and herbarium number (optional). These packets can then be stored alphabetically in shoe boxes.

Before placing the specimen in the packet, all trash and as much dirt as possible should be removed from the sample. You should preserve only clean specimens; a dirty specimen is not worth saving. It is not necessary to press the moss or liverwort; if you do, use only light weights. With your moss or liverwort placed in the packet and properly labeled, it will remain unharmed for an undetermined number of years. If years later you wish to re-examine or compare this specimen with another, just simply soak in water. The mosses will turn green, unfold, and appear much as they did the day you collected it.

You will find that after a few trips to the field, and many hours in the lab you will be rewarded with a good beginning of a bryological herbarium. In a year or two, you possibly will have a valuable representation of the local flora.

Laboratory

Many useful experiments can be attempted in the laboratory; however, with many of these experiments, a considerable amount of technique is required. After several attempts at these more precise experiments, the problems that previously arose seem to iron themselves out.

It is good to keep a record of some of the outstanding microcharacteristics of the bryophytes. This can be accomplished by making slides that will be relatively permanent. Perhaps the best medium for both preserving and mounting is a "gum choral" mounting medium. This preparation is made as follows:

Distilled water	100 ml
Gum arabic	40 g
Glycerine	20 ml
Chloral hydrate	50 g

Dissolve the gum arabic in cold distilled water,

add the glycerine and chloral hydrate. Heat gently in a water bath until all solutes are completely dissolved. Filter while still hot.

A more simple process and still quite permanent is to place the tissue on a slide with a drop of water. Cover with a glass cover slip. Gently heat over an alcohol lamp until the water begins to steam; this will remove air bubbles. After this has dried, place a drop of concentrated glycerine near the cover slip so that the glycerine will diffuse between the slide and the cover slip. Allow to dry thoroughly for forty-eight to seventy-two hours.

Still a third method (not recommended) is to use a drop of Canadian balsam cement, then cover with a glass cover slip.

The more common material you will want to mount are: leaves, whole mount and cross-sections, peristome showing the teeth, archegonia, antheridia, capsule and spore preparations, and cross-sections of thallus.

A variety of physiological experiments can be attempted. For example, paper chromatography of moss or liverwort chlorophyll pigments, x-ray irradiation experiments often produce dramatic results, spore cultures, and chromosome counts and genetics in general. Not much has been done with the genetics of the bryophytes.

Conclusion

Whether as a hobby, a profession, a thesis problem, or a subject to teach, the bryophytes should be taken more seriously. If a sincere effort is put forth to study the ecology, morphology, taxonomy, or what have you, you will find that the mosses can develop a fascination that will send you to the field again and again. Not just the peculiarities of these plants alone can convince you upon delving into the subject deeper, but with repeated contact with the bryophytes you will find them filling a gap in your biological knowledge.

It is an excellent field to get into professionally. Since there are so few bryologists, much is still to be known about these plants. The amount of literature is scarcely available when compared with other facets of botany. Fortunately, the American Bryological Society is serving the extreme thirst for knowledge about these "strange" little plants.

In time to come, I hope to make available several laboratory experiments that would perhaps help the student understand the significance of the bryophytes.

Synopsis of Moss and Liverwort Classification[3]

PHYLUM Bryophyta
- CLASS Musci (mosses)
  - ORDER Sphagnales (1 family)
  - Andreaeales (1 family)
  - Eubryales (34 families)
- CLASS Hepaticae (liverworts)
  - ORDER Jungermanniales (14 families)
  - Metzgeriales (6 families)
  - Marchantiales (2 families)
  - Sphaerocarpales (1 family)
- *CLASS Anthocerotae (hornworts)
  - ORDER Anthocerotales (1 family)

A Simple Dichotomus Key to the More Common Genera of Mosses and Liverworts[4]

1.	Plant thallus	A
1a.	Plant leafy	2

*Many bryologists list this as a sub-class of the class Hepaticae, while others place it as an order.

[3]After H. S. Conard.
[4]Adapted from E. V. Watson, *British Mosses and Liverworts.*

2.	Leaves without a well defined nerve, arranged in two or three ranks. Leaves usually rounded or deeply divided	B
2a.	Leaves usually with a single or divided nerve. Leaves sheathing or apparently petioled. If present, a capsule	C

A. *Thallus Liverworts*

1.	Upper surface of thallus with diamond shaped markings with a raised pore in each diamond	2
1a.	Without diamond markings	4
2.	Gemmae in goblet-shaped receptacles	*Marchantia*
2a.	Gemmae in crescent-shaped receptacles	*Lunularia*
2b.	Gemmae absent	3
3.	Pores on dorsal side, large and visible to naked eye. Thallus not purple-brown at margin	*Conocephalum*
3a.	Pores hardly visible. Margin purple-brown	*Pressia*
4.	Plants deep, vivid green, not rosette. Thallus flat and branched	5
4a.	Plant pale green. Rosette with medial lines	*Riccia*
5.	Thallus less than 2 mm wide	6
5a.	Thallus 3-10 mm or more wide	7
6.	Found on trees	*Metzgeria*
6a.	Never found on trees, usually in marshes	*Riccardia*
7.	Thallus broad, thin and delicate. Capsule long and narrow	*Anthoceros*
7a.	Thallus narrow, thin and brittle. Capsule ovoid	*Riccardia*

B. *Leafy Liverworts*

1.	Creeping plant in dense mats, stems pinnately branched	3
1a.	Branching few and irregular, not pinnate	2
2.	Leaves unequally divided into two lobes, the small lobe lying flat across the larger one	4
2a.	Leaves symmetrical, two or three cleft	5
2b.	Leaves simple and rounded, margin is entire or with minute teeth	8
3.	Plant deep green, no fringe on leaf lobes. Leaves apparently five ranked	*Porella*
3a.	Plants dull green, very small leaves 0.2-0.3 mm. Leaves divided into 3-4 lobes	*Lepidozia*
4.	Each leaf divided to the base into two narrow oblong segments	*Diplophyllum*
4a.	Each leaf divided half way to the base. Segments not narrowly oblong	*Scapania*
5.	Leaves transversely inserted on the stem	6
5a.	Leaves almost longitudinally inserted on stem	7
6.	Green plant, pale green clusters of gemmae at tips of stem and upper leaves	*Lophozia*
6a.	Leaves minute 0.3-0.6 mm, plant light green	*Cephalozia*
7.	Leaves narrow at apex with two small teeth very close together	*Calypogeia*
7a.	Leaf teeth long and wide set so that leaf has two prong appearance	*Lophocolea*
8.	Leaves with margin decurrent on stem with forward edge on each leaf concealed beneath the hind edge of the leaf next above it (succubous)	*Plagiochila*

8a.	Leaves not decurrent. Forward edge of each leaf rests upon the hind edge of the leaf next above it (incubous)	*Calypogeia*

C. *Mosses*

1.	Stems creeping and branching. Sporophyte borne on a very short lateral branch	32
1a.	Erect separate plants, not branched. Capsule terminal, usually at end of seta	2
2.	Capsule on a pseudopodium. Plants are spongy, light green, yellow, pale red or purplish. Found in bogs	*Sphagnum*
2a.	Capsule on a seta. Habitat varies. Plants green to dark green some yellow green, all vivid	3
3.	Leaves comparatively firm. Wide sheathing at base, blade of leaf is deep green with vertical plates (lamellae)	*Polytrichum*
3a.	Leaves soft, delicate in texture. Usually translucent. Lack lamellae	4
4.	Most of the leaves ending in a whitish hair point	8
4a.	Leaves lacking a hair point	5
5.	Leaves two ranked	12
5a.	Leaves not two ranked	6
6.	Leaves narrowly lanceolate. 3-10 mm long, tapering to a long fine point	13
6a.	Leaves broadly lanceolate, blunt apex. 6-8 mm long, large dense cushions. Very whitish when dry	*Leucobryum*
6b.	Leaves not tapering to a fine point. Less then 3 mm long (in some cases longer)	7
7.	Leaves large, plants robust forming large patches	20
7a.	Leaves medium size to small. Habit varies forming compact cushions	26
8.	Leaves long 6-9 mm, very narrow	*Campylopus*
8a.	Leaves shorter, not as above	9
9.	Found on trees, stumps	10
9a.	Found on rocks	*Grimmia*
9b.	Found on other substratum	11
10.	Dull green, leaves taper into a wide hair point. Capsule on a very short seta	*Orthotrichum*
10a.	Bright green. Narrow hair point. Capsule on a long seta	*Tortula*
11.	Shoot pale green with hair point appearing as the entire apex of leaf. Capsule is immersed. The whole growth looks "bushy"	*Hedwigia*
11a.	Not as above	12
12.	Leaves with tubular sheathing base. Blade is drawn out to a fine point	*Distichium*
12a.	Leaves not as above. Aquatic	*Fissidens*
13.	Robust. 2-15 cm tall	14
13a.	Small, less than 2 cm tall	19
14.	Leaves long and all strongly curved to one side	15
14a.	Not as above	17
15.	Leaves 10-14 mm long, sickled-shaped	*Dicranum*
15a.	Leaves shorter, 6-8 mm	16

16.	Stems thread-like, leaves 3-5 mm, widely spaced and suddenly narrowing above the base then drawn to a fine point	*Ditrichum*
16a.	Stems heavier, leaves 4-8 mm and crowded, with a gradual tapering to apex	*Dicranum*
17.	Plants of marshes, bogs and very wet areas	*Aulacomnium*
17a.	Some other habitat	18
18.	Leaves change little when dried	*Breutelia*
18a.	Leaves much twisted and curled when dry	*Tortella*
19.	Medium green. Capsule is inclined, curved and asymmetrical	*Dicranella*
19a.	Dark green. Plant quite fragile	*Campylopus*
20.	Leaves lanceolate or tongue-shaped at least 4 times as long as broad, flattened on the sides	21
20a.	Leaves round or ovate, two or three times as long as broad	25
21.	Longest leaf 7-10 mm, wrinkled transversely	22
21a.	Leaves not as above (6 mm), not wrinkled	23
22.	Stem erect, narrow cylindrical capsule	*Atrichum*
22a.	Stem straggling, some branching	*Mnium*
23.	Leaf margin toothed	*Fabronia*
23a.	Leaf margin entire	24
24.	Leaf apex rounded. Conspicuous calyptra extending over the capsule	*Encalyptra*
24a.	Forming short rosettes. Capsule 7-9 mm long, on a very long seta	*Tortula*
25.	Leaf apex round, nerve is not excurrent	*Mnium*
25a.	Leaf apex acute, small leaves, nerve slightly excurrent	*Bryum*
26.	Habitat on rocks	27
26a.	Habitat on soil	28
26b.	Habitat on wood	31
27.	Cushions vivid light green, leaves curled, each leaf several times long as broad	*Barbula*
27a.	Leafy shoot with metallic bronze gloss	*Bryum*
28.	Capsule immersed in leaves	29
28a.	Capsule on a visible seta	30
29.	Plants bud-like, leaves broad	*Phascum*
29a.	Plants not bud-like, leaves narrow	*Ephemerum*
30.	Seta 1.5-4 cm. Leaves lanceolate, found on peat soils	*Pohlia*
30a.	Seta bright red or wine color	*Ceratodon*
30b.	Ripe capsule is furrowed, on recent burnt ground, seta very long	*Funaria*
31.	Seta yellow, 5-10 mm long	*Dicranoweisia*
31a.	Leaves very curled when dry, usually olive green, calyptra very hairy	*Ulota*
32.	Stem strongly flattened in one plane so that leaves appear to be in two irregular ranks	34
32a.	Stems not flattened	33
33.	Leaves near the tip of short strongly curved and turned downward or to one side	38
33a.	Leaves straight, even at the tip of shoot	40
34.	Tips of branches somewhat curved downward	35

34a.	Tips of branches all flat	37
35.	Leaves transversely wrinkled	*Neckera*
35a.	Leaves not wrinkled	36
36.	Branches ascending	*Homalia*
36a.	Branches prostrate, pale yellow	*Neckera*
37.	Leaves large, translucent, large cells in leaves can be seen with a hand lens	*Hookeria*
37a.	Leaves smaller, cells cannot be seen	*Plagiothecium*
38.	Stems green or blackish, habit on trees	*Hypnum*
38a.	Some other habit	39
39.	Shoot bright glossy green tinged golden brown	*Brachythecium*
39a.	Shoots dull yellowish-green to brown	*Hygrohypnum*
40.	Plants aquatic	41
40a.	Plant not aquatic	42
41.	Leaves long and keeled (folded) three ranked	*Fontinalis*
41a.	Not as above	*Eurhynchium*
42.	Shoots tassel-like looking like a miniature tree	*Climacium*
42a.	Not as above	43
43.	Main branches regularly bipinnate in one plane (frond-like)	44
43a.	Main branches simple and pinnate only once	45
44.	Stem red, not rigid. Leaves glossy pale yellowish-green	*Hylocomium*
44a.	Stems green or blackish, rigid. Leaves not glossy. Very green	*Thuidium*
45.	Stems red or orange	46
45a.	Stems green	47
46.	Leaves at shoot tips large 3-5 mm clear pale green, slightly curved, branches short and crowded	*Rhytidiadelphus*
46a.	Uppermost leaves rolled together to form a sharp spearhead shoot tip	*Acrocladium*
47.	Semi-aquatic	*Campylium*
47a.	Not semi-aquatic	48
48.	Usually creeping. Tips of branches darker green, not glossy	*Leptodictyum*
48a.	Leaves very minute 0.5 mm	*Amblystegium*

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