UNIVERSITY OF UTAH BIOLOGICAL SERIES

VOL. XII MAY 30, 1961 No. 2

The Hepaticae of Utah

BY

SEVILLE FLOWERS

PUBLISHED BY

UNIVERSITY OF UTAH

SALT LAKE CITY, UTAH

UNIVERSITY OF UTAH BIOLOGICAL SERIES

Volume 12, No. 2, pp. 108, figures 1–26, plates I–XVIII

Submitted by editors — January 25, 1961

Issued May 30, 1961

Price, $3.00

UNIVERSITY OF UTAH PRESS SALT LAKE CITY, UTAH

PREFACE

The Hepaticae, or liverworts, are small green plants mostly growing in damp or wet places, although a considerable number of them inhabit dry shady places, even in desert regions. As a whole, they are inconspicuous and, together with the mosses, lichens and other primitive forms of plant life, occupy a lower stratum of vegetation which seldom attracts attention. To the layman they form a vague background upon which more conspicuous plants are displayed. They are very tenacious of life and are able to endure lack of moisture and extremes of temperature. They may dry out completely for many months and revive within an hour or two when moisture returns.

Thus far, sixty species distributed in thirty-two genera have been found in Utah and, considering the climate and topography of the state, these figures compare favorably with the number of species and genera occurring in other western states. The populations are thinly spread and sparse in comparison with those of more humid regions.

The present paper presents the results of the slow accumulation of specimens and data covering thirty-five years. The more frequent species were gathered within the first five or six years of collecting while the discovery of the remaining ones came painfully slow. There is little doubt that there are many others infrequent in the state which await future discovery. Literature pertaining to the liverworts of this region is scanty and most references had to be sought in general manuals and journal articles dealing with hepatics in neighboring states. These are listed in the bibliography.

The organization is aimed toward giving a substantial introduction to the morphology, ecology and distribution of the known species in Utah so as to enable students to use the systematic treatment to best advantage.

I am indebted to Drs. T. C. Frye, Lois Clark and Margaret Fulford for identifying numerous specimens.

S. Flowers

CONTENTS

INTRODUCTION

Classification of Hepatics

The classification of the hepatics adopted in this treatment is based on that of V. Schiffner in Engler and Prantl's Die naturlichen Pflanzenfamilien, Edition I, 1909, except that certain modifications have been made better to suit the limited number of species found in Utah. The table below is a conspectus of the orders and families of hepatics in general, and includes some groups not known in Utah for purposes of comparison in the part dealing with morphology. The latter are indicated by an asterisk (*). Only a limited number of representative genera is given.

I. Order Marchantiales: Thalloid forms with air chambers and simple sporophytes.

Family Ricciaceae: Sporophyte an evanescent capsule without elaters, sunken in the thallus.

Genera: *Riccia* and *Ricciocarpus*.

Family Marchantiaceae: Sporophyte composed of foot, seta and capsule, mostly raised on stalks, elaters present.

Genera: *Targionia, Clevea, Reboulia, Dumortiera,* Plagiochasma,* Mannia, Asterella, Conocephalum, Lunularia, Preissia* and *Marchantia*.

II. Order Jungermanniales: Forms having a solid thallus without air chambers, or forms having a stem with leaves.

Family Metzgeriaceae (Jungermanniaceae anacrogynae): Thallus solid (leafy in transitional forms), archegonium arising from a segment of the apical cell of the thallus, not terminating its growth.

Genera: *Riccardia, Pellia, Metzgeria, Pallavicinia, Blasia, Petalophyllum,** and *Fossombronia*.

Family Jungermanniaceae (acrogynae): Forms with stem and leaves; archegonium arising from the apical cell, terminating its growth.

Genera: *Jungermannia, Nardia, Lophocolea, Chiloscyphus, Plagiochila, Lophozia, Blepharostoma, Cephalozia, Cephaloziella, Calypogeia, Scapania, Radula, Porella, Frullania.*

III. Order Anthocerotales:* Thallus solid; sporphyte without a true seta, green, partially independent, elongating by basipetal growth, with a central columella and with stomata in the outer wall.
Genus: *Anthoceros.*

GENERAL MORPHOLOGY

THE GAMETOPHYTE

The gametophyte of liverworts is either a flat thallus or a stem with leaves. The latter are often called leafy liverworts and are almost all restricted to the Family Jungermanniaceae while a few genera of intermediate relationships are placed among the Metzgeriaceae.

THALLOID LIVERWORTS

General form and structure. The term thallus, as used for liverworts, denotes a flat, prostrate, green body, dorso-ventrally differentiated and bears ventral scales or rhizoids or both. The thalli of different liverworts vary in size from the small *Riccias* which may reach only five millimeters in length and a half millimeter in width to *Conocephalum* which may become twenty-five centimeters long and two centimeters wide. Some forms may be relatively simple but most of them are more or less dichotomously branched while in a few forms branches arise from the ventral side of the midrib. The medial longitudinal region is usually the thickest and constitutes a midrib while lateral expansions on either side are more or less progressively thinner toward the margins and form the wings. The ventral scales are borne in two to three rows on each side of the midrib and generally overlap one another in an anterior direction. They consist of a single layer of cells except at the base where they may be two or more layers thick and are generally colored some shade of red or purple although they may be hyaline in some species. Specific characteristics of the scales are often cited in distinguishing species. The rhizoids may be of two kinds: those with smooth walls and those with internal peg-like or ridge-like thickenings, both kinds often being present on the same thallus. They are usually hyaline or brownish in color but frequently reddish or purplish at the base where they join the thallus.

Internally the thallus may be solid throughout its entire thickness or it may show a highly developed photosynthetic system of air chambers separated by partitions, mostly one cell thick. These chambers may extend through the entire thickness of the thallus as in *Riccia fluitans* (Plate I, 3), or the ventral region may be composed of a solid tissue of variable thickness, this sometimes more or less restricted to the midrib as in *Riccia crystallina* (Plate I, 9). In some species, such as *Riccia glauca,* there are no chambers in the usual sense, but the dorsal portion of the thallus has very narrow air spaces between closely disposed vertical plates of cells arising from a ventral stratum of solid tissue (Plate II, 12–15). These plates of cells are often so close together that they appear to form a solid tissue when viewed in cross sections. Among other thallose forms the air chambers form a green dorsal portion of the thallus while the ventral portion is composed of a compact colorless tissue. In *Clevea, Asterella, Mannia* and *Reboulia* the air cavities constitute a half, or more, of the thickness of the thallus (Plate V, 4 and 15). In *Targionia, Lunularia, Conocephalum, Preissia* and *Marchantia* the air chambers are restricted to a relatively thin chlorophyll-bearing dorsal stratum subtended by a thick, solid, colorless basal tissue from which short filaments or chains of cells rich in chloroplasts arise (Plate VII, 13).

The epidermis forms a covering over the air chambers and it is often marked off into little areas, or areolae, by its junctions with the vertical walls of the partitions underneath. The areolae vary in shape, size and distinctness. They are usually more or less hexagonal in shape, and while they are small and scarcely visible to the naked eye in some species, they are quite large and conspicuous in others. Usually there is an air pore in the center of each areola, sometimes revealed as a whitish dot. All of these structures may be seen in surface view to better advantage under low magnification while the cellular details are best studied in sections cut horizontally and parallel with the epidermis using a sharp razor blade.

In some *Riccias* the cells surrounding the air pores are scarcely differentiated except for the more or less convex cell walls facing the pore opening (Plate IV, 3), but in *Asterella, Mannia, Targionia, Lunularia, Clevea, Reboulia* and *Conocephalum* the pores are slightly raised and surrounded by radiating rows, or concentric rings, of smaller cells. In some instances the walls of these cells are thinner or thicker than the walls of the surrounding epidermal cells. For example, in *Clevea* the cells forming the pore are rather large with heavy thickenings on the walls facing and radial to the pore opening (Plate III, 16 and 17). The pores of *Preissia* and *Marchantia* are surrounded by four tiers of cells forming a chimney-like or barrel-shaped structure, the upper margin of which extends above the level of the epidermis while the lower margin projects slightly into the air chamber (Plate VII, 3 and 13). The two types of pores are customarily designated as simple and barrel-shaped.

In *Riccardia* and *Pellia* the thallus is solid, without air chambers or pores. The midrib and wings are well differentiated in *Pellia,* but in *Riccardia* the thallus is thick and more or less fleshy with poorly demarked wings.

Pallavicinia, Metzgeria and *Blasia* have solid conspicuous midribs and broad unistratose wings. These three genera form a transitional group between the strictly thallose types and the leafy liverworts. The wings of *Blasia* are often more or less lobed on either side of the slender midrib suggesting incipient leaves on a stem (Plate IX, 13). The transition is carried further by *Petalophyllum* which has a short basal stalk spreading into a fan-like, simple or branched expansion three to four cells thick in the middle region and becoming unistratose at the margins. The upper surface bears erect, parallel, unistratose, leaf-like lamellae. In *Fossombronia* the midrib is flattened above and arched below, and generally regarded as a stem. The lateral wings are represented by distinct succubous leaves two or three cells thick at the base and unistratose above.

Cellular structures. The cells of the solid ventral portion of the thallus of the Marchantiales are mostly four- to six-sided in longitudinal optical view, but in the region of the midrib they are more or less longitudinally elongated. In some genera, for example *Marchantia,* there is a central core in the midrib composed of elongated cells having pitted walls suggestive of primitive tracheid-like elements. In most genera of the Metzgeriaceae the central cells of the midrib are moderately elongated but otherwise not strongly differentiated. *Pallavicinia* is a notable exception in that the midrib has a strongly differentiated central strand of very small, thick-walled pitted elements (Plate IX, 7).

The green tissue of some thallose forms is mainly dorsal. Discoid chloroplasts are numerous in the upper cells, but toward the ventral side they become fewer and finally disappear in the deeper tissues. In other forms, particularly those with thin wings, the green tissue extends to the lower epidermis, or nearly so.

Variously distributed in the tissues of the thallus there may be cells containing mucilage, oil bodies or starch grains. Mucilage cells often occur in the ventral regions but more particularly at the apical growing point and around the reproductive organs. Mucilage hairs form a protective cluster around the apical cells of most thallose forms although they are lacking in others. They are present in the gemmae cupules, and sometimes around the sex organs. Oil bodies are yellowish or brownish, spherical, ovoid or irregularly shaped structures, often wrinkled, and have more or less granular contents. They contain oil, in form or an emulsion, albuninous material and tannins. In some species they are large and conspicuous, a single one sometimes occupying considerable volume of a cell (Plate VII, 14). In other species they may be smaller and less conspicuous, one to many occurring in a single cell.

The ventral scales and/or rhizoids in most thallose forms arise close to the apical cell, at first close together, but intercallary growth soon separates them as the thallus elongates.

Leafy Liverworts

The stems of leaf liverworts are dorso-ventrally differentiated and mostly grow prostrate on the substratum although many of them are ascending, or even erect when growing in dense tufts or among mosses. Most of them form interwoven mats or tufts, sometimes becoming gregarious or even solitary among other plants. The stem might be interpreted as a midrib and the leaves as segments of divided wings. Branches are mainly lateral in origin but in a few genera they arise from the underside of the stem. In cross section the stem usually shows rather large, thin-walled, angular cells in the central region with one or more layers of smaller cells at the periphery. The walls of the latter may be thin or variously thickened.

The leaves are unistratose without a costa and are mostly alternately disposed in two opposite rows. In most genera the leaves are narrowed at the insertion but in a few the base of the leaf is as wide or wider than the upper part. In many species one or both basal margins of the leaf are decurrent on the stem. The insertion may be strongly oblique to nearly transverse, with one margin directed toward the dorsal side of the stem and the opposite margin toward the ventral side.

In some groups there may be a third row of underleaves transversely inserted on the ventral side of the stem. They are usually small, frequently torn, scraped off, or obscured by the rhizoids so that they are often difficult to demonstrate. In a few forms they are large, sometimes nearly as large as the upper leaves.

Usually the leaves are more or less imbricated or overlapping but may be approximate when they are close together or distant when widely spaced. When the anterior margins of the leaves overlap the posterior margins of the leaves in front of them they are described as incubous (Plate XI, 14, 15). When the reverse position occurs they are said to be succubous, that is, the posterior margins overlap the anterior margins of the leaves back of them (Plate XV, 6). The incubous or succubous habit applies only to the dorsal view of the plant. Figure 15 in Plate XI is the dorsal aspect of the stem of *Porella* showing the incubous habit of the leaves, and Figure 16 is the ventral aspect showing the underleaves. Figure 6 in Plate XII shows the succubous habit of the leaves of *Chiloscyphus*, and Figure 7 shows the ventral aspect with underleaves.

The stance of the leaves is described as complanate when they spread out more or less horizontally from the stem so that the plant as a whole has a flattened appearance. This is characteristic of most leafy liverworts, but in many of them the leaves tend to curve upward so as to be directed dorsally in more or less the same direction, a habit described as secund.

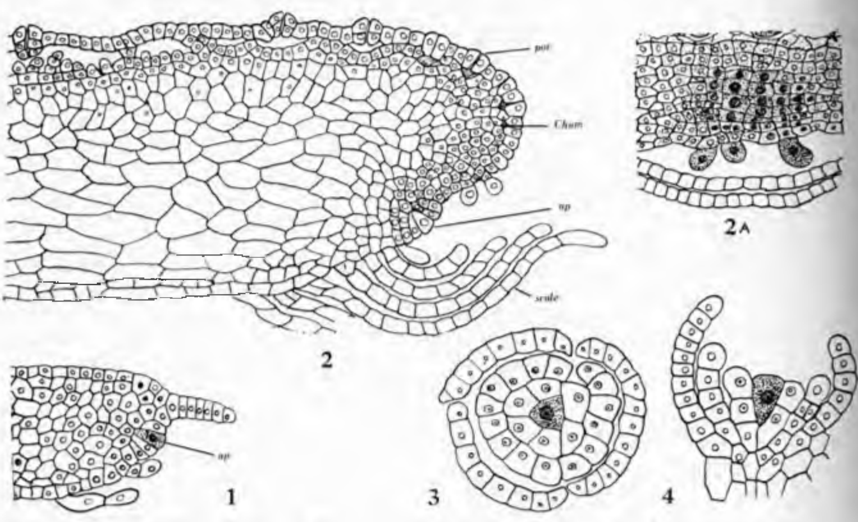
The long axis of the leaf may extend at right angles to the stem or project forward at various angles. The uppermost leaves frequently stand more or less erect.

The leaves are mostly broad, being orbicular to oblong or sometimes broader than long and more or less reniform. They may be entire or variously lobed to divided. The apices of entire leaves or of leaf lobes may be broadly rounded, obtuse, emarginate, acute or acuminate while the sinuses between leaf lobes may be rounded, obtuse or acute. The degree of lobing is described by the fraction of the total leaf length and the number of lobes present; for example, one-third bilobed describes a leaf with two lobes cut about one-third the distance from the tips of the lobes toward the base of the leaf. In certain genera the leaves are conduplicately bilobed, that is, one lobe is folded over upon the other one. In most species one lobe is larger than the other, but in a few forms they are about equal. In some genera the smaller lobe is ventral, as in *Porella* (Plate XI, 16) while in other genera it is dorsal as in *Scapania* (Plate XVII, 1). The margins of the leaves or their lobes may be entire or variously dentate; the bases of certain ones have slender hair-like processes called cilia.

The leaf cells are mostly short, more or less isodiametric to oblong, and either four- to six-angled or rounded. Usually the marginal cells are the smallest and the inner ones somewhat larger while the basal cells are generally the largest and more elongated. The cell wall may be thin or thick, those in the base of the leaf often inflated. The surface may be smooth or minutely roughened. Trigones are triangular thickenings often formed at the point where the walls of three cells converge. In some species they are lacking, in others small, while in some they are large, often bulging into the lumen of the cells (Plate XIV, 23).

Growth

The growth of the thallus and stems of liverworts proceeds by the division of apical cells cutting off segments which divide repeatedly in a



FIGURES 1–4. Apical cells. 1. *Pallavicinia lyellii*, longitudinal section through the apex of the thallus showing the wedge-shaped apical cell, X 150; 2. *Marchantia polymorpha*, longitudinal section of the thallus showing one of the apical cells (ap), the origin of the ventral scales (scale) and the origin of the air chambers (cham) and air pore (por), X 150; 2a. vertical cross section through the growing point showing the transverse row of several apical cells. X 150; 3 and 4. *Porella bolanderi*, cross and vertical sections through the stem tip showing the single pyramidal apical cell, X 150.

very orderly fashion giving rise to the various structures of the plants. Several types of apical cells occur among the various groups and while a given type is not always constant in a given genus it is usually constant for a given species. The wedge-shaped apical cell is typical of the Marchantiales and some of the thalloid Metzgeriaceae. In most forms there is a single apical cell as in *Targionia, Riccardia* and *Pallavicinia* (Figure 1), but in *Riccia* and *Marchantia polymorpha* there is a transverse row or group of apical cells (Figures 2–2A). In these forms the wedge-shaped cells first cut off segments dorsally and ventrally and subsequently right and left. In some species of *Pellia* and *Pallavicinia* there is a single flattened, two-sided, or dilabiate type of apical cell. The prevailing type in the Jungermanniaceae is the tetrahedral or three-sided pyramidal apical cell. It is oriented so that the base of the pyramid is free at the tip of the stem with one narrow side ventral and the two broader sides dorsal. (Figures 3, 4). Segments are cut off from the three inner faces in regular clockwise or counter clockwise order.

Vegetative Reproduction

The simplest form of propagation is brought about by progressive death of the thallus or stem. When death reaches the bases of the branches the latter become independent plants. A great many liverworts produce gemmae, or asexual buds, which become detached and grow into new individuals. Among the thalloid forms *Marchantia* and *Lunularia* develop cupules on the dorsal side of the thallus in the neighborhood of the midrib in which gemmae are borne. These are little flat discs with two opposite lateral notches in which apical cells develop, and they are borne on short, one-celled basal stalks. In *Marchantia* the cupules are round with fringed margins, but in *Lunularia* they are crescent-shaped, one side being open (Plate VI, 8). In *Blasia* the gemmae are of two kinds: minute oval or rounded bodies borne in dorsal flask-shaped vessels with long necks (Plate IX, 14, and 17), and stellate, scale-like bodies borne naked on the dorsal side of the thallus near the apex. (Plate IX, 15 and 16.)

In *Riccardia* the gemmae are formed within an epidermal cell. The protoplast of the cell shrinks away from the wall and becomes more or less rounded up. In this state it becomes an amoeboid gemma which escapes by squeezing through a pore in the old cell wall. These so-called gemmae resemble zoospores and are the last representatives of this type of reproductive body in the forward progress of evolution. They suggest an algal ancestry of the liverworts.

Numerous genera among the leafy liverworts produce one- to several-celled gemmae on the tips and upper margins of the leaves, sometimes in great numbers (Plate XI, 12 and 13).

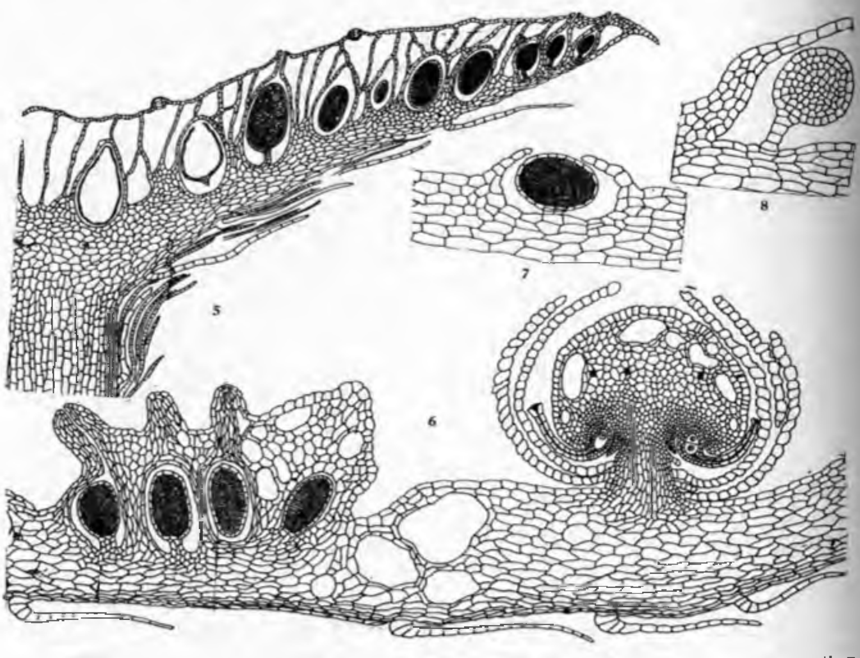
The Sex Organs

Some species of liverworts have distinctly male and female plants whence they are described as dioicous or unisexual. Other species have both sex organs on the same plant, a condition described as monoicous or bisexual. In the latter instance the antheridia and archegonia may be disposed in three different ways. When they are borne on separate branches of the same shoot the plant is said to be autoicous; when they occur on the same branch, the antheridia usually below the archegonia, the plant is paroicous, and when both sex organs occur mixed together in the same cluster the plant is synoicous. The term monoicous is frequently used in a general way in describing thalloid liverworts when the sex organs are scattered or in groups on the same thallus, or when they are on special branches.

The antheridium is a spherical or ovoid sac, one layer of cells in thickness, and borne on a short basal stalk. The archegonium is a flask-shaped organ consisting of a more or less swollen basal portion, called the venter, and an elongated neck. The venter contains a single egg and when fully developed it is mostly one cell thick above and two to three cells thick at the base. The neck is a tubular structure consisting of a single layer of cells disposed in superimposed circular tiers of five or six cells each while a single axial row of cells occupies the neck canal. At maturity the neck canal cells dissolve forming a sticky mucilaginous liquid which swells up in the presence of water, rupturing the tip of the neck and squeezing out. This liquid is believed to have a chemical attraction for the sperms.

Position of the antheridia. In the Marchantiales the antheridia are mostly sunken in the thallus, usually in acropetal succession so that they are progressively older toward the posterior end. In *Riccia* they are solitary and scattered in the thallus with no particular grouping or localization. Each one is borne in a deep pit the ostiole of which projects more or less above the surface of the thallus (Plate II, 14). In the succeeding higher forms there is a progressive series in which the antheridia become more and more localized and at length they are restricted to a strongly delimited area called a receptacle. The terms antheridial disc, pad and cushion are also used in the literature to designate the receptacle.

In *Ricciocarpus natans* the antheridia arise in longitudinal rows in the bottom of a deep medial groove extending lengthwise down the thallus. In *Oxymitra androgyna* the antheridia are sunken mainly in the peripheral portion of a rather wide medial groove forming a sort of receptacle the central area of which is occupied by the sunken archegonia. The genus



FIGURES 5–8. Antheridial structures. 5. *Marchantia polymorpha*, vertical section of an antheridial receptacle showing the sunken antheridia, X 300. 6. *Plagiochasma rupestre*, longitudinal section of the thallus showing a sessile antheridial receptacle on the left, and a young, stalked archegonial receptacle arising as an outgrowth from the surface of the thallus on the right, X 300. 7. *Pellia epiphylla*, section showing an antheridium sunken in the thallus, X 300. 8. *Pallavicnia lyallii*, section showing a superficial antheridum on the surface of the thallus, with involucral scale, X 300.

Corsinia has a broad, elongated, slightly sunken receptacle with a marginal rim raised slightly above the surface of the thallus. It frequently forks with the dichotomous branches. In *Clevea* and *Sauteria* the receptacles are round to elongated-oval, sometimes not very well defined, and stand at about the same level as the thallus. In other genera the receptacles become more or less raised, forming sessile cushions on the thallus and show a tendency toward an apical position. They occur in a medial acropetal series in *Mannia, Reboulia* (Plate V, 2, 3, 13) and *Plagiochasma* (Fig. 6), and also in some species of *Asterella*. In *Conocephallum* the receptacle is terminal and includes the apical cell, thus terminating the growth of the thallus. This situation usually induces dichotomous branching which later places the receptacle in or near the sinus between the two branches (Plate VI, 1–3). *Targionia* and some species of *Asterella* have terminal receptacles on very short lateral or ventral branches. In the most specialized genera the antheridial receptacle is raised on a stalk which is a highly modified branch of the thallus. While standing more or less erect this stalk has morphologically dorsal and ventral sides which can be distinguished by the presence of two to four furrows on the ventral side in which rhizoids and scales occur. The wings of the thallus curve inward giving the stalk a more or less cylindrical shape, and obscure the rhizoidal furrows. However, cross sections of the stalk show its structures clearly. The antheridial receptacle is borne at the apex of the stalk and is peltate, round or oval in shape, often slightly eccentric, flattened above and convex below with ventral scales and rhizoids. The margins are more or less lobed, and at the tip of each lobe there is an apical cell so that the whole structure represents four to nine short, non-diverged, dichotomous branches of a highly modified thallus. The upper portion of the receptacle has internal air chambers and in some genera air pores are present.

In *Dumortiera* the stalk is very short so that the receptacle is quite close to the surface of the thallus, its lobes often obscure. The antheridia are in acropetal sequence but not in definite radiating rows. In *Preissia* and *Marchantia* the stalks are one to seven centimeters long and the receptacles are quite regularly crenately lobed with the antheridia disposed in radiating rows on each lobe. (Plate VII, 9, and Fig. 5.)

In the thallose Metzgeriaceae the antheridia are variously arranged. In *Riccardia, Blasia* and *Pellia* (Figure 7) they are sunken singly in the thallus. In *Pallavicinia* they are solitary and form a superficial row on each side of the midrib, each one covered by minute overlapping scales which arch forward (Plate IX, 6 and Figure 8). *Metzgeria* produces very short antheridial branches on the ventral side of the main midrib of the thallus. Each branch is rolled up like a little hollow ball and bears the antheridia in two acropetal rows on either side of the tiny midrib.

Fossombronia is a leafy form in the Metzgeriaceae and bears the antheridia on the dorsal side of the stem, either scattered or in clusters, and either naked or partly covered by small bracts.

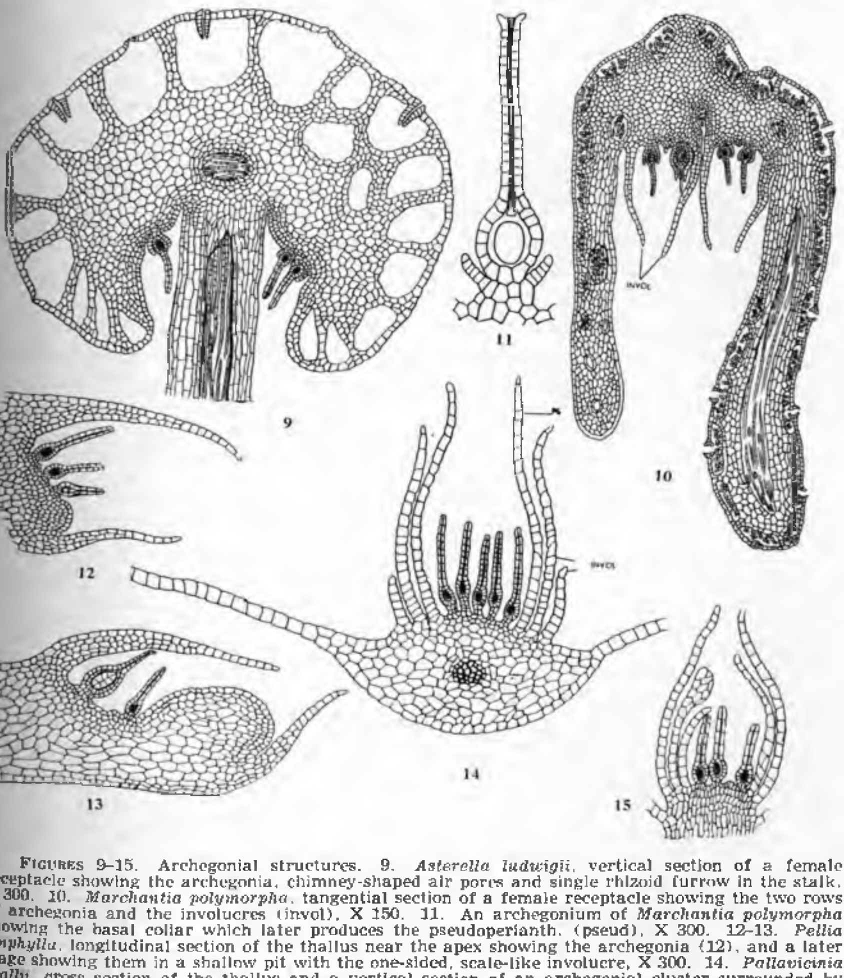
In the leafy Jungermanniaceae the antheridia are naked, spherical or ovoid, and are borne on slender stalks in the axils of bracts which differ only slightly from the ordinary stem leaves in being saccate at the base, sometimes with a small spur on one basal margin (Plate X, 14). Each bract subtends one to several antheridia. Usually the antheridial bracts occur in a short or long, terminal or intercallary series commonly designated as an androecium or antheridial spike.

Position of the archegonia. The archegonia of the Marchantiales and Metzgeriaceae are borne either on the dorsal surface of the thallus or on special receptacles. In *Riccia* they are sunken in a pit or in a medial groove (Plate I, 4 and 17). In *Targionia* they are borne at the apex of the thallus, often apparently on the ventral side. Actually they are morphologically dorsal in being dorsally posterior to the apical cell. The forward and overarching growth of the thallus throws both the apical cell and the archegonia on the underside. In *Corsinia* the archegonia are located in a circular depression in the center of which is a little hump while the margins are slightly raised and arched inward. The hump of sterile tissue is believed to be the forerunner of a raised receptacle.

In all of our other genera of the Marchantiales the archegonia are developed on special receptacles which become raised on short or long stalks, the whole structure sometimes being called a female gametophore. In *Clevea* and *Plagiochasma* (Plate III, 12 and Figure 6) the stalk and receptacles are a dorsal outgrowth of the thallus arising some distance back of the apical cell and do not represent a complete branch. This view is further supported by the fact that there is no rhizoid furrow in the stalk. In most other genera the stalk and receptacle are a highly modified branched system involving the apical cell of the thallus in which the stalk forms a direct continuation of the thallus including one to four rhizoid furrows. The receptacle forms early and at first is more or less concealed by the scales and rhizoids of the main thallus. In its earliest recognizable state it is a little short cylindrical structure with a slightly dilated apex. The dilation of this apical portion is occasioned by the formation of four or more apical cells, the number corresponding to the number of lobes characteristic of the receptacle. Shortly after the lobes appear the archegonia arise singly or in acropetal succession a few cells back of the apical cells on the morphologically dorsal side of the young receptacle. As the archegonia develop the tissue surrounding each group forms a more or less circular or elongated outgrowth called an involucre. At maturity it may be cup-shaped, campanulate or cylindrical, and serves as a protective sheath. Usually the young receptacle grows fastest on its dorsal side while growth is suppressed on the ventral side. This causes the overarching of the dorsal tissues throwing the apical cells, archegonia and involucres on the underside of the receptacle although they are still morphologically dorsal (Figures 6 and 9). The receptacles have four to nine lobes which represent very short, non-diverged, dichotomous branches of a highly modified thallus of limited growth. The internal structure is similar to that of the main thallus except that it may be modified in having deeper or longer air chambers and other minor differences. Externally the surface may show areolae with pores, the latter being similar to those of the main thallus in some species, but modified in others. For example, in *Asterella* the pores of the thallus are simple, but in the female receptacle some of them are compound and internally chimney-like (Figure 9).

In *Reboulia, Asterella, Mannia, Clevea,* and *Preissia* the receptacles are hemispherical to shortly conical and normally have four short lobes, but one to three of them may fail to develop while occasionally five lobes appear. In these genera a single row of two to five archegonia arises on each lobe. *Lunularia* has a cross-like or cruciate receptacle with four cylindrical, nearly horizontal involucres, but it is rarely formed in this country. In *Conocephallum* the receptacle is conical, normally with six lobes and elongated involucres, although five or seven may be present (Plate VI, 7). *Marchantia polymorepha* has the most complex female receptacle. The conspicuous elongated pendent segments are homologous with the wings of the thallus while the lobes proper are more or less obscured in being located between the segments at their bases, near the stalk. Nine lobes and segments normally form but seven or eight are not unusual (Plate VII, 11, 17). Each lobe bears an elongated, two-lipped involucre with fringed margins inclosing two rows of archegonia (Figure 10).

At maturity the involucres are more or less conspicuous and inclose one, two or several sporogonia in a row. In *Conocephallum* and *Lunularia* they are terminal on the lobes, tubular in shape and entire on the free margins. In the other genera of this group they are located more or less on the undersides of the lobes and are mostly cup-shaped or campanulate, two-lipped in *Clevea* and *Reboulia,* entire or two-lobed in *Asterella,* and entire in *Mannia* and *Preissia.* In *Marchantia* they are radially elongated and two-lipped (Figure 10). *Targionia* has no female receptacle, and, as previously mentioned, the archegonia are borne on the underside of the thallus near the apex. In addition, however, it has a two-lipped involucre which becomes black and very conspicuous at maturity (Plate III, 4 and 5).



FIGURES 9–15. Archegonial structures. 9. *Asterella ludwigii*, vertical section of a female receptacle showing the archegonia, chimney-shaped air pores and single rhizoid furrow in the stalk, X 300. 10. *Marchantia polymorpha*, tangential section of a female receptacle showing the two rows of archegonia and the involucres (invol), X 150. 11. An archegonium of *Marchantia polymorpha* showing the basal collar which later produces the pseudoperianth. (pseud), X 300. 12–13. *Pellia epiphylla*, longitudinal section of the thallus near the apex showing the archegonia (12), and a later stage showing them in a shallow pit with the one-sided, scale-like involucre, X 300. 14. *Pallavicinia lyellii*, cross section of the thallus and a vertical section of an archegonial cluster surrounded by the pseudoperianth (ps) and involucral scales (invol), X 300; 15. *Porella bolanderi*, vertical section of a stem tip showing a cluster of archegonia surrounded by involucral bracts (outer) and the perianth (inner), X 300.

Some genera have a pseudoperianth. This is a special membranaceous sheath arising either as a collar-like outgrowth from the base of each archegonium (Figure 11), or it may arise from the thallus, just within the involucre. In the latter instance it surrounds a group of archegonia (Figure 14). When mature the pseudoperianth incloses the sporogonium or surrounds the base of the seta. In *Asterella* it is large and at maturity projects conspicuously from the involucre, becoming cleft into a fringe of segments (Plate IV, 12 and 18). In *Preissia* and *Marchantia* it is inconspicuous and shortly campanulate with fringed margins. A pseudoperianth is lacking in *Clevea, Mannia, Reboulia, Conocephallum* and *Lunularia*.

In the Metzgeriaceae the archegonia are borne on the dorsal side of the main thallus or on small short branches. *Riccardia* produces very short lateral branches which later appear to be ventral in origin due to the expansion of the dorsal tissue of the main thallus. These small branches are mostly fringed on the margins and bear two to eight archegonia in two rows, either naked, or surrounded by a primitive involucre composed of slender scales and hairs. A pseudoperianth is lacking.

Metzgeria develops minute archegonial branches on the ventral side of the midrib of the main thallus. These branches are rolled up like tiny balls with the archegonia on the inside dorsal surface while the outside ventral surface is usually hairy. Following fertilization large hollow, obcordate, hairy involucres develop from the tiny branches obscuring their identity. A pseudoperianth is not formed.

In *Pellia* the archegonia are borne in groups of four to twelve within a pocket-like cavity opening forward at the apex of the thallus. They arise just posterior and dorsal to the apical cell, and as growth proceeds the thallus extends forward throwing the archegonial cavity on the dorsal side (Figures 12 and 13). In *P. neesiana* the margin of the archegonial cavity grows upward into a short tubular involucre, sometimes shorter on the anterior side. In contrast, the involucre of *P. epiphylla* grows upward only on the posterior side of the archegonial cavity so that it is a one-sided, flap-like structure open at the forward side (Plate VIII, 21 and 25). At maturity a thin calyptra projects beyond the involucre. No pseudoperianth forms.

The archegonia of *Pallavicinia* occur in acropetal groups on the dorsal side of the midrib and are surrounded by an involucre composed of narrow laciniate scales coherent at their bases. A pseudoperianth originates as a ring-like outgrowth of the thallus surrounding all of the archegonia (Figure 14) and after fertilization it grows into a conspicuous cylindrical tube surrounding the base of the seta. A large calyptra develops from the old archegonium becoming fleshy at the base while the thinner apex projects from the pseudoperianth.

Blasia forms naked groups of archegonia near the apex of the thallus. Later each group becomes surrounded by a fusiform involucre with a constricted, mamillate apex. The calyptra is thin and free. A pseudoperianth is lacking.

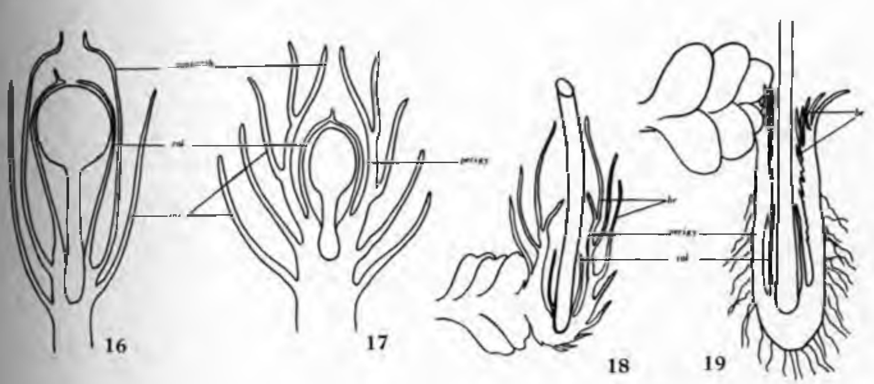
The archegonia of *Fossombronia* are borne on the dorsal side of the stem near the apex and are surrounded by a cup-shaped involucre.

The archegonia of all of the foregoing liverworts originate from a cell back of the apical cell and in no way terminate the forward growth of the thallus or stem. The term anacrogynous is used to designate this particular manner of archegonial formation. It means female not at the tip. The term Anacrogynae, when used alone, refers mainly to the Metzgeriaceae.

In contrast to the foregoing liverworts the *Jungermanniaceae* are acrogynous in that the apical cell of the stem or branch gives rise directly to an archegonium and thereby terminates the forward growth of the axis. The term acrogynous means female at the tip. Acrogynae is the noun, and it is synonymous with *Jungermanniaceae*. Other archegonia also develop from segments recently cut off from the apical cell so that there is a cluster of them at the tip of the stem (Figure 15). They are surrounded, in most genera, by a perianth formed by the union of the two uppermost leaves and the upper underleaf, when it is present. At maturity it is a conspicuous structure playing an important role in distinguishing species and genera. It ranges in form from obovate to campanulate or oblong to cylindrical. Usually it is more or less truncate at the apex, but sometimes tapering, flattened or inflated, the surface smooth or plicate. In cross section it may be round or three- to many-angled and it may be composed of one to three layers of cells. The apex may be entire or variously lobed with the margins entire, dentate or ciliate. In some genera the tip is slightly prolonged into a short tubular mouth. Some of these characteristics have been used in the establishment of certain tribes in this large family. For example, in some tribes the perianth is round, in others four- to many-angled, while in those with the triangular form some have one angle directed dorsally and others have one angle directed ventrally. In a few forms a perianth is lacking.

Immediately below the perianth is an involucre composed of two bracts similar to the stem leaves but differing in size and shape. Usually they are larger than the leaves and frequently united at their bases. In some genera the first underleaf is quite large and is called a bracteole. The calyptra is thin or fleshy, usually obovate and mostly included within the perianth, rarely exserted (Figures 16 and 26).

The perigynium. Among certain genera and species there may be further non-divergence of the bracts, perianth and stem tissue resulting in a complex structure called a perigynium or sometimes a marsupium. In its simplest form two or more pairs of involucral bracts fail to diverge completely from the perianth, as in *Plectocolea* (Figure 17). In this instance the non-diverged portion below the free part of the bracts and perianth is the perigynium. In *Nardia* (Figure 18) non-divergence has extended to include some of the stem tissue, and involves one or two addi-



FIGURES 16–19. The perigynium. 16. *Lophozia*, vertical section of the normal separate perianth and involucral bracts; 17–19. Comparative diagrams the perigynium; 17. *Plectocolea*, having the bracts and perianth partially nondiverged and forming a simple perigynium; 18. *Nardia*, in which the bracts, perianth and a portion of the stem tissue form the perigynium; 19. *Calypogeia*, in which a large part of the perigynium is made up of stem tissue, with the bracts on the inside and rhizoids outside.

tional pairs of bracts which, all together, form a cup-like pouch standing more or less at right angles to the stem axis. In *Calypogeia* (Figure 19) the perigynium becomes a fleshy tuberous outgrowth which extends downward at right angles to the stem and often burrows into the substratum. A great deal of stem tissue is involved and it represents a hollowed out tubular stem with the bracts on the inside together with numerous mucilage cells while the outside surface becomes covered with rhizoids.

Fertilization

The antheridia ordinarily mature shortly before the archegonia. In monoicous species the antheridia usually form first in acropetal succession, either singly or in groups, and then the archegonia form in a similar order. In some species the sex organs tend to form alternating groups. The events of fertilization are essentially the same for all liverworts. When the sperm mother cells are being transformed into sperms, the excess cytoplasm undergoes gelatinization, and when the mature antheridium is covered with water this gelatinous material swells up causing the antheridial jacket to break open at the tip. The mass of jelly containing the sperms oozes out as a whitish liquid which dissolves in the water setting the sperms free. Water serves both as a vehicle and a highway for their dissemination. Rain, trickling water or a thin film of dew serves to carry them about while they swim of their own accord. Eventually some of them reach the archegonia.

At maturity the neck canal cells of the archegonium undergo gelatinization, imbibe water, and burst the tip of the neck open. The sticky liquid exuded is believed to have a chemical attraction for the sperms and it may carry them down the narrow neck canal when it begins to dry out and suck back into the canal. However, many sperms are believed to swim down the neck canal under their own power. Eventually one of the sperms fuses with the egg. In species having a stalked female receptacle many of the archegonia reach maturity while the stalk is still very short and close to the surface of the thallus. If water is not present at this time the chance of fertilization taking place becomes more and more remote as the elongating stalks raise the receptacles higher and higher above the surface of the thallus. Thus, water is an absolute necessity in effecting fertilization.

The Embryo

The zygote in all liverworts divides transversely and subsequent divisions take place in a definite order, at least in part. The lower cells forming the foot soon become irregular in their divisions but the upper cells continue dividing regularly and an apical cell eventually forms. Thereafter the divisions proceed in an orderly fashion. While there is considerable variation in the order of cell division in the formation of the sporangium in the different genera and some families, they all eventually form an outer layer of jacket cells and an internal mass of archesporial tissue from which the spore mother cells are formed. The jacket may remain one cell thick or the original layer may divide further forming a jacket two to several cells thick.

The Sporophyte

The sporophyte of all hepatics is parasitic on the gametophyte. It is a relatively simple structure devoted almost entirely to the production and distribution of the spores. There is no purely vegetative tissue formed although there is progressive sterilization of the sporogenous tissue from the lower Marchantiales through the Jungermanniales to the most advanced type in the Anthocerotales. In the latter order the jacket has true stomata and the cells contain chlorophyll so that in this one instance the sporophyte is vegetative to a limited degree. These simple sporophytes are often called sporogonia and in all instances they occur more or less at the points where the archegonia were located prior to fertilization.

With the exception of the Ricciaceae the sporophyte consists of a foot, imbedded in the tissues of the gametophyte, a seta or stalk, and a capsule or sporangium. The foot draws nourishment from the mother plant. The seta may be very short, sometimes practically lacking, or it may range upward to several centimeters in length. The capsule may be globose to ovoid or shortly cylindrical to pyriform.

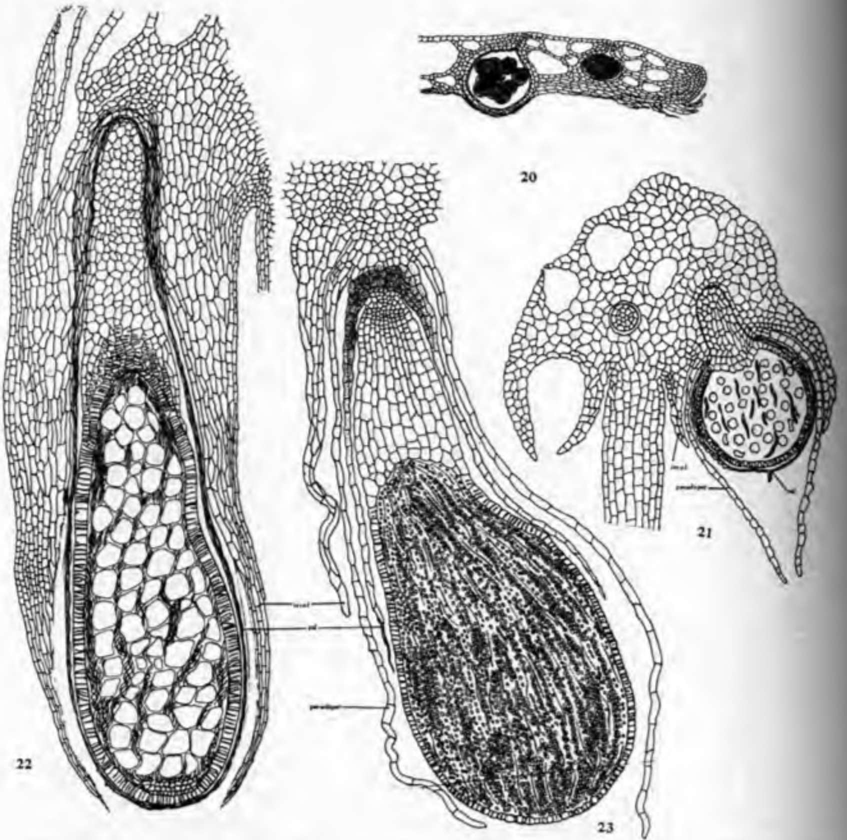
As the zygote divides and gives rise to the embryo, the old archegonium also grows and at length forms a thin sheathing membrane around the sporophyte. This membrane is called a calyptra. In a few genera it becomes large, fleshy and conspicuous, as in *Riccardia*. It is ruptured rather late by the elongation of the capsule or seta.

In the Ricciaceae the sporophytes develop in the old archegonial pits, or in the medial groove of the thallus, and are completely sunken although they may bulge out when the thallus dries and shrinks. In this family the entire sporophyte consists only of a simple globose capsule composed of a single layer of jacket cells inclosing a mass of sporogenous tissue. At the time when the spore mother cells are forming some of the sporogenous cells fail, and even the inclosing jacket cells dissolve, both forming a sticky liquid which serves as food material for the spore mother cells in their final maturation and reductional divisions. Thus, at maturity the *Riccias* have no true sporophyte left, the spores being potentially gametophytes and held in the calyptra (Figure 20 and Plate I, 16). The spores are set free only after the inclosing thallus rots away. In all other groups of liverworts certain sporogenous cells become transformed into elaters. These are mostly elongated cells with one to four stout spiral thickenings of reddish color which are hygroscopic and respond to changes in moisture. As they dry out the coiled spirals burst the thin restraining cell walls, like a suddenly released spring, and scatter the surrounding spores very effectively. Elaters are lacking in the Ricciaceae.

Marchantiaceae. The sporogonium of *Targionia* is located on the underside of the thallus at the anterior end and is inclosed within the two vertical valves of the black involucre. The foot is bulbous and the seta is very short. The capsule is usually obovate and opens at the apex by a circular lid.

In all of the other genera of this family the sporogonia are borne on the lobes of the female receptacle. In *Asterella* (Figure 21), *Mannia, Reboulia* and *Preissia* they are borne more or less in a vertical position although sometimes they diverge at a wide angle. The capsules are globose to shortly ovoid, the setae short with a bulbous foot. *Plagiochasma* has a similar sporogonium, but it is borne more or less horizontally. The foot is less well developed and the seta is practically lacking. In *Conocephallum* and *Marchantia* the capsule is obovate to pyriform with a rather long seta when fully developed. In the former the foot is narrow and in the latter it splays out in an arch, mushroom fashion (Figures 22 and 23).

In all of the Marchantiales the jacket of the capsule is composed of a single layer of cells, except at the apex where it may be two to six cells thick in some species. This is an outstanding trait of the order. The walls of the cells composing the jacket may be smooth and thin, as in *Plagiochasma*, with trigones, as in some species of *Asterella*, or they may have



FIGURES 20–23. Sporophyte structures. 20. *Riccia fluitans*, longitudinal section of the thallus showing a mature sporophyte left and an antheridium right, X 150; 21. *Asterella ludwigii*, vertical section of a female receptacle showing the sporophyte inclosed by the calyptra, pseudoperianth and involucre, X 150; 22. *Conocephalum conicum*, vertical section of a lobe of the female receptacle showing the sporophyte with calyptra and involucre, X 150; 23. *Marchantia polymorpha*, vertical section of a sporophyte showing the calyptra, pseudoperianth and involucre. cal, calyptra, pseudoper, pseudoperianth, invol., involucre.

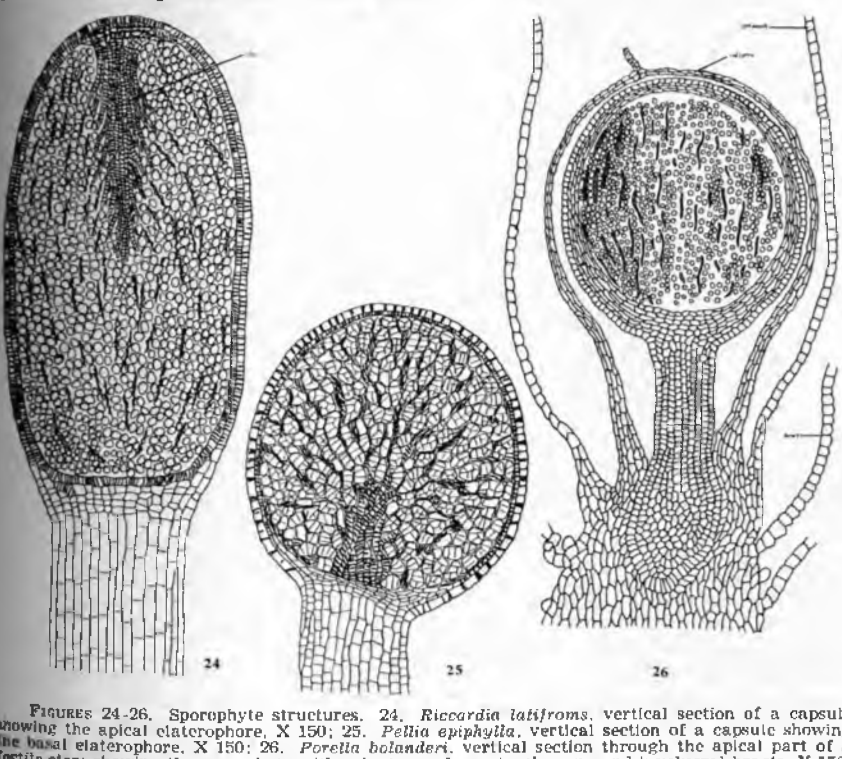
internal annular thickenings variously developed in *Targionia*, and completely formed in *Dumortiera*, *Conocephallum*, *Preissia* and *Marchantia*. The dehiscence of the capsule may be by a definite lid which falls entire or in fragments as in *Targionia*, *Plagiochasma*, *Asterella*, *Mannia* and *Reboulia*. In other species and genera the capsule may split irregularly at the apex, either forming rather definite valves or a ragged opening, as in *Dumortiera*, *Conocephallum*, *Preissia* and *Marchantia*.

The spores among the Marchantiales vary widely in size and surface markings. *Marchantia polymorpha* has the smallest spores. They measure twelve to sixteen microns in diameter, and the walls are nearly smooth. In most species of *Riccia* the spores are unusually large, ranging from forty to more than one hundred and twenty microns in diameter. They are usually more or less tetrahedral in shape and the surface is variously sculptured with coarse papillae, ridges or reticulations. In *Conocephallum* the spores are very large, rather elongated, green, thin-walled and multicellular.

Jungermanniales: In the Jungermanniales, as treated here, the sporophytes are much the same and differ from those of the Marchantiales in having longer setae and capsular jackets two to eight cells thick. The jackets are most commonly two layers thick, the outer layer often with nodular thickening on the inside of the cell walls, and the inner one usually with semiannular, band-like thickenings. In some instances the inner layer disintegrates. Elaters with one to four spiral bands of reddish-brown color are constantly present.

Metzgeriacae. The seta is generally rather short in *Metzgeria, Blasia* and *Fossombronia,* and long in *Riccardia, Pellia* and *Pallavicinia.* In some genera a columella-like mass of sterile cells with spiral thickenings similar to the elaters extends either from the base or the apex of the capsule vertically toward the center. These structures are called elaterophores and are suggestive of an incipient columella. They are basal in *Pellia* (Figure 25) and *Blasia*, and apical in *Riccardia* and *Metzgeria* (Figure 24). Dehiscence of the mature capsule is apical by four valves which split to the base or nearly so. When the elaterophore is apical, it also splits so that each valve has a fringed segment extending from the tip. When the elaterophore is basal it remains entire and forms a bushy crown in the center of the widely spreading valves. The spores vary in size and surface markings in about the same manner as in the Marchantiales. In *Pellia* they are large, thin-walled, green and multicellular, much the same as in *Conocephallum.*

Jungermanniaceae. In this large family the sporophyte is remarkably uniform. The foot is more or less bulbous and the seta ranges from about one millimeter to several centimeters in length. The capsules may be included, that is, immersed in the large perianth, or long exserted. They range from globose to shortly cylindrical and open by four valves splitting to the base (Figure 26 and Plate X, 10).



FIGURES 24-26. Sporophyte structures. 24. *Riccardia latifroms*, vertical section of a capsule showing the apical elaterophore, X 150; 25. *Pellia epiphylla*, vertical section of a capsule showing the basal elaterophore, X 150; 26. *Porella bolanderi*, vertical section through the apical part of a fertile stem showing the sporophyte with calyptra, cal., perianth, per., and involucral bracts. X 150.

ECOLOGY AND DISTRIBUTION

The distribution of hepatics in Utah is traceable mainly to climate which in turn is influenced largely by the topography of the land. The character of the residual rocks and the mineral conditions of the soil have a marked influence on certain species. Some of them are restricted mainly to regions of acidic rocks while others are mainly restricted to regions of calcium bearing rocks.

The lowlands below 4,500 feet elevation are principally saline deserts receiving about ten inches average annual rainfall, or less. Some higher desert areas extending upward to 5,500 feet elevation receive a similar amount of precipitation. The vegetation of these regions is dominated by salt desert shrubs and short grass communities too dry or too saline to support any form of liverwort. Except in very mildly saline soils, none has been found, and none can be said to be halophytic. The closest approach that hepatics make to actual desert conditions is in local damp situations, occasioned by seepage areas and small rivulets, or on dry slopes under overhanging rocks.

According to the locality, the basal regions skirting the mountains, at elevations between 4,500 and 6,000 feet, harbour bunch grass, sagebrush, Gambel oak, juniper-pinyon pine and yellow pine communities receiving between twelve and twenty inches average annual precipitation.

A chain of high mountains ranging from 10,000 to 13,000 feet elevation extends from the Wasatch and Uintah mountains in the northeastern part of the state southward, and slightly westward, to the mountainous region between the Aquarius Plateau and the Pine Valley Mountains at the southwestern extremity. The Wasatch Plateau and Tushar mountains are in the middle portion of this chain. Extending eastward from the main axis in the north-central region are the East and West Tavaputs plateaus, and at the southern end the Kaiparowitz plateau. The high La Sal, Abajo and Henry mountains are isolated island-like groups of peaks arising from the dissected canyon lowlands of the Colorado River basin. On the western border of the state are the Deep Creek monutains while the Grouse Creek and Raft River mountains are isolated in the northwestern corner. In these mountains igneous sedimentary and metamorphic rocks of great variety range from pre-Cambrian to recent with almost every geologic period being represented. They provide a wide variety of mineral conditions. In these mountains the average annual rainfall increases with rise in elevation, the basal zone receiving amounts varying between sixteen and twenty-five inches while the alpine zone receives thirty to forty inches, or more. The atmosphere is more humid and the temperature lower. Beginning at about three thousand feet elevation there is approximately three degrees decrease in average temperature for every thousand feet rise in elevation. Abundant snow maintains many permanent springs, seepage areas, streams and small lakes. Aspen, spruce and fir with local mountain meadows and open grassy slopes characterize the vegetation over the greatest part of the montane zone while at higher elevations spruce and lodge-pole pine predominate. The stream side vegetation is dominated by the narrowleaf cottonwood, river birch, alder, river hawthorne and several willows. On the lower canyon slopes the bigtooth maple and Gambel oak are conspicuous. The greatest number and variety of liverworts grow in these mountains. A wide variety of habitats is afforded by shaded cliffs, ledges and crevices, by seepage springs, wet meadows, bogs and ponds.

Many minor mountain ranges are scattered and more or less isolated in the Great Basin portion of the state, but few have sufficient elevation and extent to maintain permanent streams or to support a mesophytic vegetation. They are more or less ecologically alike and harbour few or no hepatics.

Communities of Hepatics

Targionia hypophylla, Mannia californica, M. fragrans and *Reboulia hemispherica* inhabit dry situations, and may be regarded as xerophytes. They occur frequently in southern Utah, usually in dry canyons or on slopes bordering the desert floor, especially on sandstone ledges. Each species ordinarily forms isolated colonies in crevices or on the soil under overhanging rocks which provide a little shade and protection, and where dripping rain water is concentrated. They are active only in the winter and early spring before drouth sets in. During moist periods they are green, but when they dry out the wings of the thalli curve inward longitudinally, obscuring the green upper surface, while the dark ventral scales give them the appearance of little black "worms." Along desert streams in box canyons and around fairly permanent water holes and moist cliffs the ubiquitous *Marchantia polymorpha* may be found. *Frullanias* occur sparsely at the foot of sandstone cliffs or on the bases of trees where it is damp.

Along streams and ditches of the lowlands and the lower reaches of canyons *Riccias* are common on damp silty soils. *Riccia fluitans* and *Ricciocarpus natans* occur in ponds and the swampy borders of lakes. *Riccia frostii* is extremely abundant along the banks of the Green and Colorado rivers. Occasionally in shaded seepage areas, springs or swampy thickets *Riccardia punguis* grows in local abundance while less frequently *Riccardia latifrons* grows sparingly and scattered among mosses and plant debris. *Chiloscyphus fragilis* and *C. pallescens* appear on the banks of slow streams or standing water. *Marchantia polymorpha* and *Conocephalum conicum* grow sparingly in the lowlands, but near the bases of high mountains, in favorable places they may be locally abundant.

About seventy per cent of the hepatics of Utah are confined to the higher mountains and deep canyons subtending them. Mineral conditions appear to be the dominant factor in their abundance and variety. Areas of igneous or silicious rocks harbor the richest hepatic flora. In the Uintah mountains pre-Cambrian quartzites predominate and form one of the state's most extensive areas of silicious conditions where the soil is mildly acid. Here species of *Lophozia, Lophocolea, Scapania, Chiloscyphus, Jungermannia, Cephalozia, Blepharostoma* and *Calypogeia* grow on wet brook banks, in meadows, seepage areas and bogs. *Chiloscyphus rivularis* is common in ponds and slow streams. Species of *Pellia, Riccia, Riccardia, Blasia* and *Priessia* are quite common on muddy banks or among mosses and grasses.

In the high La Sal mountains many of the same genera and species grow. The rocks exposed at higher elevations are igneous and consist mainly of light gray, fine-grained porphyry. The Aquaris plateau is a great tableland capped with lava and is, perhaps, second only to the Uintah mountains in abundance of hepatics. Local areas in the Wasatch mountains and other ranges present silicious or ferromagnesian rocks where their influence is reflected in the hepatic flora. While many species are not restricted to areas of acidic rocks they are, on the whole, favored by them.

Limestones are abundant in the Wasatch mountains and in many other localities. The hepatic flora in these regions is noticeably less in variety and abundance. Some species are said to be calciphiles and for the most part this habit appears fairly well borne out in our region, although some species appear to grow equally well in areas of acidic rocks. In Utah *Clevea hyalina* is the most prominent calciphile and is commonly encountered in talus, crevices and ledges of high mountains or in deep, cool canyons at elevations as low as 6,000 feet. *Asterella ludwigii* and *A. lindenbergiana* are likewise known mainly in regions of calcic rocks at high elevations. *Preissia quadrata* is said to be a calciphile, but in Utah it occurs more commonly in silicious areas, frequently in regions of granitic rocks. *Porella bolanderi* occurs in greatest abundance in cool shaded limestone crevices and at the bases of cliffs, but it also seems to grow nearly as well on granite and lava.

In general Utah is poor in hepatics, both in species and populations. It is only in certain localized areas where they can be said to flourish and elsewhere one is obliged to search for them, even though the situations appear favorable. It is not uncommon to find a large colony of a given species only in one particular locality in a canyon, although there may be many favorable habitats near by. Several records are based on such circumstances. Species new to the state are being discovered a few at a time, and usually at wide intervals of time.

DESCRIPTIVE CATALOG OF THE HEPATICAE OF UTAH

Class HEPATICAE

Gametophyte thalloid or leafy; rhizoids non-septate, ventral scales often present; the thallus with or without a midrib, often furrowed, mostly dichotomously branched, sometimes simple or irregularly branched or merely lobed; leafy plants prostrate, ascending or erect; leaves arranged in 2–3 rows, complanate, often 2–5-lobed, without a distinct midvein or costa; leaf cells isodiametric or nearly so. Antheridia and archegonia originating from epidermal cells, apical and terminating the growth of the thallus or dorsal, either superficial or becoming sunken in chambers or furrows on the main thallus, a special branch, or a specialized receptacle, the latter sessile or raised on a stalk. Sporophyte mostly with foot, seta and capsule; the capsule without a well-formed lid, peristome lacking, dehiscence mainly by 4 valves; elaters usually present; columella present only in the Anthocerotales. Protomena rudimentary or none.

Key to the Orders

Gametophyte thalloid, mostly with epidermal pores and dorsal air chambers separated by unistratose partitions, with a sharp distinction between the green photosynthetic tissue and the more or less colorless ventral tissue; some of the rhizoids with internal peg-like thickenings on the walls. .... I. **Marchantiales**

Gametophyte thalloid or leafy; the thalloid ones solid, without pores or air chambers, without a sharp distinction between the green photosynthetic tissue and the colorless ventral tissue; all rhizoids with smooth walls. .... II. **Jungermanniales**, p. 43.

Order I. **Marchantiales**

Plants dorsiventrally thalloid, flat and prostrate, small and short to elongated and ribbon-like, dichotomously branched, with a midrib; rhizoids unbranched, mostly of 2 kinds, either smooth-walled or with internal peg-like or ridge-like thickenings; ventral scales in 1–2 rows on either side of the midrib or sometimes lacking; epidermis with simple or barrel-shaped pores; dorsal part of the thallus chlorophyllose, with air chambers, the ventral part of colorless, solid tissue. Monoicous or dioicous. Antheridia short-stalked, ovoid to elongated, sunken in the dorsal side of the thallus or in sessile or stalked receptacles; the antheridial chambers opening by raised ostioles; archegonia borne singly or in rows, sunken in the thallus, or superficial near the apex of the thallus or on raised receptacles. Sporophyte composed of capsule only, or of a capsule with a foot and short seta; wall 1 cell thick except at the base and/or apex where it may be 2–6 cells thick; columella lacking; elaters present or absent.

Key to the Families

Plants small; segments of the thallus 3 mm. wide or less, 2–5 times dichotomously branched; terrestrial forms developing small circular rosettes on soil, 0.5–3 cm. in diameter; pores, when present, simple, not bordered by differentiated cells; sporophyte consisting of only a capsule imbedded in the thallus, often protruding on the ventral side; elaters lacking. .... 1. RICCIACEAE

Plants small to large; segments of the thallus mostly exceeding 3 mm. in width, mostly dichotomously branched, often with ventral branches also; pores bordered by differentiated cells; sporophyte consisting of a foot, a short seta and a capsule; elaters present. .... 2. MARCHANTIACEAE

Family 1. RICCIACEAE

Plants small, thalloid, annual or perennial, mostly closely adhering to wet or damp soil, some species floating in water, dichotomously branched and usually forming rosettes; rhizoids mostly of 2 kinds in terrestrial forms, lacking in aquatic forms; ventral scales lacking to large and conspicuous; air chambers present or apparently lacking, epidermal pores simple, often minute and sometimes lacking. Monoicous or dioicous. Antheridia and archegonia sunken singly in the thallus in deep pits or in a medial groove, scattered or in groups; antheridial chambers opening on the surface by an ostiole; archegonial necks protruding. Sporophyte deeply embedded in the thallus, composed of a capsule only; wall 1 cell thick except at the apex or base, disintegrating as the spores mature. Spores mostly large, dark brown, variously sculptured, reticulate or spinose; elaters lacking.

Key to the Genera

Plants mostly on wet or damp soil (*R. fluitans* floating) and forming closely adhering circular rosettes; ventral scales in two rows, not very conspicuous; air chambers and pores present, or lacking and the thallus solid. .... 1. Riccia

Plants mostly floating; the thallus short and very thick; segments obcordate or obovate, inflated and with a conspicuous median groove; pores surrounded by 5–8 elongated cells; under side with large, broad, brownish, reddish or purplish scales; when stranded on soil rhizoids replace the scales. .... 2. Ricciocarpus

1. Riccia L., Sp. Pl. 1138; 1753.

Thalli mostly forming rosettes on wet or damp soil (*R. fluitans* usually floating in water), mostly thick and with a median dorsal groove; air chambers polyhedral with partitions mostly 1 cell thick or the dorsal tissue arranged in vertical plates with narrow air spaces between them; pores minute, not bordered by cells of special form; dorsal surface often becoming lacunose or spongiose by the disintegration of the epidermis. Mostly monoicous, a few species dioicous; antheridia and archegonia scattered or grouped, deeply sunken singly. Capsule deeply sunken, often protruding on the ventral side of the thallus, mostly spherical.

The name honors P. F. Ricci, an Italian botanist.

Riccias are to be found on damp or wet mud and sand bordering lakes, ponds, rivers and ditches or in meadows or wet boggy situations in the mountains. Mostly they occupy open places but frequently they may be under shrubs or among grasses. Only *Riccia fluitans* floats in water.

Plants floating; thallus thin and narrow, segments distantly and widely forked; air chambers and pores very small, not becoming lacunose .... 1. *R. fluitans*

Plants on wet or damp soil forming rosettes; segments broader, 2–3 times as long as wide.

Thallus with conspicuous polyhedral air chambers.

Segments broadly triangular, furrowed at the apex, surface glistening when fresh, becoming strongly lacunose in the older part, rectangular in cross section; spores dark brown, often opaque, with coarse papillae and branched ridges, discontinuous-reticulate............ 2. *R. crystallina*

Segments triangular or ligulate, furrowed throughout, obtuse, often becoming somewhat lacunose in the older part, rectangular to subelliptical in cross section; spores brown, with fine radiating, branched ridges, rarely anastomosing. .... 3. *R. frostii*

Thallus without polyhedral air chambers, the upper portion composed of vertical plates of cells with narrow air spaces between them, often appearing solid; finely reticulate on the dorsal surface.

Margins of the thallus bearing 1–2 rows of stout cilia or setae, mostly toward the apex. .... 4. *R. beyrichiana*

Margins of the thallus not bearing cilia or setae.

Cross section of the segments 4–5 times as broad as thick, broadly channelled above; epidermal cells thin-walled; plants often pale or whitish, especially on the margins. .... 5. *R. glauca*

Cross section of the segments 2–3 times as broad as thick, sharply furrowed above; epidermal cells with thick walls..... 6. *R. sorocarpa*

1. *Riccia fluitans* L., Sp. Pl. 1139; 1753.

Thallus very narrow, 10–50 mm. long, 0.51 mm. wide, green or yellowish green, usually dichotomously branched several times, the branches widely divergent; upper surface channeled toward the apex; ventral surface smooth, without rhizoids or scales; when stranded on soil numerous rhizoids and a few scales at the apex develop; in cross-section semi-lunate, rather thickish, the margins rounded; air chambers large with very small pores on upper surface, usually closed by the swollen epidermal cells.

Monoicous. Antheridia mostly solitary in a deep pit in the dorsal median region; archegonia also in a deep pit anterior to the antheridia. Capsule spherical and forming a conspicuous protuberance on the ventral surface, usually covered with rhizoids. Spores large 75–90 μ, yellowish brown, very coarsely reticulate on outer face, inner face with irregular branched ridges.

Floating on ponds, slow streams and ditches. Not common in Utah. It seems to be abundant in Salem Pond near the town of the same name in Utah County, also in several ditches and canals in same locality. It occurs sparingly in the outflow of the Springville Fish Hatchery and in the stream which it enters. The plant is easily overlooked, especially when duckweed is abundant. World wide in distribution.

Illustrations: Plate I. 1–5.

Collections examined: Flowers 8038. Utah County, in stream at the Springville Fish Hatchery, 4,500 feet; 8048. Utah County, Salem Pond, 4,500 feet.

2. *Riccia crystallina* L., Sp. Pl. 1138; 1753.

Plants in circular rosettes 10–24 mm. in diameter, grayish-green or yellowish, pale green and glistening when young. Thallus small, 5–10 mm. long, quite thick, 1–3 times dichotomous, branches very short, wedge-shaped to obcordate, the upper surface appearing spongy in the older part due to the disorganization of the epidermis; in cross section 2–3 times as broad as thick, rectangular with rounded or truncated ends; air chambers large with small pores in the epidermis of the younger part, becoming large and gaping in the older portions; rhizoids present, scales lacking on ventral surface.

Monoicous; sex organs sunken; capsules embedded in the thallus toward ventral side; spores yellowish-brown or dark brown 60–110 μ, with coarse papillae and irregularly branched ridges which rarely form closed areolae.

On damp or wet soil, on banks and in wet meadows in the mountains. United States, Mexico, West Indies, Europe and Asia.

Illustrations: Plate I, 6–12 and Figure 20.

Collections examined: Flowers 8034. Utah County, Mt. Timpanogos, First Falls above Aspen Grove, on damp and wet soil around falls and dripping cliffs. 2726. Salt Lake County, east bench of Salt Lake City, on damp soil under rocks, very dry in summer. About 5,000 feet.

3. *Riccia frostii* Austin, Bull. Torr. Bot. Club 6: 17; 1875.
Riccia watsoni Austin, l.c. 1875.

Plants forming rosettes, 10–15 mm. in diameter, pale green or grayish-green, closely adhering to the soil; thallus 3–8 mm. long, segments 0.5–2 mm. wide, 2–6 times dichotomous, rather thin but proportionately thicker in the branches, in cross section oblong with rounded or truncated ends, in the older portion tapering at the ends; dorsal surface more or less reticulate, the older portion becoming spongy with large lacunae; air chambers rather large, some narrow and vertically elongated with smaller polyhedral chambers below; rhizoids numerous; scales none or very few and small.

Dioicous. Sex organs immersed; capsules imbedded in the thallus toward the ventral side, usually numerous, spherical and dark brown; spores light brown, 45–60 μ with slender, sinuous, more or less radiating ridges, usually branched but not anastomosing.

On wet or damp soil bordering streams and ponds. Abundant on mud and sand along many of our streams and ditches. It occurs along the Provo and Weber Rivers and has been collected in Cache, Ogden, Kamas and Heber valleys. It is especially abundant on flood plains of the Colorado and Green rivers. Vermont to Virginia, westward through Oklahoma and New Mexico to California and Washington. Mexico, Europe and Asia.

Illustrations: Plate I, 13–18.

Collections examined: Flowers 8033. Utah County, Provo River north of Provo, on damp silt and sand of river bank; 8033A. Provo Canyon near Wildwood, similar habitat, 4,550–5,200 feet.

4. *Riccia beyrichiana* Hampe, in Lehm., Stirp. Pugill. 7: 1; 1838.

Riccia lescuriana var. *cruciata* Aust., Proc. Acad. Nat. Sci. Philadelphia 21 (1869): 232; 1870.

R. lecuriana var. *trichotoma* Aust., l.c.

R. glaucenscens Carr., Carr. & Pears., Hep. Brit. Exsic. No. 66; 1878.

R. glauca var. *ciliaris* Warnst., Verh. Bot. Brandenberg 27: 87; 1885.

R. lesquereuxii Steph., Bull. Herb. Boissier 6: 324; 1898.

Thalli 1–4 times dichotomous, 4–10 mm. long, gregarious or sometimes forming rosettes; branches often forming a wide angle; pale green above, pale below, often reddish-purple on the sides near the apex; dorsal surface reticulate; young segments cordate-obovate with a narrow median groove, the older ones obovate-cuneate to linear with a broad median groove, narrowing and closed at the apex, obtuse to subacute; margins ascending, blunt to subacute, bearing 1–2 rows of stout, hyaline, smooth or granular cilia or setae, 73–300 μ long, sharply pointed or blunt, straight or sometimes slightly curved; ventral scales hyaline to reddish-purple, near the apex, usually few; air chambers lacking; dorsal tissue more or less compact, made up of vertical plates of cells with very narrow spaces between them; epidermal cells hemispherical to obovate, often papillate, soon collapsing; hypodermal cells broad.

Monoicous. Antheridia and archegonia scattered in the thallus; antheridial ostioles prominent; sporangia prominent, especially when dry; spores brown to dark brown, angular or flattened, 65–140 μ in longest diameter, wing margin 3–12 μ wide, usually discontinuous; outer face strongly reticulate, areoles 9–18 μ across, cristate or papillose at the junctions of the ridges; inner faces smooth or lightly and irregularly areolate. Type locality in Northwestern Georgia.

On damp soil, often among mosses. Widely scattered. Connecticut to Florida, British Columbia to California, Texas and Arizona. Europe and Africa.

Illustrations: Plate II, 1–9.

Collection examined: Flowers 8037. Summit County, Henry's Fork, on damp soil among mosses, 8,500 feet; 8148. Salt Lake County, Brighton, on damp soil, Silver Lake meadow, 8,700 feet; 8175, Utah County, Mt. Timpanogos, 8,000 feet.

The spores of the present plant are more closely reticulate than typical and resemble those of *Riccia californica*. The areoles are mostly 10 microns across which is the minimum size for *R. beyrichiana* and the maximum size for *R. californica*. The latter species probably occurs in Utah although it has not been found up to the present time. It differs in having much more slender and longer marginal cilia, a few of them often extending to the dorsal surface of the thallus, and it does not have protruding antheridial ostioles.

5. *Riccia glauca* L. Sp. Pl., 1139; 1753.

Plants irregularly spreading or forming loose rosettes, 10–15 mm. in diameter; green or glaucous-green above and whitish-green below, margins pale; thallus 5–10 mm. long and 1–3 mm. wide, 2–3 times dichotomously branched, the branches often divergent and oblong when growing solitary; in rosettes shorter and more approximate, obovate to wedge-shaped; segments rather thin with a broad median channel toward the apex and disappearing in the older portion; in cross section oblong with attenuated and often downward arched thin margins, 4–5 times as broad as thick; colorless ventral scales and rhizoids present, the former often disappearing early; polyhedral air chambers lacking, dorsal tissue more or less compact, of vertical plates of cells with narrow spaces between them, often appearing solid; epidermal cells rounded or pyriform and thin-walled, soon collapsing and becoming more or less concave or cup-like; hypodermal cells broad.

Monoicous; sex organs and capsules immersed in the thallus. Spores large, 75–90 μ, dark brown, the outer face coarsely reticulate with high branched, ridges, appearing coarsely papillose in profile.

On wet or damp soil. Abundant on open soil in alpine meadows, around lakes and ponds and along rivulets. It is especially common in the Uintah Mountains around the numerous lakes. It has also been collected at Brighton, Alta and Mt. Timpanogos. Washington, Wyoming, Nebraska to Texas, westward to California. West Indies, Europe, Asia and Africa.

Illustrations: Plate II, 10–16.

Collections examined: Flowers 8011. Summit County, Upper Provo River at Lily Lake, Uintah Mountains, on damp soil, 9,700 feet; 8011A. Duchesne County, Uintah Mountains, damp soil around Mirror Lake, 10,300 feet. B. F. Harrison 10596. Utah County, Mt. Timpanogos, on damp soil, Hidden Lake Cirque, 10,000 feet.

6. *Riccia sorocarpa* Bisch., Nova Act. Acad. Nat. Cur. XVII, 1053; 1835.

Plants solitary or in loose rosettes, 8–12 mm. in diameter, glaucous-green, more or less crystalline above, pale green below, whitish on the margins; margins incurved or erect when dry. Thallus small 4–9 mm. long and 1–1.5 mm. wide; 2–3 times dichotomously branched, the segments oblong to ovate, more or less narrowed and with a deep furrow at the apex; rhizoids present; scales present only at the apex, colorless; in cross section thick, strongly convex with a deep furrow and high attenuated, acute margins; epidermal cells in 2 layers, the upper layer thin-walled and mamillate but soon disappearing; the lower layer thick-walled, quadrate, with slightly projecting upper margins; polyhedral air chambers lacking, dorsal tissue compact, cells in vertical plates with narrow spaces between them.

Monoicous. Sex organs and capsule immersed in the thallus. Spores 65–80 μ, dark brown, outer face coarsely reticulate with high ridges, irregularly crenulate in profile.

On wet or damp soil, river and ditch banks, possibly common in the lowlands. It resembles *Riccia glauca* but can easily be distinguished by characters in the key. Greenland, United States, Guadelupe Island off Western Mexico; Europe, Asia and Africa.

Illustrations: Plate II, 17–21.

Collections examined: Flowers 8035. Washington County, Zion Canyon, on wet sandy soil at the Grotto, 4,500 feet.

2. RICCIOCARPUS. Corda, in Opiz, Beitr. 651; 1829.

Plants solitary, floating, sometimes becoming stranded; thallus 5–10 mm. long and 4–8 mm. wide, 2–3 times dichotomously branched; the branches approximate, lobes thick, obcordate with a deep narrow medial furrow throughout, green above, often tinged with purplish-red; ventral scales long, pendent and purplish, very conspicuous; air chambers large with unistratose walls except at near the ventral side; pores very small, surrounded by 6–8 small cells with slightly thicker walls; in cross section flattish oblong, ends rounded, furrow conspicuous; ventral scales linear, acute or rounded serrate; rhizoids few or none. Stranded plants becoming more elongated, tinged with red and forming loose, one-sided rosettes; scales reduced; rhizoids numerous.

Dioicous. Sex organs in the medial furrow. Capsules apparently rare, single or in pairs in the furrow, globose, near the center of the thallus. Spores about 51 μ, dark brown, with irregularly branched ridges.

Ricciocarpus natans (L.) Corda. l.c.

Riccia natans L. Syst. Veget. 956. 1781.

One species with characters of the genus.

Floating on ponds, lakes, slow streams, ditches and swamps. Not uncommon and abundant where found. It occurs in swamps around Utah Lake, in Salem Pond, and elsewhere in Utah County; in a side stream at Stoddard in Weber Canyon, near Centerville and in Cache Valley. Nearly world wide in distribution.

Illustrations: Plate IV, 1–6.

Collections examined: Flowers 8039. Cache County, floating on ponds west of Logan, 4,550 feet. 8043. Utah County, floating on pond near Geneva, 4,500 feet. 8055. Weber County, stream sides and swamps near Stoddard, 5,100 feet; 8056. Salt Lake County, stream sides and swamps along Spring Run, Holladay, 4,460 feet.

Family 2. MARCHANTIACEAE

Plants thalloid, small to large, thin or fleshy, simple, dichotomously branched or forming innovations by ventral branches; costa strong; thallus with an upper stratum of chlorophyllose cells, mostly divided into air chambers, and a lower colorless stratum of compact tissue; pores simple, often elevated, and surrounded by 4–8 radiating rows of smaller cells or pores barrel-shaped, surrounded by tiers of cells vertically superimposed, projecting above the epidermis externally and below it internally (air chambers lacking or very small and pores lacking in *Dumortiera*); antheridia immersed in the thallus, or in sessile or stalked receptacles; seta short to rather long, often practically lacking; capsule globose to ovoid, opening irregularly, or by a lid, or by valves; elaters present.

Key to the Genera

a. Stalked receptacles lacking; capsule borne at the apex of the thallus on the underside, surrounded by a black or purplish-black, 2-lipped involucre; growing mostly in desert regions; thallus becoming strongly inrolled when dry, the margins connivent, exposing the black ventral scales. .... 1. Targionia

aa. Stalked receptacles present; plants mostly growing in damp or wet places, the margins of the thalli not becoming inrolled when dry, or if growing in dry regions the margins becoming inrolled and black when dry.

b. Epidermal pores simple, surrounded by radiating rows of smaller cells; antheridia immersed in the thallus or in sessile disc-like receptacles.

c. Air chambers without photosynthetic filaments.

d. Stalk of the female receptacle without a rhizoid furrow, arising from the dorsal side of the thallus, often in the center; cells bordering the pores with very thick walls facing the pore opening and the radial walls stellately thickened; cell walls of the capsules with semi-annular thickenings. .... 2. Clevea

dd. Stalk of the female receptacle with 1 rhizoid furrow, terminal on the main thallus or on a short lateral or ventral branch, often appearing lateral or axillary; cells bordering the pores in radial rows, not thickened as above; cell walls of the capsules without semi-annular thickenings.

e. Female receptacle hemispheric; pseudoperianth lacking.

f. 2–3 cells in each radial row of cells surrounding the pores; female receptacle slightly lobed, entire; involucre entire; plants xerophytic; thallus strongly inrolled longitudinally and black when dry. .... 3. Mannia

ff. 4–5 cells in each radial row of cells surrounding the pores; female receptacle distinctly lobed; involucre vertically split into two valves or lips; plants mostly mesophytic; the thallus usually only incurved when dry, the green surface evident, but sometimes strongly inrolled and black, resembling the last. .... 5. REBOULIA

ee. Female receptacle conic to hemispheric; pseudoperianth large and conspicuous. .... 4. ASTERELLA

cc. Air chambers containing photosynthetic filaments.

d. Gemmae cups none; areolae large and conspicuous, each with a prominent white or brownish pore; female receptacle conic; plants large, common in mountains. .... 6. CONOCEPHALUM

dd. Gemmae cups present, crescent-shaped; areolae distinct but not conspicuous; female receptacle cruciate; plants medium-sized, rare, found mainly in greenhouses. .... 7. LUNULARIA

bb. Epidermal pores barrel-shaped; antheridia in stalked, discoid receptacles.

c. Thallus usually with numerous cordate apical innovations, gemmae cups lacking; ventral scales in 2 rows; female receptacle hemispheric with 4 dorsal ridges and 4 alternating shallow lobes below; spores 50–60 μ. .... 8. PREISSIA

cc. Thallus conspicuously dichotomously branched, without apical innovations; gemmae cups frequent; ventral scales in 4–6 rows; female receptacle stellate with 5–9 slender, finger-like rays; spores 12–15 μ. .... 9. MARCHANTIA

1. TARGIONIA L., Sp. Pl. p. 1136; 1753.

Thallus thick and coreaceous, simple or 1–3 times dichotomously branched, often with innovations arising from the side of the midrib, bright green above, margins black or purplish, areolae indistinct; pores evident but not conspicuous; ventral scales imbricated, in 2 rows, purplish or black, extending to the margins; rhizoids numerous; air chambers in a single dorsal stratum, rather closely packed with erect photosynthetic filaments; pores simple, slightly raised, bordering cells very small; epidermis thick-walled, whitish, with trigones; gemmae lacking.

Monoicous. Antheridia immersed in small, sessile discs at the apex of short side branches arising from the ventral side of the midrib. Archegonia borne in groups on the dorsal side of the thallus just back of the apical notch; after fertilization the apical notch arches downward, the mature sporophyte appearing to be ventral; sporophyte completely inclosed within a conspicuous obovate, iridescent, black or purplish, 2-lipped involucre with a vertical slit-like opening; seta very short; capsule globose to shortly ovate; wall 1-cell thick except at the apex; cell walls with semiannular thickenings; pseudoperianth lacking; spores brown, reticulate on the outer face. Named in honor of Giovanni Targioni-Tozzetti, 1712–1782, a botanist and artist of Florence.

Targionia hypophylla L. l.c.

Thallus thick and coreaceous, somewhat brittle, obovate to linear-oblong simple or branched 10–20 mm. long and 4–6 mm. wide; emarginate at the apex, margins undulate, in cross section thick, the midrib broad, tapering to the thin margins, becoming 1-cell thick; ventral scales triangular, usually black; when dry the thallus margins become erect or inrolled and connivent, the dark scales exposed all around, appearing like little black, cylindrical, "worm-like" objects.

Involucre blackish, slightly projecting from the underside of the thallus at the apex, overlapped at the sides by blackish, iridescent scales; capsules usually abundant, spores brown, 50–80 μ, of two sorts: larger, very coarsely reticulate with high branched ridges on the outer face, inner face granular, and smaller more minutely and irregularly reticulate; elaters branched or simple, with 2–3 spirals.

On damp, wet or intermittently wet soil, in shade or under overhanging rocks. It is favored by sandy or rocky soil and is quite common on dry hillsides in desert regions especially under rocks where water drips down during rainy weather. In Utah it is abundant in Washington, Kane and San Juan counties growing on sandy soil among cliffs and under rocks. It also grows in damp shady places and probably is scattered throughout the state. British Columbia, southward through Washington, Utah, Arizona, westward to the Pacific Coast states, Mexico, South America, South Pacific Islands, Europe, Asia, and Africa.

Illustrations: Plate III, 1–11.

Collections examined: Washington County: Flowers 8022. near Berry Spring, 3,250 feet; 8023. near Hurricane, 3,250 feet; 8059. Santa Clara Creek, 2,700 feet, 8062. Zion Canyon, 4,500 feet. 8057. Millard County: 5516. Canyon Mountains, Oak Creek, 4 mi. E. of Oak City. Dry soil, hillside, 5,800 feet. Arizona: Mohave County, Virgin River narrows. 2,450 feet.

While *Targionia* is a decided xerophyte in our region, it should be pointed out that *Mannia fragrans* and *M. californica* are also xerophytic and share at least part of the range of the former in southern Utah and adjacent Arizona. In the dry condition the thalli of these three species become longitudinally inrolled, the margins becoming connivent, and exposing the purplish-black, often iridescent, ventral scales. When sterile, in this condition, they appear superficially alike and may be easily confused. *Reboulia hemispherica* assumes a similar dry habit when growing in more or less xeroyhptic conditions and in the sterile state it might be confused with those mentioned above.

2. Clevea Lindb., Not. Saellsk. Fauna et Fl. Fennica 9: 289. 1868.

Plants mostly small, simple or sparingly branched, dichotomous, pale or dull green, often tinged with purple; areolae small, slightly elevated; epidermal pores surrounded by cells usually having conspicuous crescent-shaped thickenings on the walls facing the pore opening, more or less stellate; epidermal cells thin-walled with small trigones, often indistinct; ventral scales narrow and slenderly acuminate, entire, in two longitudinal rows, hyaline or purplish; air chambers numerous, in one or many layers, the walls unistratose, without supplementary partitions; gemmae lacking.

Dioicous or autoicous. Antheridia immersed in the thallus, scattered along the medial line; stalk of the female receptacle arising from the medial line of the thallus, pale, without a rhizoidal furrow; receptacle small, convex, 1–4-lobed; involucres horizontal or diverging downward at wide angle, obovate or nearly globose, more or less laterally compressed, vertically split into 2 valves or lips; hyaline scales present on the underside and distal margins; pseudoperianth lacking; capsule sessile or nearly so, dehiscent to about the middle by 3–8 irregular valves; walls of the cells with annular or spiral thickenings; spores yellowish to reddish-brown, covered with large, dense, warty papillae; elaters with 2–4 spirals. Two species, one rather common. Named in honor of P. T. Cleve, a Swedish algologist.

Clevea hyalina (Sommerf.) Lindberg, l.c. p. 291.

Marchantia crcuiata var. *hyalina* Sommerf., Suppl. Fl. Lapp. 79; 1826.
Fimbriaria nana Lindenberg, Hep. Eur. 109; 1829.
Marchantia hyalina Sommerf., Mag. Naturvit. 2(1) : 284; 1833.

Plagiochasma erythrospermum Sull., in Austin, in Proc. Acad. Nat. Sci. Philadelphia 21 (1869): 229; 1870.
Sauteria limbata Austin, l.c., in part.
Clevea suecica Lindb., Mus. Scand. 1; 1879.
Clevea hyalina var. *californica* Howe, Mem. Torr. Bot. Club. 7: 38; 1899.

Thallus small, thick and concave, nearly round or obovate to narrowly oblong, 2–6 X 5–12 mm., simple or once forked, green above, pale whitish on the thin crenate margins; costa very thick, of many layers of cells, becoming thinner toward the upturned margins, the border finally one cell thick; ventral scales acute to slenderly acuminate, numerous, entire to crenulate on the margins, usually purplish at the base, hyaline at the tips, extending beyond the margins of the thallus forming a whitish fringe and a conspicuous apical cluster; rhizoids present, internally pegged; areolae small, slightly elevated; pores simple, surrounded by 6–7 cells, more or less stellately thickened but the radial walls often thin, walls facing the pore thick, more or less crescent-shaped, usually very distinct but sometimes pale and difficult to make out; air chambers numerous, mostly narrow and vertically elongated, the partitions one cell thick.

Dioicous. Female receptacles usually solitary, rarely in a short row, medial dorsal; stalk 5–15 mm. long, pale; disc mostly 4–lobed (sometimes 1–3), convex, becoming shrunken and rugulose when dry; involucres nearly horizontal, obovate or broadly campanulate; purplish or reddish when mature, the head 2–4 mm. across; ventral scales, hyaline and numerous, extending from between the involucres; capsule immersed, rarely slightly exserted from the involucres; spores yellowish to reddish-brown, 45–66 μ, coarsely papillose with dense, large, obovate, warty papillae; elaters brownish with 2–3 (4) spirals, 150–400 μ long, 6–15 μ wide.

On damp soil, crevices of rocks or shaded slopes, often where it dries out in the summer, in mountains above 6,000 feet elevation.

British Columbia to Alberta, southward in the high mountains to California, Utah and Colorado; Quebec, Greenland, Ellesmere Land; northern Europe.

Illustrations: Plate III, 12–20.

Collections examined: Flowers 8017. Salt Lake County, Big Cottonwood Canyon, Stairs Fork, on damp soil in quartzite crevices, 6,000 feet; 2724. above Brighton, near Lake Mary, on soil among granite boulders, 9,800 feet; 8063. Lamb's Canyon, among mosses on damp soil, limestone crevices, 7,800 feet; 845, 864, 8146. Utah County, Mount Timpaogos, above Aspen Grove, on damp soil under rocks, on damp banks and in crevices of limestone and quartzite, usually in shade or partial shade, 7,000–9,000 feet; 8157. Daggett County: Uintah Mountains, Spirit Lake, on soil among quartzite boulders at base of talus slope, 10,700 feet. S. J. Preece 10. Boxedler County, Raft River Mountains, on moist soil under Douglas fir, 9,000 feet.

Not uncommon in our mountains above 6,000 feet. The small, thick, concave thalli with whitish margins and pores bordered by cells with radial or crescent-shaped thickenings on the walls facing the openings will serve to identify sterile plants which are most frequently encountered. The plant fruits rather freely but the female stalk and receptacle shrivel and disappear soon after maturity so that one may miss them. However, older plants that have borne the female receptacle commonly leave a cavity or depression in thallus, usually near the center, from which the shrivelled stalk has broken free leaving a fringe of hyaline scales around the perimeter. *Clevea* is our only liverwort with the female stalk arising from the dorsal surface of the thallus near the center.

3. MANNIA Corda, in Opiz, Beitr. 646; 1828.

Duvalia of Nees, Mag. Gesel. Nat. Freunde Berlin 8:271, 1817;* not of Haworth, 1812.

Grimaldia of Raddi, Opusc. Sci. Bologna 2:357, 1818;* not of Schrank, Bot. Zeit. Regensb. 4:184, 1805.

Thalli perennial, small to medium in size, dichotomous, also with apical innovations, sometimes with ventral branches, usually more or less purplish, delicate to firm in texture; gemmae lacking; ventral scales in 2 rows, appendiculate; dorsal epidermis distinct, colorless or pale, 1 cell thick, with some oil cells, with thin or thick walls, often with distinct trigones; air chambers apparently in more than one layer, sparingly to closely subdivided by supplementary partitions, their margins sometimes bearing short teeth; the partitions 1 cell thick; green filaments wanting; green tissue loose to compact; pores simple, surrounded by several radiating rows of cells, the radial walls thin or more or less thick; ventral tissue sometimes with oil cells, without sclerenchymatous cells, with thin unpitted walls.

Autoicous or dioicous. Antheridia on more or less distinct sessile receptacles, or forming an irregular median dorsal group, arising in acropetal succession; the epidermal pores associated with the antheridia simple; female receptacles terminal, stalked; stalk without green tissue, with 1 rhizoid furrow; disk strongly convex above, with low coarse tubercles, slightly or not at all lobed; its pores barrel-shaped; lobes mostly 3–4; archegonia 1–4 beneath each lobe or its equivalent. Involucre membranous, not 2-lobed although sometimes less developed on the side next to the stalk, reaching to the margin of the disk; pseudoperianth wanting: seta short; foot bulbous: Capsule wall 1 cell thick in apical region, with distinct lid which remains intact in dehiscence, containing both elaters and spores; elaters with 2 or more spirals; spores tetrahedral; winged at edges, reticulate on the outer or on all faces. (From Frye & Clark, 1937.)

Appendages of the ventral scales white, forming a conspicuous apical cluster; female receptacle usually on an ordinary branch; spores and elaters yellowish-brown to brown. .... 1. *M. fragrans*

Appendages of the ventral scales mostly purple, not forming a conspicuous apical cluster; female receptacle usually on a short ventral branch; spores and elaters dark purple. .... 2. *M. californica*

1. *Mannia fragrans* (Balbis) Frye & Clark, Hep. N.A. 62; 1937.

Marchantia fragrans Balbis, Mem. Acad. Turin 7:76, pl. 2, fig. 3. 1804.
Grimaldia fragrans Corda, in Nees, Naturg. Eur. Leberm, 4:225; 1838.
Grimaldia sessilis Sull., in A. Gray, Manual, Ed. 2. 688; 1856.
Duvalia fragrans Lindb., Not. Saellsk. Fauna et Fl. Fennica 9:285; 1868.

Thalli usually aromatic when fresh, mostly 1–2 cm. long and 2–3 mm. wide, mostly dichotomously but sometimes ventrally branched, green or glaucous green in upper middle, purplish along margin, deep purple beneath; vein forming a rounded or bluntly angled keel beneath; margin undulate, strongly inrolled when dry; ventral scales deep purple, closely imbricated, lunate, with marginal appendages; appendages 1–3, subulate, mostly 450–700 μ long and 90–150 μ wide, acuminate, entire, sometimes purple but usually somewhat bleached, considerably larger in fruiting plants and forming a dense white apical cluster; dorsal epidermis distinct; its cells averaging about 14 x 17 μ, with thick walls, usually with conspicuous trigones, oil cells few, scattered; air chambers with crowded vertical

* *Duvalia* and *Grimaldia* are preoccupied by genera of flowering plants.

supplementary partitions; walls unistratose, green tissue compact; pores slightly elevated; surrounding cells radiately arranged in 6–8 rows, each of 2 or 3 cells, their radial walls more or less thick. Ventral tissue with some oil cells.

Autoicous or dioicous. Antheridial receptacle sessile, distinct, oval to broadly lunate, limiting the growth of the somewhat elongated male branch; female receptacle stalked, from a somewhat elongated branch; stalk mostly 1–1.5 cm. long, somewhat purplish, with dense clusters of long lanceolate bractlets at base and at apex; disc mostly 2–3 mm. wide, shortly 3–4 lobed. Elaters pale brown to dark brown, mostly 8–10 μ wide, usually with 2–3 spirals in the middle and 2 at the ends. Spores yellowish-brown to brown, mostly 60–70 μ; wing margins wavy, 8–10 μ wide; faces minutely and indistinctly punctate, coarsely areolate; areolae fairly regular, mostly 10–15 μ wide. Name from the aromatic odor of the fresh thallus. (From Frye and Clark: *Hepaticae of North America*). On thin soil in rock crevices in cliffs and ledges in limestone regions. Vermont southward to Alabama, westward to New Mexico and Idaho; Greenland. Europe and Asia.

Illustrations: Plate V, 9–12.

Collections examined: Flowers 8060. San Juan County, Devil's Canyon, on dry soil under overhanging sandstone ledges, 6,500 feet.

2. *Mannia californica* (Gottsche) Wheeler, Bryol. 37: 88. 1934.

Grimaldia californica Gottsche, in Underw., Bot. Gaz. 13:114. 1888.

Thalli dichotomously and ventrally branched, 2–4 mm. wide, up to 2 cm. long, green above with a purplish margin, dark reddish-purple below, thick and strongly keeled, wings ascending, strongly inrolled when dry, the plants then appearing as prostrate blackish vermiculae; dorsal epidermal cells mostly elliptic or ovoid, 16–26 x 23–33 μ, walls moderately thick with small distinct trigones, not at all bulging into the cell lumen, oil bodies lacking; air pores slightly raised, surrounded by 5–8 radial rows of cells with 2–3 cells in each row, their radial walls not conspicuously thickened; dorsal air chambers crowded with more or less vertical supplementary partitions, forming a very compact green tissue with very narrow spaces between them; cells with oil bodies rather numerous and conspicuous; ventral tissue solid, without a vein of pitted cells; ventral scales imbricated, purple, lunate to obliquely ovate, appendages single or in pairs, narrowly triangular to subulate, acuminate, 60–100 x 290–420 μ, purple, composed of larger cells than the main body of the scale, the apical ones inflexed over the apex of the thallus in a characteristic manner.

Autoicous or dioicous. Antheridial disc not formed, antheridia forming an irregular and vaguely defined medial cluster, not limiting the growth of the more or less elongated branch; archegonial receptacle borne on a short, cordate or obovate ventral branch, the stalk with one rhizoid furrow, reddish, surrounded by a few slender scales at the base, naked at the apex, 0.2–2.5 cm. long; receptacle shortly conic-convex, scarcely lobed but appearing 4-lobed by the broadly campanulate, entire involucres, 1–3 lobes commonly aborting; capsule wall dark reddish-purple, firm; elaters purple, mostly 9–15 μ wide, with 3 spirals; spores dark purple, 53–66 (75) μ, wing margins 3–4 μ wide, apical face with low irregular wrinkled ridges, scarcely forming areoles, inner faces with a triradiate ridge, minutely wrinkled, all faces finely punctate. Type locality Yosemite Falls, California.

On damp or wet soil and rocks, often soon drying out, usually under overhanging rocks where intermittent water trickles; dry hills and ledges of desert regions.

Illustrations: Plate V, 13–16.

Collections examined: Flowers 8058. Utah: Washington County, near Hurricane. On dry soil under overhanging sandstone ledges, 4,200 feet; 2728, 2729. Arizona, Mohave County, near Pipe Spring, on dry sandstone ledges where intermittent water trickles, 4,600 feet.

The present plants are very typical, according to the original description, except that the stalks of the female receptacles are very short, only 2–5 mm. long.

4. ASTERELLA Beauvois, Dict. Sci. Nat. 3:257; 1805.

Fimbriaria Nees, Horae Physicae Berol. 45; 1820.
Hypenantron Corda, in Opiz, Beitr. 648; 1829.

Plants mostly small, thallus simple or once forked, rarely twice, obovate, cordate or shortly oblong; margins entire, crenate or ruffled; innovations terminal or lateral from the costa; costa very thick at the center, the margins becoming thinner; areolae and pores distinct when moist, mostly small; dorsal surface green; ventral surface dark purplish; ventral scales violet or whitish; rhizoids both smooth and internally pegged; air chambers deep and narrow or broader with supplementary chambers, mostly with unistratose partitions; pores mostly slightly elevated, simple, bordering cells small, in radial rows, cell walls not thickened.

Monoicous. Antheridia immersed in the thallus or in slightly raised discs on the costa; archegonial stalk with one rhizoid furrow, the receptacle 3–4-lobed, flattish, hemispheric or conic, smooth to coarsely tuberculate, pores in the epidermis chimney-shaped; involucre membranaceous; pseudoperianth large and conspicuous, conic, becoming much split or cleft, the segments free or coherent; capsules 1–4, rarely more, globose, oval or obovate, slightly emergent, opening by a lid; walls one cell thick without thickenings; seta very short; spores large, mostly more than 50 μ, yellowish, brown or blackish, very rough and wrinkled with reticulate ridges; elaters with 1–4 spirals. The name, *Asterella* (Greek aster), means little star, referring to the star-like radiating rows of cells around the air pores.

Pseudoperianth white, its segments separate at maturity; dorsal air chambers not divided by supplementary partitions, mostly narrow with 1 pore to a chamber; pores only slightly raised, cells bordering the opening only slightly smaller than the adjacent epidermal cells; dorsal epidermis thin-walled; spores 60–70 μ. .... 1. *A. ludwigii*

Pseudoperianth purplish, its lobes connate at the apex; dorsal air chambers more or less divided by supplementary partitions, several chambers to a pore; pores distinctly raised, the cells bordering the opening much smaller than the adjacent epidermal cells; epidermal cells thick-walled; spores 60–90 μ. .... 2. *A. lindenbergiana*

NOTE: *Asterella tenella* (L.) Beauv. (as *Fimbriaria tenella* Nees.) was reported from the "Wahsatch mountains near Salt Lake City, 6000 feet" in King, Clarence, U.S. Geol. Expl. 40th Parallel 5: 411. 1871. This is probably *A. ludwigii*.

1. *Asterella ludwigii* (Schwaegr.) Underwood, Bot. Gaz. 20:61; 1895.

Marchantia tenella Retz., Fl. Scand. Prod. Ed. 2, 270; 1785. Not L. Sp. Pl. 1137; 1753.
Marchantia ludwigii Schwaegr., Hist. Musc. Hep. Prodr. 33; 1814.
Marchantia gracilis F. Weber, Hist. Musc. Hep. Prodr. 195; 1815.
Fimbriaria gracilis Lindb., Not. Saellsk. Fauna et Fl. Fenn. 10:282; 1868.
Fimbriaria ludwigii Limpr. in Cohn Krypto. Fl. Schlesien 1:340; 1876.
Hypenantron gracilis Trev., Mem. Istit. Lomb. 13:440; 1877.
Asterella gracilis Underw., Bot. Gaz. 20:61; 1895.
Fimbriaria macounii Steph., Bull. Herb. Boissier 7:99; 1899.

Plants small; thallus green when young, reddish-brown or purplish when old, ovate to oblong, 4–15 mm. long, 1–4 mm. wide, very thick, rather abruptly tapered to the purplish crenate or undulate margins, more or less concave, becoming incurved when dry; areolae and pores distinct; air chambers vertically elongate, deep; pores simple, only slightly raised; ventral scales purple, extending to the margins or beyond; rhizoids numerous, long.

Monoicous. Antheridia immersed in the midrib of the thallus back of the archegonial branch; archegonial stalk arising from the main thallus or a short branch, 4–15 mm. long, smooth, brown or reddish and surrounded by a few hairs at the base, receptacles conic to subglobose, 1–3 mm. in diameter, obscurely 3–4-lobed, smooth, becoming wrinkled when dry, margins thin; pseudoperianth conspicuous, much lobed, the lobes adherent or spreading, whitish; capsules slightly emergent, yellowish, opening by a lid around the middle; spores 50–70 μ in diameter, yellow to brown, very coarsely reticulate and roughened with irregular ridges; elaters with 2–4 spirals, rather short, sometimes branched.

Growing on wet or damp soil and rocks, often in crevices, in the mountains, particularly in deep cool ravines, often under rocks and around streams and waterfalls. Being monoicous it fruits quite freely. Common in our higher mountains but one may have to search for it. Greenland south to New York, westward to Alaska and California, Colorado and Missouri. Europe, Asia, Iceland, Canary Islands.

Illustrations: Plate IV, 8–13 and Figures 9 and 21.

Collections examined: Flowers 8040. Utah County, Mt. Timpanogos, on damp banks and in the crevices of rocks, 9,000 feet. 2727. Salt Lake County; Brighton, wet soil among rocks in seepage area, Lake Mary Trail. 9,700 feet.

2. *Asterella lindenbergiana* (Corda) Lindb., Musci Scand. 1. 1879.

Fimbriaria lindenbergiana Corda, in Nees, Naturg. Eur. Leberm. 4:283; 1838.
Hypenantron lindenbergiana Kuntze, Rev. Gen. 89. 1891.

Larger than the last species; thallus thinner, the midrib very thick but narrow and suddenly tapering to broader and thinner borders, green, becoming reddish or reddish-brown, simple or more often 1–2 forked, 10–30 mm. long and 6–9 mm. wide, ovate to linear-oblong, more or less flat. becoming concave when dry; areolae and pores very distinct, obscure when dry; ventral scales, red or violet-red, rounded or triangular; rhizoids numerous; air chambers with supplementary partitions, rather broad, pores raised, the bordering cells very much smaller and when viewed from the surface appear to be partially superimposed on the larger cells adjacent to them.

Monoicous. Antheridia immersed in the thallus or in a slightly raised disc, solitary or in groups in the disc, necks of the ostioles papillose; archegonial stalk arising from the costa, 1–4 cm. long more or less hairy and scaly, especially at the base and apex, reddish-brown; receptacle subglobose or conical, the surface papillose, 2–4 lobed; pseudoperianth large and conspicuous, inflated, 16-lobed, the lobes adherent at the tips, reddish-violet; capsules slightly emergent, brownish or yellowish, splitting irregularly around the middle freeing the cap; spores large, 60–90 μ in diameter, very coarsely reticulate, brownish, often irregularly papillose with branched ridges; elaters with 1–3 spirals, rather short.

On wet or damp soil, among mosses or on rocks in high mountains. Alaska southward to Oregon, Alberta to Wyoming. Mexico, South America, Europe.

Illustrations: Plate IV, 14–18.

Collections examined: Flowers 8016. Utah County, Mt. Timpanogos, damp soil and among mosses, Cirque above Aspen Grove, 9,600 feet; 8065, Salt Lake County, Brighton, damp soil among granite boulders, shady, 9,800 feet.

5. REBOULIA Raddi, Opusc. scient. di Bologna II: 357; 1818.

Thallus rather thick and coreaceous, dichotomously branched, light green; areolae indistinct; pores simple, raised; air chambers deep in the region of the midrib, occupying the entire thickness of the wings of the thallus, divided by secondary walls; ventral scales purplish, imbricated, in 2 rows, obliquely lunate with 2 linear acute appendages.

Monoicous or dioicous. Antheridia immersed in a sessile disc surrounded by a fringe of small scales, near apex of the thallus lobes; archegonia in stalked receptacles; stalk with one rhizoidal furrow, base fringed with narrow scales; receptacle conical or hemispherical, divided to the middle into 4–7 obtuse lobes; involucres arising from the ventral margin of the lobes, 2-valved, each enclosing a rather small capsule; pseudoperianth lacking; capsule subglobose; seta short; foot large; irregularly dehiscent at apex leaving a lower cup-like half; spores brown; elaters with 2–3 spirals. Named in honor of E. de Reboul, a botanist of Florence, Italy.

Reboulia hemispherica (L.) Raddi, Opusc. Sci. Bologna 2: 357; 1818

Marchantia hemispherica L., Sp. Pl. 1138; 1753.
Marchantia crinata Michx., Fl. Bor. Amer. 2: 267; 1803.
Asterella hemispherica Beauv., Dict. Sci. Nat. 3: 257; 1805.
and many other synonyms.

Thallus 1–3 cm. long, 4–7 mm. wide, mostly dichotomously branched, sometimes ventrally branched from the midrib, green above with a crenulate and undulate purplish border, very dark purplish or reddish-purple below; midrib broadly convex to thick and bluntly keeled, the wings usually upturned, but sometimes strongly incurved when dry, the plants then appearing as prostrate blackish vermiculae; ventral scales mainly lunate to broadly ovate, closely imbricated, reddish-purple; margins irregularly dentate, with 2–3 widely-spaced appendages, these mostly abruptly linear-subulate to linear-lanceolate, a few acuminate at the base, entire, purple, not forming a dense apical cluster, mostly 0.45–0.8 (1) mm. long; dorsal epidermis distinct, cells isodiametric, 20–34 μ in diameter, to elongated, 20–34 x 23–50 (60) μ, rather thick-walled with distinct trigones, these often bulging into the cell lumen; air chambers much divided by unistratose supplementary partitions, in cross section, in the median region, appearing more or less isodiametric, becoming obliquely and horizontally elongated in the wings, all longitudinally elongated; cells of the partitions bulbous and swollen, green and forming a spongy network, a few with oil bodies; ventral tissue compact, cells smaller, with a vein composed of elongated cells having purplish pitted walls and denser contents, the color often fading in some plants, oil bodies frequent to nearly lacking; air pores slightly raised, surrounded by 6–8 radial rows of cells, each row composed of 2–3 (4) cells with more or less heavily thickened radial walls.

Autoicous, monoicous or dioicous. Antheridial receptacle sessile to half sunken in the thallus, sometimes more or less sunken in a broad pit, ovate to lunate, reddish-purple, surrounded by short purplish bracteoles in a single row; ostioles protruding; air pores simple; archegonial receptacle stalked, borne immediately anterior to the antheridial receptacle or on a separate branch; stalk 2–3 cm. long, purplish, with 1 rhizoid furrow, with a cluster of linear or hair-like, hyaline or faintly tinted bractlets at the base and apex, 2–3 cells wide at the base, those at the apex long, projecting from between and beyond the lobes of the receptacle; receptacle widely conic, apex rounded, mostly 4-lobed, 2–2.5 mm. in diameter, 2–3 mm. high, strongly tuberculate and coarsely wrinkled when dry; involucres rather enlongated, divergent to more or less vertical, bilabiate, sometimes only split on the side toward the stalk; capsule globose, equaling or slightly exceeding the involucre when mature, mouth erose-dentate after dehiscence; elaters brown, mostly 10.3 μ wide and up to 100 μ long, with 3 spirals in the middle and 2 on the ends; spores yellowish-brown to brown, 66–73 μ in diameter with wings about 10 μ wide, forming coarse, irregular reticulate ridges enclosing areoles 16–33 μ across, surface finely punctate.

On damp soil and rocks. Infrequent in Utah. World wide in distribution.

Illustrations: Plate V, 1–8.

Collection examined: Flowers 2725. San Juan County, Cottonwood Creek near Bluff, on damp sand under shrubs, 4,500 feet.

The single collection is a little unusual in several respects. In the dry condition the wings of the thallus become rather strongly incurved giving the plant the appearance of prostrate blackish vermicules after the fashion of *Targionia* and *Mannia*. Ordinarily the wings are only upturned, leaving much of the green surface exposed. The involucres are not as strongly bilabiate as in typical plants.

6. CONOCEPHALUM Wiggers, Prim. Fl. Hols. 82; 1780.

Fegatella Raddi, Opusc. Scientif. di Bologna 2: 356; 1818.

Thallus large, 10–25 cm. long, 8–12 mm. wide, bright green, becoming brownish, oblong to linear, dichotomously branched, emarginate at the apex of the lobes, margins thin and undulate, slightly channelled down the midrib; dorsal surface with large conspicuous areolae, mostly hexagonal and forming a regular net-like configuration, each areola with a conspicuous raised simple pore surrounded by 5–6 concentric rings of small narrow cells, each ring composed of 6–7 cells; ventral surface green with a thick and rather narrow midrib; scales in 2 rows, distantly imbricated pale or brownish with violet orbicular or reniform appendages; in cross section the midrib composed of small cells abruptly becoming enlarged toward the thin wings, the margin finally 2-cells thick; air chambers broad, forming a shallow dorsal stratum; photosynthetic filaments in younger portion of the thallus composed of large inflated basal cells forming the floor of the chamber, each with a long slender colorless beak or, cell, in older portion, cells in chains, 2–5 cells long; gemmae and cupules lacking.

Dioicous. Antheridia immersed in a sessile disc at the apex of a branch, disc slightly raised, papillose on the surface, surrounded by a thin outgrowth of the thallus, and terminating its growth; archegonia borne on stalked conical receptacles; stalk with one rhizoid furrow, receptacle 5–8 furrowed toward margins and bearing 5–8 tubular involucres each bearing one capsule; pseudoperianth lacking; capsule becoming exserted on a rather long seta, obovate to pyriform, dehiscent by a small cap and the lower portion splitting into 4–8, recurved valves; spores large, many-celled, coarsely papillose; often germinating while still in the capsule; elaters with 2–4 spirals, rather short and blunt. One species only. *Cono-*

cephalum comes from the Greek, *konos,* a cone, and *kephale,* a head; referring to the conical female receptacle.

Conocephalum conicum (L.) Wiggers, l.c. 1780.
Marchantia conica L., Sp. Pl. 1138; 1753.
Conocephalum trioicum Weber in Wiggers, Prim. Fl. Holsat. 82; 1780.
Fegatella officinalis Raddi, Opusc. Sci. Bologna 2: 356; 1818.
Fegatella conica Corda in Opiz, Beitr. 649; 1829.

With characters of the genus. Our largest liverwort.

Common on damp soil, rocks, humus and rotten logs, usually in cool shaded places along streams and in woods. Mostly found in our canyons and mountains but rarely fruiting in our region. It probably occurs in every county of Utah. Throughout the United States and northward; Europe, Asia, Africa, Azores and Canary Islands.

Illustrations: Plate VI, 1–7 and Figure 22.

Collections examined: Flowers 8041, 8053. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, Mill D Fork and at the Spruces, on damp humus and soil, brook banks, 6,700 feet; 8173. Utah County, Mt. Timpanogos, Aspen Grove, damp soil, shady woods, 6,700 feet; 8086. Summit County, Uintah Mountains, Black's Fork, on damp banks along stream, 9,200 feet; 8165, 8166, 8096A. Grand County, La Sal Mountains, Oowah Lake, on wet humus and among mosses, 8,880 feet; 8172. Garfield County, ca. 20 miles northwest of Escalante, on wet stream banks, 9,500 feet.

The large, thin, bright green thallus with conspicuous areolae and air pores makes this liverwort easy to identify in the field.

7. LUNULARIA Adans., Fam. Pl. 2: 15; 1763.

Thallus rather large, 1–3 cm. long, 6–12 mm. wide, more or less irregularly dichotomously branched, obcordate to oblong, emarginate at the apex, the margins undulate, light or dark green; dorsal surface with small but distinct areolae and slightly raised, simple pores; dorsal epidermal cells irregularly 5–6-sided, mostly hexagonal, usually thickened at the angles; pores composed of 4–5 concentric rings of narrow cells, each ring with 6 cells; ventral surface green with 2 rows of scales; rhizoids numerous; midrib not conspicuous, gradually narrowed toward the margins, becoming 1-cell thick, 3–4 cells wide; air chambers rather large forming a shallow dorsal stratum; photosynthetic filaments short and branched, of 2–3 cells; gemmae cups lunate, the open side forward, nearly always present.

Dioicous: Antheridia immersed in a sessile disc at the apex of a branch; archegonia on a stalked receptacle bearing 4 narrow, horizontal, tubular involucres, cruciate, each with one capsule; pseudoperianth lacking. Only one species. The name comes from the Latin, *lunularis,* a little moon; referring to the crescent-shaped gemmae cups.

Lunularia cruciata (L.) Dumort., Comm. Bot. 116; 1822.
Marchantia cruciata L., Sp. Pl. 1137; 1753.

With characters of the genus.

This plant is easily identified by its lunate gemmae cups and is found almost exclusively in greenhouses or near them in North America. It is almost always sterile having been found fruiting only in the vicinity of San Diego, California. It is rare in Utah but has been observed in three different greenhouses. Maine to West Virginia westward to Washington and California, West Indies, South America, Europe, Asia, Africa and Australia.

Illustrations: Plate VI, 8–13.

Collection examined: Flowers 8042. Salt Lake City, on soil in greenhouse, 4,400 feet.

8. PREISSIA Corda in Opiz, Beitr. I, 647; 1829.

Chomiocarpon Corda in Opiz, Beitr. 647; 1829.

Thallus prostrate, bright green above, purplish below, rather small, 2–3 cm. long, 0.5–1 cm. wide; fertile plants mostly simple, usually forming cordate, cuneate or elongated apical innovations; sterile plants often 2–3 dichotomous, often forming thick mats; margins more or less crenate and lobed; costa strong and prominent, many layers of cells thick, gradually becoming thinner toward the margins, border finally 1-cell thick, 4–6 cells wide; areolae rather indistinct, except under lens; pores distinct and barrel-shaped, composed of 4–5 superimposed rings of cells, the two upper rings circular, of 4–6 cells, the lower inner ring of large cells with walls projecting inward in the pore tube forming a cruciate opening; air chambers in a single dorsal layer, walls uniseriate, filled with simple or branched photosynthetic filaments; upper 3–4 layers of cells of the costa chlorophyllose, the under layers with starch grains and oil droplets, the lower medial line with brown, thick-walled fibers with tapering ends; lower cells often with a mycorrhizal fungus forming a compact layer; ventral scales in two rows, purplish, more or less rounded with triangular appendages fringed with projecting cells; rhizoids smooth or internally pegged, numerous.

Dioicous. Antheridial stalk short, 1–2 cm. long, with 2–4 rhizoid furrows; receptacle 2–3 mm. across, purplish, convex on upper surface, pores barrel-shaped; margins slightly or not at all lobed; antheridia in 3–6 radiating rows, ostioles raised; ventral side with paraphysial scales; archegonial stalk long, 3–10 cm. long, with 2–4 rhizoid furrows; receptacle 3–5 mm. wide, often purplish, convex to hemispherical, 3–5-lobed with conspicuous alternating ridged rays; archegonia in groups under each ray, surrounded by a membranaceous involucre with subentire margins; pseudoperianth present, inflated, hyaline and membranaceous, surrounding a single capsule; capsule with a distinct seta when mature, subglobose, wall 1 cell thick, except at the apex; cell walls with annular thickenings; dehiscence by several irregular valves, the thickened apical portion breaking up; spores tetrahedral with large lamellated ridges and a narrow winglike margin, brown, 60–70 μ; elaters long and slender, with 2–3 spirals. Named in honor of Prof. Balthasar Preiss, a physician of Praha, Czechoslovakia. One species only.

Preissia quadrata (Scop.) Nees, Eur. Leb. IV, 135; 1838.

Marchantia quadrata Scop., Fl. Carnolica Ed. II, 355; 1772.

With characters of the genus. Growing on wet or damp soil, and rocks, on stream banks or along rivulets, usually shaded places or in open areas in cool ravines in the mountains.

Apparently not common in Utah. It has been collected at Alta in the Wasatch Mountains and on the banks of streams in the Uintah Mountains. Greenland to Alaska, southward to Virginia, Iowa and Utah. Mexico, Europe and Asia.

Illustrations: Plate VII, 1–8.

Collections examined: Flowers 8032. Salt Lake County, Wasatch Mountains, Alta, on wet soil in shade, brook bank, 8,600 feet; 8052. Summit County, Uintah Mountains, Stillwater Fork of the Bear River, on wet stream bank, 9,000 feet; 8082, 8083. Summit County, Black's Fork, on wet stream banks, 9,100–9,300 feet.

9. MARCHANTIA L. Sp. Pl. 1137; 1753.

Plants solitary or forming dense mats; large and dichotomously branched several times, green, becoming brown with age; areolae more or less rhombic or hexagonal and distinct on dorsal surface; pores barrel-shaped, rather indistinct to naked eye; costa rather broad, ventral surface with scales and rhizoids; air chambers forming a distinct stratum on the dorsal side; photosynthetic filament dense, of 2–6 cells; gemmae cups arising from the dorsal surface of the costa.

Dioicous. Antheridia immersed in disc-shaped stalked receptacles; in radiating rows alternating with the lobes; disc crenate on the margins; ostioles of the antheridial chambers elevated, lower surface with scales; stalk with 2–3 rhizoid furrows; archegonia on stalked, stellate receptacles, in rows on the underside and alternating with the curved or spreading rays; involucres membranaceous, cleft and radially elongated, 2-valved; pseudoperianth cleft; capsules with short setae, emergent or slightly exserted from the involucre, dehiscent by several valves; spores mostly smooth, brownish; elaters long and slender, with 1–4 spirals. 67 species mostly tropical or subtropical. Only one is found in Utah. *M. domingensis* extends from the West Indies to the southern gulf states. Named in honor of Nicolas Marchant, director of the botanical garden of Gaston d'Orleans in Blois, France.

Marchantia polymorpha L. l.c.

Plants large and prostrate, 2–15 cm. long and 7–22 mm. wide, dark or bright green, flat or slightly concave, oblong to sublinear, margins undulate-lobed, apex emarginate; midrib broad, darker in middle; ventral surface brownish, smooth and internally pegged rhizoids numerous; scales in 3 rows on each side of the midrib; in cross section midrib not distinct, gradually tapering to the wings, margin finally 1-cell thick and 3–8 cells wide; air chambers usually shallow; pores of 4 superimposed rings of cells, each ring of 4 cells, 2 rings above the surface of the thallus and 1 ring below the surface and in the air chamber, cells of the latter with protruding walls forming a cruciate pore opening; gemmae cups sessile, margins erect or later ascending, erose or ciliate dentate; gemmae discoid with 2 opposite notches.

Dioicous. Antheridial stalk 1–2 cm. long, with 2 rhizoid furrows, green, becoming tinged with red; receptacle discoid, flat or convex above, 6–10 mm. across, crenate or 8-lobed; archegonial stalk 2.5 cm. long, with 2 rhizoid furrows; receptacle stellately branched, rays 5–9, finger-like, curved downward when young, more spreading with age, capsules ovoid to pyriform, the wall 1 cell thick, cell walls with annular thickenings; spores yellowish-brown, smooth, 12–15 μ; elaters long and slender, with 2 spirals, 3–5 μ wide.

Common on wet or damp soil, humus and rocks, both in lowlands and mountains, occasionally growing in water whence it becomes much elongated and the branches more distant. It probably occurs in every county in Utah as our commonest liverwort. Nearly world wide in distribution.

Illustrations: Plate VII, 9–19 and Figures 2, 5, 10 and 23.

Specimens examined: Flowers 8029. Salt Lake County, Big Cottonwood Canyon, submerged in slow rivulet, shade, 6,500 feet; 8054. At the Spruces, on wet soil in seepage area, 7,200 feet; 8069. Lamb's Canyon, Wasatch Mountains, on damp soil, shady limestone crevices, 7,800 feet; 8061. Grand County, La Sal Mountains, near Warner Ranger Station, on wet banks of rivulet, 9,700 feet; 8061. Oowah Lake, wet brook banks, shade, 8,100 feet; 8071. San Juan County, Abajo Mountains, Johnson Creek, on wet sandy stream bank, exposed to sun, 8,700 feet; 8050. Washington County, Zion Canyon, Emerald Pool, on wet sand, 5,500 feet. B. F. Harrison 9151. Garfield County, east of Escalante, Calf Creek Falls, wet sand at foot of dripping cliff, 5,300 feet. S. J. Preece 37. Boxelder County, Raft River Mountains, George Creek, on mud by spring, 6,700 feet.

Order II. **Jungermanniales**

Gametophytes thalloid or composed of stems and leaves with a few intermediate forms. Thalloid types either a solid, fleshy body without air chambers or unistratose; in either form with or without a costa, air pores lacking, sex organs borne singly or in clusters on the dorsal side, never on stalked receptacles. In the leafy forms the leaves are alternate in 2 opposite rows, sometimes with a third ventral row of underleaves, without a costa, unistratose; sex organs terminal or axillary in leaves.

Sporophyte mostly solitary with a large foot and short to long seta; capsule with wall 1–several cells thick, bearing spores and elaters, columella lacking, opening by 4 valves.

Key to the Families

Plants mostly thalloid (a few leafy); sporophytes arising from the dorsal side of thallus, not terminal; sex organs not terminal; involucre not formed by leaves; seta long; capsules with elaterophores.....1. METZGERIACEAE

Plants composed of stems and leaves, the leaves in 2 opposite rows, some genera with a third ventral row; sporophyte terminal; archegonium arising from the apical cell of a stem or branch; involucre of true leaves; seta short to long; capsules without elaterophores....2. JUNGERMANNIACAE

Family 1. METZGERIACEAE SPRUCE

Gametophyte mostly thallose, rarely composed of stem and leaves; the thallus solid without air chambers, or unistratose with a distinct midrib; archegonium arising from a cell back of the apical cell on the dorsal side; sporophyte dorsal, often appearing terminal; involucre not composed of true leaves. Capsule wall of two layers of cells, sometimes one layer by the reabsorption of the inner one; elaters present.

Key to the Genera

Plants with stem and succubous leaves in 2 opposite rows; sporophyte from the dorsal side of the stem below the apex. ....6. Fossombronia

Plants without stem or leaves; thallus entire or lobed.

Thallus with hairs on the margins and midrib..............................3. Metzgeria

Thallus without hairs on the margins or midribs.

Thallus more or less regularly lobed, with distinct dark spots within the tissue at the bases of the lobes; ventral surface with ovate, toothed scales; gemmae of 2 kinds: stellate scales borne on the dorsal side of the thallus near the apex, and multicellular globose to ovate, stalked bodies within long necked, flask-shaped receptacles borne on the midrib. ....5. Blasia

Thallus entire to irregularly lobed, without dark spots within the tissue; scales on the ventral side lacking; gemmae, when present, of one kind, none as above.

Midrib distinct, thick, with a central strand of very small thick-walled cells; wings unistratose. ....4. PALLAVICINIA

Midrib lacking or when present indistinct and without a central strand; wings multistratose except at the margins of some species.

Thallus 10–16 cells thick in the middle, in cross section the cells show thickenings on the vertical walls in our species; elators with 2–4 spirals; spores 56–100 μ, multicellular............2. PELLIA

Thallus 3–12 cells thick in the middle, without vertical thickenings on the walls; elaters with one spiral; spores 10–24 μ, unicellular. ....1. RICCARDIA

1. RICCARDIA S. F. Gray, Nat. Arr. Brit. Pl. 1, 683; 1821

Aneura Dumort., Comm. Bot. 115; 1822.

Plants thalloid, fleshy, pinnate, palmate or subdichotomous, mid portion 5–13 cells thick, middle cells larger than those near the surface, neither the midrib nor wings sharply differentiated, margins rather thick, rhizoids few.

Monoicous or dioicous. Sex organs borne on short lateral branches; female branch with thin laciniate margins, appearing ventral by growth of the main axis; archegonia 2–8 on the margin; antheridia spherical, borne in sunken cavities in 2 rows on the margins of short oblong or lobed branches; calyptra papillose, large and conspicuous, cylindrical or clavate; involucre inconspicuous; pseudoperianth lacking; seta long, fleshy, often becoming soft and flaccid when old; capsule oblong to cylindrical, dark brown, opening by 4 spreading valves; walls 2 cells thick with seminannuar thickening, reddish-brown; elaterophores apical, slenderly tapered and splitting at dehiscence of the capsule, the tip of each valve bearing a segment; elaters with one broad, reddish-brown spiral; spores small; gemmae 2-celled formed within a superficial cell and escaping by pore, often present at the tips of the stems and branches.

Thallus 3–10 mm. wide, lustrous with a greasy appearance, irregularly branched, 10–13 cells thick at the center. ....1. *R. pinguis*
Thallus much smaller and more slender, 1–2 mm. wide, pinnately to palmately branched, not lustrous, 5–6 cells thick at the center. ....2. *R. latifrons*

1. *Riccardia pinguis* (L.) S. F. Gray, Nat. Arr. Brit. Pl. 1, 683; 1821.

Jungermannia pinguis L., Sp. Pl. 1: 1136; 1753.
Aneura pinguis (L.) Dum., Comm. Bot. 115; 1822.

Plants dark green and lustrous, 2–3 cm. long, 2–10 mm. wide, subsimple to irregularly branched, not pinnate, some branches often very slender, fleshy and rather brittle, margins slightly ascending, undulate-crisped or nearly flat, apex rounded; midrib weakly differentiated, the thallus merely thicker along the median line and gradually decreasing in thickness toward the rounded margins, 10–13 cells thick; rhizoids few or lacking in aquatic forms.

Dioicous. Antheridia in 2–3 rows, immersed along the margins of short oblong or lobed branches; archegonia marginal on short branches arising from sinuses of the main thallus; calyptra cylindrical or clavate, scaly from base to apex, 6–10 mm. long; seta green and fleshy, turgid at maturity becoming weak and flaccid with age, 6–10 mm. long; capsule oblong, dark brown with ripe spores, about 2 mm. long; valves elongate-elliptical, bright reddish brown, the tip of each one with an erect or deflexed segment of the elaterophore; walls 2 cells thick, the outer layer with nodular thickenings, the inner layer with conspicuous seminannular thickenings; elaters with 1–spiral; spores reddish brown 19–23 μ, finely papillose.

Growing on damp or wet soil, humus or rotten logs and branches, sometimes floating in water. World wide in distribution.

Illustrations: Plate VIII, 1–8.

Collections examined: Flowers 8005. Juab County, Deep Creek Mountains, Birch Creek, floating and submerged in large spring, 5,000 feet; 8176. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, on steep seepage bank, 7000 feet; 8028. Salt Lake County, Wasatch Mountains, City Creek Canyon, North Fork, on wet muddy soil, deep shade, 6,100 feet; 8175. Salt Lake County, Holladay, on wet rocks above swift stream, 4,550 feet; 8132. Rich County, Bear Lake, Lakota, seepage area along lake shore among willows, 6,000 feet; 8098. Daggett County, Uintah Mountains, Spirit Lake, submerged in brooklet, 10,700 feet; 8095, 8162. Grand County, La Sal Mountains, Oowah Lake, wet humus among mosses, brook bank 8,900 feet. B. F. Harrison 9152. Garfield County, east of Escalante, Calf Creek Falls, on wet sand at foot of dripping cliff, 5,300 feet.

2. *Riccardia latifrons* Lindb., Not. pro Fauna et Fl. Fennica 13: 372; 1874.

Aneura latifrons Lindb., Bot. Notis, 62; 1873.

Thallus small, solitary or forming thin mats, light or dark green, becoming blackish-green when dry, fleshy but rather thin and translucent, mostly pinnately branched, often regularly so, linear, the branches oblong to linear, 2–10 mm. long, 0.8–1.5 mm. wide, margins plain to undulate, apex emarginate; midrib not differentiated, slightly concave above, convex below, in cross section 4–6 cells thick in the middle, the margins 1 cell thick and 1 cell wide; gemmae oval, borne at the tips of the branches.

Monoicous. Antheridial branch narrowed at the base and united with the base of the archegonial branch, margins erect and laciniate; antheridia in 3–5 pairs; archegonial branch short, with numerous 1-celled lacinae; calyptra shortly clavate, rough at the apex, 2.5–3.5 mm. long; seta 4–10 mm. long, firm and green, becoming weak and flaccid with age; capsules oval to shortly oblong; inner walls with semi-annular thickenings, reddish-brown; elaters 1-spiral, reddish-brown; spores yellowish brown 10–16 μ, very finely papillose.

Growing on wet or damp soil, rocks or rotten wood, frequently among mosses. Not abundant in Utah but frequently found among mosses, usually solitary or a few thalli clumped together. City Creek Canyon, Big Cottonwood and Bells Canyon. Virginia westward to California and northward. Europe and Asia.

Illustrations: Plate VIII, 9–16 and Figure 24.

Collection examined: Flowers 8076. Salt Lake County, Bell's Canyon, on wet humus in shade, 4,900 feet.

The small size and pinnate branching easily distinguish it in the sterile condition.

2. Pellia Raddi, Mem. Soc. Ital. Mod. 18: 38; 1818.

Scopulina Dumort., Comm. Bot. 115, 1822.

Plants solitary or in thick masses; thallus thin or rather fleshy, flaccid, bright green, becoming dark green, brown or blackish when dry or old, simple to irregularly dichotomous; midrib broad and indistinct; wings thin and up-turned, undulate to lobed; ventral scales lacking but rhizoids numerous; in cross section tissues solid, middle cells larger than the epidermis, midrib up to 15 cells thick, in longitudinal or oblique section showing vertical band-like thickenings (in our species); wings tapering to 1-cell thick; gemmae lacking.

Paroicous or dioicous. Antheridia immersed in the dorsal surface of the midrib usually solitary; archegonia in groups of 4–12 borne in a pocket-like cavity on the dorsal side of the midrib and covered by a scale-like involucre opening forward or in a tubular involucre; calyptra immersed or exserted; capsule on a long fleshy seta, spherical, the walls 2 or more cells thick, opening by 4 valves; elaterophore basal; elaters with 2–3 spirals; spores very large and multicellular. The name honors Leopoldo Pelli-Fabbroni, a Florentine lawyer and a friend of Raddi.

In the two species treated here the thallus shows vertical band-like thickening which will serve to distinguish them in sterile condition from species of *Riccardia*. The species are difficult to distinguish without involucres.

Thallus mostly short and broad, obovate to oblong, simple or dichotomous, lobed, 10–15 mm. wide, dark green; involucre scale-like, open toward the apex of the thallus, margin often incised but not crisped; monoicous..1. *P. epiphylla*

Thallus mostly elongated, cuneate, or spatulate, narrower and mostly simple, 3–7 mm. wide, dark green, often tinged with dark red; involucre tubular, low or split on the side toward the apex, margin entire to lobulate, usually more or less crisped, often strongly so; dioicous..........................2. *P. neesiana*

1. *Pellia epiphylla* (L.) Corda in Opiz. Beit. 654; 1829.

Jungermannia epiphylla L. Sp. Pl. Ed. 1, 1135; 1753.
Scopulina epiphylla Dumort., Comm. Bot. 155; 1822.
Blasia epiphylla Fries, Stirp. Fremson. 31; 1825.
Gymnomitrion epiphyllon Heuben., Hep. Germ. 42; 1834.
Marsilia epiphylla Lindb., Musc. Scand. 10; 1879.

Thalli solitary or in mats, prostrate, bright or dark green, occasionally tinged with red on the midrib, blackish-green when dry; branches few, dichotomous, obovate, cuneate or shortly oblong, the posterior end often narrow, 1–7 cm. long, 10–15 mm., wide, expanded, with upturned wings, cordate at the apex, flat to undulate on the margins; midrib convex, rather broad, in cross section 11–15 cells thick; cells with numerous oil bodies, the walls with thick, violet-red vertically interlacing thickenings, these appearing, in longitudinal section as vertical band-like thickenings.

Monoicous. Antheridia sunken in the midrib, in groups back of the archegonia; ostioles of the antheridial cavities papillose, reddish and quite conspicuous; archegonia in a pocket-like cavity covered by a scale-like flap forming a one-sided involucre, open at the forward side, the margins usually incised; calyptra exserted, cylindrical or urn-shaped, swollen above, roughened and reddish; seta hyaline, short or up to 5 cm. long, delicate and fleshy; capsule globose, dark olivaceous or blackish-green; elaterophores numerous, with 2–4 spirals, 15–25 μ thick, forming a bushy basal cluster; elaters very long and slender, contorted, about 8 μ wide, mostly with 2 yellowish spirals; spores multicellular, oblong-oval, 75–100 μ long, yellowish-green.

On wet soil and humus, often among mosses, usually in shady places.

Widely distributed in the United States and Canada; Alaska, Europe and Asia.

Illustrations: Plate VIII, 17–22 and Figures 7, 12, 13 and 25.

Collections examined: Flowers 2005, 2011, 2132. Duchesne County, Uintah Mountains, near Bald Mountain, wet brook banks, shade, 10,400 feet. B. F. Harrison 10,757. Summit County, Uintah Mountains, half way between Star Lake and Notch Peak, moist soil on bank of small stream, border of montane forest, 10,500 feet.

2. *Pellia neesiana* (Gottsche) Limpr. in Cohn, Krypt. Fl. Schles. 1: 329; 1876.

Pellia epiphylla forma *neesiana* Gottsche, Hedwigia 6:69; 1867.
Marsilia neesii Lindb., Musc. Scand. 10; 1879.
Pellia neesii Limpr. in Kaalaas, Leverm. Norge 456; 1893.

Thalli solitary or in mats, prostrate, dark green, tinged with red on the midrib, blackish-green when dry; branches few, dichotomous, obovate, cuneate or oblong, 5–17 mm. long, 3–10 mm. wide, more or less expanded with upturned wings; margins flat to undulate, midrib 10–12 cells thick in cross section, with interlacing band-like thickenings in the cells, appearing in longitudinal section as vertical band-like thickenings; rhizoids numerous, pale brownish.

Dioicous. Male plants often growing in patches among the females; antheridia sunken in the midrib; ostioles of the antheridial cavities slightly raised, appearing as darker spots; female plants often growing by themselves, hence rarely fruiting; archegonia borne in a slight depression in the midrib, surrounded by a shortly cylindrical involucre with the anterior side shorter or split to the base, more or less plicate; margins entire, crenulate or lobulate, often crisped; calyptra usually exserted, rough, often swollen at the apex; seta hyaline, short or up to 4 cm. long, delicate; capsule globose, pale brown, cleft nearly to the base into 4 ovate valves; elaterophores numerous, forming a globose or shortly cylindrical basal, bushy cluster, spirals 2–4, 15–25 μ wide; elaters very long and slender, with 2 spirals, yellowish, 9–12 μ wide; spores multicellular, 2–3 cells wide, 4–5 cells long, 50–62 μ wide, 85–105 μ long.

On damp or wet soil and humus, often among mosses, usually in shaded places.

Widely distributed in the northern part of the United States and adjacent Canada; Alaska, Europe and Asia.

Illustrations: Plate VIII, 23–25.

Collections examined: Flowers 8081. Summit County, Uintah Mountains, Henry's Fork, on moist soil among mosses, 8,900 feet; 8089, 8089A, 8126. Black's Fork, on wet soil under rotten log, stream side among grass and on damp shaded banks, 9,200–9,300 feet; 8144. Salt Lake County, Wasatch Mountains, on wet soil and humus among mosses, Lake Mary trail above Brighton, ca. 9,100 feet.

Without the reproductive organs it is practically impossible to identify species of *Pellia*. I have numerous specimens from the Uintah Mountains without means of definitely identifying them and although some of them reach the maximum size of *Pellia epiphylla* they still remain on the doubtful list. The present plant is locally abundant, often forming extensive mats on wet soil and on banks. It also occurs solitary or scattered among mosses in many localities in the Uintah Mountains.

3. METZGERIA Raddi, Mem. Soc. Ital. Sci. Modena 18:45; 1818.

Jungermannia L., Sp. Pl., Ed. 1. 1136; 1753 (in part).
Rhizophyllum Beauv., Fl. d'Ow. Ben. 1:21; 1804 (in part)

Papa S. F. Gray, Nat. Arr. Brit. Pl. 1:679; 1821.
Hervera S. F. Gray, Nat. Arr. Brit. Pl. 1:685; 1821.
Fasciola Dumort., Comm. Bot. 114; 1822.
Echinogyna Dumort., Sylloge Jung. Eur. 83; 1831.
Echinomitrium Corda, in Sturm, Deutschl. Fl. 2:77; 1832.

Plants mostly small, thallus more or less linear, subsimple, irregularly or dichotomously branched, often with ventral branches arising from the midrib, wings of the lamina unistratose; midrib narrow and distinct, several cells thick; cells forming the epidermis large, the inner ones small; rhizoids ventral few or lacking; margins of the thallus and the ventral side of the costa bearing straight or hooked one-celled hairs (in some species one or both surfaces of the wings also bear hairs). Gemmae multicellular, arising from a single cell on the margins or dorsal surface of the lamina.

Antheridia in two rows in acropetal succession on the dorsal (inner) surface of very small male branches borne on the ventral side of the main midrib and rolled up like a little ball, with a distinct midrib but no hairs; archegonia on similar special branches that lack a midrib and are hairy on the outside; calyptra large, more or less shortly clavate and hairy on the outside; pseudoperianth lacking; seta short; capsule oval to oblong, opening by four valves, the walls two layers thick; the outer cells with nodular thickenings, the inner ones with semiannular thickenings, elaterophore segments persistent on the tips of the valves forming tufts; elaters with one spiral, spores globose, finely papillose. Named in honor of Johannes Metzger, an engraver in the town of Staufen, in Baden, Germany, a friend of Raddi.

A large family of 70 or more species of which we have only one representative.

Metzgeria furcata (L.) Dumort., Rec. d'obs. 26: 1835.

Jungermannia furcata L., Sp. Pl., Ed. 1. 1136; 1753, in part.

Plants in pale or yellowish green mats, sometimes solitary; thallus linear, 0.5–2.5 cm. long, 0.5–1 mm. wide, irregularly or dichotomously branched; the branches usually short, flat or somewhat convex; the margins slightly recurved and slightly undulate; costa 2 cells wide above, 4 cells wide below and more convex on lower side; wings naked above, with scattered hairs below, on the margins and costa, hairs straight or slightly curved, single, often short, sometimes ending in short, palmately branched tips; cells mostly hexagonal, 25–40 μ, walls thin, the angles slightly thickened.

Dioicous. "Calyptra narrowly pyriform with rather numerous hairs; pedicel of capsule 1.5–2.5 mm. long; capsule oval-globose, reddish-brown; spores 21–28 μ, granular-papillate, appearing finely punctate, greenish-yellow to brownish-yellow; elaters 5–7 μ broad, the spiral pale reddish-brown." After MacVicar.

On wet or damp soil, humus or rock, often among mosses; nearly world wide in distribution.

Illustrations: Plate IX, 1–3.

Specimen examined: Flowers. 8177. Salt Lake County, Bell's Canyon at mouth, on base of tree in damp seepage area, shade, 5,000 feet.

Several scattered thalli were found mixed with mosses.

4. PALLAVICINIA S. F. Gray, Nat. Arr. Brit. Pl. 1, 775; 1821.

Thallus prostrate and creeping throughout or with a cylindrical prostrate base and an erect or ascending winged, fan-like apical portion; simple or branched by ventral innovations from the midrib; midrib distinct, thick, with a central strand of very small, thick-walled, elongated cells; wings 1-cell thick; margins entire, sometimes lobed or with incipient leaf-like lobes; underleaves lacking, rhizoids present on the midrib.

Dioicous. Antheridia on short stalks, solitary in 2 rows on the dorsal side of the midrib toward the anterior end, surrounded by imbricated, dentate or laciniate scales; archegonia in clusters surrounded by an involucre variously cleft and laciniate, often with small scales; pseudoperianth present, becoming very large and cylindrical in fruit; calyptra large, fleshy and cylindrical; sporophyte with a long fleshy seta; capsule cylindrical; the wall of 2 layers of cells, without semiannular thickenings, incompletely dehiscent by 2–4 valves which often cohere at the apex; elaterophore lacking; elaters with 2–3 spirals. Named in honor of L. Pallavicini, an archbishop of Genoa, Italy. About 30 species, most of which are exotic and rare. Our single species is cosmopolitan.

Pallavicinia lyellii (Hook). S. F. Gray l. c. 775; 1821.

Jungermannia lyellii Hook., Brit. Jung. pl. 77; 1816.

Plants solitary or forming mats; thallus pale green obovate to oblong or shortly linear 1–4 cm. long, 2–4 mm. wide, simple or with branches arising from the ventral side of the costa; young plants and branches often very narrow; midrib 10–15 cells thick, rather broad, flat above, convex below, abruptly tapering to the unistratose wings; central strand of small, thick-walled cells, usually darker in color; median cells of the lamina hexagonal or pentagonal, elongated, 23–40 x 34–85 μ, becoming shorter at the margin, more or less isodiametric; rhizoids pale brownish, numerous on the older portions of the midrib.

Dioicous. Male plants smaller than the female plants; antheridial scales mostly imbricated, broadly ovate to rounded, margins shortly laciniate; antheridia solitary within a cluster of scales, forming a regular row on each side of the midrib; archegonial clusters solitary or few in a row on the midrib; involucre a cup-like scale, variously cleft or incised and laciniate; pseudoperianth becoming large and cylindrical in fruit, 5–7 mm. long; calyptra large, fleshy and cylindrical, slightly exceeding the pseudoperianth; seta 2.5–4 cm. long, pale and fleshy, becoming weak and flaccid after the spores are shed, early disintegrating; capsule cylindrical, 3–4 mm. long, dark brown until the spores are shed; empty walls reddish-brown, walls of 2 layers of elongated cells, the inner layer disintegrating before the spores are shed, dehiscing by 4 valves; spores globose or with one side flattened, 23–28 μ, reddish-brown, finely reticulate, appearing papillose on the margins; elaters of 2 spirals, very long, mostly only slightly attenuate.

On wet soil and rocks in boggy areas, around springs and on wet banks. Thus far it has been collected only once in Utah. A large patch in fine fruit was found on a wet bank fed by a seepage area in City Creek Canyon. Easily distinguished in the sterile state from forms of *Pellia* by the central strand in the midrib. Nearly world wide in distribution.

Illustrations: Plate IX, 4–10 and Figure 14.

Collection examined: Flowers 8044. Salt Lake County, Wasatch Mountains, City Creek Canyon, on wet bank of spring, in shade, 4,800 feet.

5. Blasia L., Sp. Pl., Ed. 1, 1138; 1753.

Jungermannia Hook., Brit. Jung. pls. 82–84; 1816, in part.

Thallus small, prostrate, simple or slightly dichotomously branched, midrib distinct, the wings unistratose often more or less regularly lobed;

ventral scales and rhizoids present on the midrib. Gemmae of two kinds, one kind globose to oval multicellular bodies borne on long stalks within curious long-necked, flask-shaped receptacles located on the dorsal side of the midrib, the other kind irregular stellate scales borne on the dorsal surface of the thallus near the apex; the latter usually more common.

Dioicous. Male plants smaller than the female; antheridia immersed singly in the dorsal side of the thallus, ellipsoidal on short stalks; archegonia grouped near the apex of female plants, at first naked, the first one fertilized becoming immersed in a fusiform involucre with a constricted mamillate apex; seta rather long; capsule ovoid with a basal collar; walls of 3–4 layers of cells, radial walls of outer layer with nodulose thickenings, the inner layer disintegrating, without semiannular thickenings; elaterophores few or rudimentary, basal; elaters 2-spiral; spores 1-celled. Named in honor of Blazius Biagi, a Benedictine monk of Florence, Italy, and a well-known botanist.

One species only.

Blasia pusilla L. l.c.

Jungermannia Blasia Hook., l.c.
Blasia hookeri Corda, in Sturm., Fl. Germ. 2:49, pl. 13; 1830.
B. immersa Dumort., Syll. Jung. 81, pl. 2, fig. 20; 1831.

Plants usually in thin mats, sometimes solitary, green or yellowish-green, thalli at first forming circular, dichotomously branched rosettes, later the branches becoming elongated, 1.5–2.5 cm. long, 3–5 mm. wide, prostrate to ascending, the wings often turned upward, more or less crisped, 3–12 cells thick through the midrib; margins irregularly to somewhat regularly lobed, unistratose, sometimes becoming quite leaf-like, nearly always with *Nostoc* colonies within, appearing as dark spots.

On damp or wet soil, usually in open places, often on banks or gravel.

Widely distributed in the United States and Canada, Alaska; Europe, Asia and Australia.

Illustrations: Plate IX, 11–17.

Collections examined: Flowers 8077. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, Mill B. Fork, on damp soil along trail, 6,200 feet; 8078. Brighton, on damp soil, seepage area along trail to Lake Mary, 9,200 feet.

6. FOSSOMBRONIA Raddi, Mem. Soc. Ital. Sci. Modena 18: 29. 1818.

Codonia Dumort., Comm. Bot. 111. 1822.
Jungermannia L., Sp. Pl. Ed. I. 1136. 1753.

Plants prostrate, often ascending at the tips; stems fleshy and dichotomously branched, flat or convex on the upper side, strongly convex on the lower side and bearing numerous rhizoids; leaves in 2 opposite rows, obliquely inserted, succubous, ventral margin decurrent, broadly ovate to somewhat quadrate, often broader than long, flattish to strongly ascending; margins mostly ruffled, usually more or less lobed, 1 cell thick above, sometimes 2 or more cells thick at the base; upper leaf cells rounded, oval or polygonal, thin-walled.

Monoicous or dioicous. Antheridia and archegonia surrounded by bracts on the dorsal side of the stem near the apex, near the bases of the young leaves, single or in small groups; pseudoperianth large, campanulate, plicate, subtended by narrow scales, usually divided nearly to the base on one side, mouth wide and lobed; calyptra pyriform, thick at the base; seta short, tender; capsule globose, irregularly splitting at maturity into

4 imperfect valves, wall of 2 layers of cells, the inner one with incomplete semi-annular thickenings; elaters short with 2–3 spirals; spores large, variously sculptured. Named for Bittorio Fossombroni, an Italian statesman.

There are eleven species known in North America of which I have found only one thus far.

Fossombronia braziliensis Steph., Mem. Herb. Boissier 16: 28. 1900 and Sp. Hep. 1: 382. 1900.

Plants pale green, forming loose or intricate mats close to the substratum. Stems simple or dichotomously branched, reaching 1 cm. long, very strongly convex on the ventral side; rhizoids numerous, purplish, becoming reddish-brown; leaves broadly obovate, as wide as long or wider, spreading to ascending, margins with shallow lobes, ruffled, 1 cell thick to the base; upper leaf cells variable in size, 24–34 x 34–56 μ, smaller toward the margins and larger toward the base.

Autoicous. Pseudoperianth shortly campanulate, about 1 mm. long, lobed and plicate at the mouth, split to the base on forward side; seta about 2.5 mm. long; elaters with 2–3 spirals, irregular; spores 40–52 μ, brown to reddish-brown, outer face with low narrow irregularly branched ridges, either not forming meshes or forming 2–12 irregular meshes, rarely regularly reticulate, on the spore margin appearing as low, sharply acute projections irregularly spaced. Type locality, Brazil.

On moist soil or rocks, usually in shade. Rhode Island to Florida, westward to Oklahoma and Texas; Mexico, West Indies and South America.

Specimen examined: Kane County: 5558-A, 5558-B. Colorado River at Hall's Creek. On damp sandy soil and on soil over sandstone rocks, among *Marchantia polymorpha*. 3,360 feet, in fruit.

The two specimens were growing on a vertical cliff near the base where water seeps from bedding planes of the rocks. They appear to be typical, especially the spores.

Family 2. JUNGERMANNIACEAE

Plants leafy, procumbent and creeping, ascending or nearly erect; stems simple or branched; the branches arising ventrally or laterally, fleshy, pale green or tinted; tissue uniform or only slightly differentiated; growth by a triangular pyranidal apical cell; leaves disposed in two opposite rows, mostly alternate, less commonly opposite, often with a third row of ventral leaves, these often small, inconspicuous and difficult to demonstrate; rhizoids smooth, hyaline, pale brown or tinted, arising from the underside of the stem or bases of the leaves; gemmae often present, commonly on the margins of the upper leaves, 1-several-celled, rounded or angular.

Paroicous, autoicous or dioicous. Male bracts resembling the stem leaves but usually saccate at the base and slightly larger, disposed in terminal or intercallary groups or spikes (androecia), when paroicous subtending the female inflorescence; antheridia minute, 1-several in the axil of each bract, globose to ovoid, on short slender stalks. Female inflorescence consisting of an involucre composed of 2-3 modified leaves called bracts, these usually much larger, and more strongly lobed and indented than the normal stem leaves, and sometimes 1-3 subtending bracteoles of intermediate modification; archegonia in terminal groups arising from the apical cell and its immediate segments, terminating the growth of the stem; perianth nearly always present, formed by the union of the two uppermost leaves, or, when underleaves are present, the 3 upper leaves may be involved; sporophyte terminal, included within, or emergent from the perianth, seta mostly hyaline, fleshy and delicate, often long; capsule subglobose to ellipsoidal, wall 1-8 cells thick, opening by 4 valves; elaterophores lacking; elaters present.

Key to the Genera

a. Leaves divided to the base into 3–4 filamentous lobes, plants more or less plumose. .... 7. Blepharostoma

aa. Leaves entire or variously lobed, the lobes not filamentous.

- b. Leaves sharply conduplicately bilobed.
  - c. Ventral lobes of the leaves saccate; leaves incubous; elaters 1-spiral. .... 14. Frullania
  - cc. Ventral lobes of the leaves not saccate.
    - d. Underleaves present throughout; leaves incubous.... 13. Porella
    - dd. Underleaves lacking.
      - e. Dorsal leaf-lobe the smaller, or the two nearly equal; entire to variably dentate; the dorsal lobes more or less incubous, the ventral lobes succubous. .... 11. Scapania
      - ee. Dorsal leaf-lobe the larger; margins entire; leaves incubous. .... 12. Radula
- bb. Leaves not conduplicately bilobed, or only concavely so.
  - c. Leaves incubous. .... 10. Calypogeia
  - cc. Leaves succubous, or transversely inserted..
    - d. Leaves obtuse or merely emarginate, not lobed.
      - e. Leaves more or less dentate. .... 5. Plagiochila
      - ee. Leaves entire.
        - f. Bracts more or less united with the perianth, forming a perigynium, often at right angles with the stem; underleaves present only toward the apex of the stem. .... 2. Nardia
        - ff. Bracts entirely free from the perianth, perigynium lacking.
          - g. Underleaves lacking. .... 1. Jungermannia
          - gg. Underleaves present throughout, mostly narrowly bifid. .... 4. Chiloscyphus
    - dd. Leaves 2–5-lobed.
      - e. Leaves with 2–5 principal lobes. .... 6. Lophozia
      - ee. Leaves with 2 principal lobes.
        - f. Underleaves present throughout, bifid; rhizoids tufted; plants usually branched. .... 3. Lophocolea
        - ff. Underleaves lacking or common on the sterile stem, but not present throughout, entire to bifid; rhizoids scattered.
          - g. Leaves 2-lobed 1/10–1/3 of their length; stems mostly simple, sometimes forming innovations from below the perianth; perianth terete, not angled; plants medium-sized to large. .... 6. Lophozia
          - gg. Leaves 2-lobed 1/3–3/4 of their length; stems simple to freely branched; perianth angular; plants small to minute.
            - h. Perianth borne on a short lateral branch, 3-angled; seta of 8 or more cells in cross section; largest leaves usually 1.5–3 times longer than the diameter of the stem. .... 9. Cephalozia
            - hh. Perianth borne at the apex of the main stem, often becoming lateral by subfloral innovations, 4–5-angled; seta of 4 cells in cross section; leaves usually 1.5 longer than the diameter of the stem, or less. 8. Cephaloziella

1. Jungermannia L., Sp. Pl. 1136; 1753, in part.

Aplozia Dumort., Hep. Eur. 55; 1874.

Haplozia K. Muell., Rabenh. Krypt.-Fl. 6(1):535; 1909, in part.

Plants small to rather large, prostrate to ascending; stems simple or sparingly branched; rhizoids smooth, colorless to brown; leaves succubous, obliquely to nearly transversely inserted, alternate, orbicular, ovate or oblong, entire, usually broadly rounded at the apex; underleaves lacking.

Monoicous or dioicous. Androecia terminal or medial on stems in dioicous species; antheridia 1-3, axillary in the saccate bases of the bracts; perianth cylindrical, subtended by distinct bracts similar to the leaves, at maturity plicate and contracted at the mouth; calyptra free from the perianth tube, surrounded at the base by unfertilized archegonia; capsules on rather long setae, included, globose to ovoid, dehiscent by 4 straight valves; walls bistratose; outer cells with nodular thickenings, the inner cells with semi-annular thickenings; elaters with 2 spirals. Named in honor of J. Jungermann, a German botanist of the 17th century.

20 species widely distributed.

Trigones of the older leaves bulging into the lumina of the cells; leaves quadrate-ovate to ovate-oblong; perianth cylindrical, smooth and contracted at the mouth. .... 2. *J. lanceolata*

Trigones of the older leaves small or lacking, not bulging into the cells; leaves mostly ovate or broader; perianth more or less plicate above.

Some of the leaves slightly retuse at the apex, all broadly rounded-ovate to broader than long; trigones small to rather large; perianth obovate to shortly clavate; plant light green. .... 1. *J. sphaerocarpa*

None of the leaves retuse at the apex, obtuse to broadly rounded.

Plants large; shoots up to 8 cm. long, 2–4 mm. wide; leaves 2–2.5 mm. long, broadly cordate. .... 3. *J. cordifolia*

Plants small; shoots up to 2 cm. long, 1.5 mm. wide; leaves 0.7–1.4 mm. long, broadly ovate to oblong, not cordate.

Perianth fusiform, crenulate at the mouth; autoicous..... 4. *J. pumila*

Perianth clavate to pyriform, mouth 5-toothed, denticulate; dioicous. .... 5. *J. tristis*

1. *Jungermannia sphaerocarpa* Hook., Brit. Jung. pl. 74; 1816.

Aplozia sphaerocarpa (Hook.) Dumort., Hep. Eur. 61; 1874.

Plants pale or yellowish green, often tinged with red or golden-brown, in mats or tufts; stems prostrate to ascending, 1-3 cm. long, rhizoids long, pale brown to colorless; branches few and small; leaves distant or closely imbricated, succubous, soft, 1.5-2 mm. wide, 1-1.5 mm. long, oval-oblong, orbicular or broader than long, apex broadly rounded to slightly retuse concave, subclasping, decurrent at the dorsal basal margin, insertion oblique below, becoming nearly transverse above, squarrose to erecto-patent; margins narrowly incurved, entire; medial leaf cells quadrate-rounded to oblong-hexagonal, angles rounded, mostly 30-50 μ long (up to 70 μ), 24-36 μ wide, thin-walled with rather small trigones, toward the margins becoming smaller and more uniform, marginal cells quadrate, forming a uniform border, often tinged with brown.

Paroicous. Perianth obovate or clavate, ½–⅔ exserted, mostly 4-angled above (sometimes 3–6-angled), smooth below, mouth contracted, crenulate; involucral bracts usually 2, similar to the leaves but more erect, subtended by 2-3 pairs of antheridial bracts with saccate bases, otherwise like the leaves; capsule globose, on a seta 1-2 cm. long; spores 16-20 μ, reddish-brown; elaters 8-10 μ thick.

On wet soil, rocks or humus, rotten logs or among mosses. It occurs in the Uintah Mountains at high altitudes and probably elsewhere. Northern United States and northward, Europe and Asia.

Illustrations: Plate X, 4-6.

Collections examined: Flowers 2017, 8142. Duchesne County, Uintah Mountains, near Mirror Lake, on wet brook bank in shade, 10,300 feet; 2706. San Juan County, La Sal Mountains, near Geyser Pass, wet brook bank in shady woods, 9,900 feet.

2. *Jungermannia lanceolata* Schrad., Samml. Lief. 2, 4; 1797.

Aplozia lanceolata (Schrad.) Dumort., Hep. Eur. 58; 1874.

Plants in pale to brownish-green mats or tufts; stems prostrate to ascending, sparingly branched, 1–3 cm. long; rhizoids brownish, usually abundant nearly to the apex; leaves usually closely imbricated, succubous, quadrate-oblong to oblong-ovate, very concave at the base, becoming convex and recurved above, squarrose to erecto-patent, insertion oblique, decurrent on the dorsal margin; medial leaf cells rounded-polygonal, mostly 20–33 μ, trigones usually conspicuous, often large, marginal cells quadrate, forming a regular border.

Monoicous or dioicous; antheridia below the archegonia; perianth cylindrical-clavate, slightly incurved, not angled, apex truncate, mouth small, crenate and shortly tubular; involucral bracts larger than the leaves, squarrose above; seta 1 cm. or more long; capsule ovoid, dark brown; outer cells large with nodular thickenings, inner ones smaller and with semiannular thickenings; elaters bispiral, loosely coiled; spores yellowish-brown, 11–14 μ.

On wet or damp soil, rocks or humus, often among mosses. Growing at high altitudes in our region. Apparently common in the high Uintah Mountains. North Carolina to California and northward; Europe and Asia.

Illustrations: Plate X, 1–3.

Collection examined: Flowers 2017A. Summit County, Uintah Mountains, near Bald Mountain on wet brook bank, 10,000 feet.

Most of our plants are rather small compared with forms in other regions; also, the leaves are often quite short and simulate those of *J. sphaerocarpa* so that some difficulty may been encountered in distinguishing the two on leaf shape.

3. *Jungermannia cordifolia* Hook., Brit. Jung. pl. 32; 1816.

Aplozia cordifolia (Hook.) Dumort., Hep. Eur. p. 59; 1874.

Plants large, in spongy mats or tufts, olive-green to purplish-black; stems more or less erect or ascending, 2–8 cm. long, simple or sparingly branched, straight or flexuose, often from creeping stolons; rhizoids usually few, colorless to brown, smooth; leaves large, 2–3.5 mm. long, concave, broadly cordate-ovate, soft and flaccid, much shriveled when dry, clasping the stem, insertion narrow, nearly transverse, slightly decurrent, distant below, approximate and subimbricated above, erecto-patent, the upper portion recurved; medial leaf cells quadrate to oblong-hexagonal, mostly 32–42 μ long, 23–33 μ wide, thin-walled without trigones; marginal cells quadrate; basal cells longer, often slightly inflated.

Dioicous. Perianth elongated, fusiform, apex narrow, slightly plicated, smooth below, mouth crenulate. Rarely fruiting.

Mostly submerged or emergent in slow streams, ponds or springs, also in boggy areas or on damp soil and rocks. Our commonest species in the

Uintah and Wasatch Mountains. New York to California and northward; South America, Europe, Asia and Iceland.

Illustrations: Plate XII, 16–18.

Collections examined: Flowers 8019. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, on wet soil, bank of rivulet, 7,000 feet; 8024. Salt Lake County, Wasatch Mountains, Little Cottonwood Canyon, Tanner's Flat, attached to rocks, submerged in slow rivulet, 7,300 feet; 8005. Juab County, Deep Creek Mountains, Birch Creek, submerged in large spring, 5,300 feet. B. F. Harrison et al. 10015. Duchesne County, Uintah Mountains, Chain Lake, submerged in small drainage canal, 10,800 feet.

4. *Jungermannia pumila* With., Bot. Arr. Veg. Brit. 3:866; 1776.

Jungermannia zeyheri Hueben., Hep. Germ. 89; 1834.
Aplozia rostellata Dumort., Hep. Eur. 58; 1874.
A. pumila Dumort., l. c. 59.
Haplozia pumila K. Muell. in Rabenh., Krypt.–Fl. 6(1):567; 1909.

Plants small, in low mats or suberect tufts, prostrate, ascending or nearly erect, olivaceous to blackish-green; stems about 1.2 mm. wide, 5–12 mm. long, simple or branched; rhizoids pale to brownish, mostly dense on the ventral side often extending to near the apex; leaves 0.7–1.2 mm. long, oval to broadly ovate, succubous, usually distant, becoming rather closely imbricated at the tips of the stems; obliquely or horizontally inserted, the base contracted, apex broadly rounded, entire; cells 5–6-angled, 18–32 μ above, smaller on the margin, becoming larger toward the base, walls thin, trigones lacking or small; underleaves lacking.

Monoicous. Antheridial bracts below the terminal archegonial cluster, broadly ovate and strongly concave; antheridia solitary, globose-ovoid on a short stalk; archegonial bracts larger than the stem leaves, broadly ovate, transversely inserted, erect, the apices often spreading, base clasping the stem; perianth free, more or less elliptical, becoming somewhat obovate with age, slightly compressed, the apex quite narrow, slightly plicate, lower portion smooth, mouth crenulate, the cells elongated; capsule on a short seta, oval, dark brown to blackish, walls with semi-annular thickenings, spores finely granular, pale brown, 17–25 μ; elaters rather broad, only slightly tapered at the ends, 6–7 μ wide, reddish-brown, with 2 spirals.

Mostly on damp or wet soil or rocks, usually in rather open places in woods and along brooks in high mountains. Known in Utah from the Uintah Mountains. Tennessee to California and northward; Europe, Asia and Iceland.

Illustrations: Plate X, 7–9.

Specimens examined: Flowers 8102, 8103. Daggett County, Uintah Mountains, Spirit Lake, on damp banks, hillside among other hepatics, 10,700 feet.

5. *Jungermannia tristis* Nees, Naturg. Eur. Leberm. 2: 461; 1836.

Jungermannia riparia Tayl., Ann. Mag. Nat. Hist. 12: 88; 1843.
Alpozia tristis Dumort., Hep. Eur. 63; 1874.
A. riparia Dumort. l.c.
A. riparia var. *rivularis* Bernet, Cat. Hep. Suisse 59; 1888.
Haplozia riparia K. Muell, in Rabenh., Krypt.–Fl. 6(1):559; 1909.
Aplozia tristis var. *rivularis* Joerg., Bergen Mus. Skrift. 16: 110; 1934.

Plants small, forming mats and tufts, yellowish-green, green to dark olivaceous; stems prostrate, ascending or erect, 0.5–2 cm. long, simple or sparingly branched; rhizoids numerous, hyaline to pale brown, often lacking near tips; leaves orbicular, ovate or oblong, varying with the habitat, 0.8–1.4 mm. long, approximate to imbricated, spreading below, becoming patent and clasping above, especially on fertile stems, alternate and succubous below, becoming transverse above, not decurrent, broadly rounded at the apex, entire, not lobed; upper medial leaf cells 20–40 μ, isodiametric to shortly elongated, angular to rounded, thin-walled, trigones lacking or very small, cuticle smooth; marginal cells smaller, 16–22 μ, oil bodies few, small and spherical.

Dioicous. Male plants slender; antheridial bracts approximate to distant, erect to patent, saccate at the base; antheridia single in the bracts, ovate-globose, on a short stalk; female bracts erect to patent or squarrose, similar to the stem leaves but larger; bracteoles lacking; perianth clavate to pyriform, ½–⅔ emergent, free, plicate in the upper ⅓, mouth truncate, 5-lobed and often denticulate; seta up to 2.5 cm. long; capsule broadly ovoid, black, outer cell walls dark reddish-brown with nodular thickenings, walls of the inner cells with semiannular thickenings; elaters 7–9 μ wide, up to 100 μ long, ends blunt, spirals 2–3, united into a solid end-piece; spores reddish-brown, 14–18 μ in diameter (20–23 μ in our plants). Type locality in western Germany.

On wet soil and rocks, often submerged in water. British Columbia to California, Alberta to Utah; South Carolina; Europe.

Illustrations: Plate X, 10–12.

Collections examined: Flowers 2717, 2720. San Juan County, La Sal Mountains, near Geyser Pass, on damp soil under rotten logs in shady woods. 9,700 feet.

The leaves in our plants are shorter and broader, and the spores are larger than in typical plants. Quite variable according to habitat.

2. Nardia S. F. Gray, Nat. Arr. Brit. Pl. 1: 694; 1821, in part.

Mesophylla Dumort., Comm. Bot. 112; 1822, in part.
Alicularia Corda, in Opiz, Beitr. 1:652; 1828.

Plants small to medium sized, forming mats or tufts; stems prostrate and creeping, often ascending or becoming suberect, mostly simple, branches few and rare; rhizoids usually abundant, long, violet to pale brownish; leaves alternate, obliquely inserted, succubous, erect and incurved, dorsally secund, usually imbricated above, distant below, rounded in outline, entire to emarginate or cleft; margins entire; median leaf cells rounded to hexagonal, rather thin-walled, trigones present or absent, cuticle smooth; underleaves present but usually evident only near the apical region of the stem, lanceolate to subulate.

Monoicous or dioicous. Androecium terminal in dioicous species, subtending the involucre of autoicous species; bracts saccate at the base, otherwise much like the stem leaves, few to many; perianth immersed below the tips of the female bracts with which it is united for ½–⅔ its length, in some species the whole involucral structure forming a bulbous, cup-like perigynium (marsupium) more or less at right angles with the stem and bearing rhizoids at the base. Seta 0.8–2 cm. long; capsule ovoid or subglobose, opening by four values, wall two layers thick, the epidermal cells large, the walls with nodular thickenings, the inner cells smaller, their walls with semi-annular thickenings; elaters with 2–3 spirals. Calyptra free. (Named for S. Nardi, an Italian abbot.)

Nardia geoscyphus (DeNot.) Lindb., in Carr. Brit. Hep. 27; 1875.
Jungermannia scalaris var. *minor* Ness, Naturg. Eur. Leberm. 1: 281; 1833.
Alicularia scalaris var. *minor* Nees, Naturg. Eur. Leberm. 2: 449; 1836.
Alicularia geoscyphus DeNot., Mem. Accad. Torino, Ser. 2, 18: 486; 1859.
Marsupella silvrettae Dumort., Hep. Eur. 128; 1874.
Alicularia minor Limpr. in Cohn, Krypt.-Fl. Schlesien 1: 251; 1876.
Nardia haematosticta Lindb., Musc. Scand. 8; 1879.
Sarcoscyphus silvrettae Steph., Bot. Ver. Landshut 7: 17; 1879.
Nardia minor Arn., Leb. Stud. Nordl. Norwegen 39, 1892.

Plants small, in dense mats or tufts, green, dull brownish-green or purplish; stems short, rarely branched, prostrate or ascending at the tips, mostly less than 1 cm. long, green above, dirty violet below; rhizoids numerous, long, pale violet to nearly colorless; leaves succubous, distant below, rather closely imbricated above, alternate, erect to spreading, often dorsally secund, orbicular to broadly ovate in outline, strongly concave, emarginate, lobed or cleft; sinuses rounded, narrow to broad; apices narrowly obtuse to broadly rounded, in the apical leaves usually acute or blunt; median leaf cells mostly irregularly rounded, some oval, 20–40 μ, rather thin-walled, trigones usually strong and bulging into the cells but often small; marginal cells smaller, oil bodies 2–3, rough and irregular, obscure and often difficult to demonstrate; median basal cells oval-oblong, often violet, underleaves present only near the apex of the stem, broadly lanceolate.

Autoicous. Antheridia oval, on a short stalk, 1–2 per bract, the bracts 2-several below the archegonial involucre, ovate or orbicular, emarginate to cleft, often sinuate, saccate at the base; archegonial bracts larger and broader than the stem leaves, usually borne at right angles to the stem, clasping, emarginate to cleft, sinuately lobed and more or less crisped; bracteole large, irregularly 2–3-lobed; perianth shorter than the bracts and immersed below their tips, crenulate at the mouth, the bracts united with it for ½–⅔ its length, the whole perianth structure fleshy and cup-like, standing more or less at right angles with the stem, the lower end fleshy, bulbous and covered with rhizoids, purplish or brownish. Seta 1–2 cm. long; capsule broadly oval, reddish-brown, the epidermal cells with nodular thickenings, walls of the inner cells with semiannular thickenings; elaters 150–200 μ long, 8–10 μ thick with two broad, reddish-brown spirals; spores 14–16 μ, granular, reddish-brown. On wet banks and rocks, La Sal Mountains. Greenland to Georgia, Ohio, Utah and California, northward to Alaska. Europe.

Illustrations: Plates X, 13–18 and XVI, 21–24; Figure 18.

Specimens examined: Flowers 2704, 2711. Utah: San Juan County, La Sal Mountains, on wet soil, brook bank in shade. 9,900 feet, near Geyser Pass.

3. Lophocolea Dumort., Rec. d'obs. 17; 1835.

Jungermannia sect. *Lophocolea* Dumort., Syll. Jung. 59; 1831.

Plants medium to large sized, green to pale whitish-green, very delicate and flaccid; stems prostrate to ascending, irregularly branched; rhizoids whitish, few to numerous. Leaves succubous, imbricated, mostly bifid, in some species entire or trifid, lobes mostly sharply acute or sometimes long ciliate-spinulose, insertion nearly vertical to nearly horizontal, lamina clear and transparent, cells quadrate to hexagonal, trigones lacking or rather small; underleaves always present, bifid, 1–2 dentate.

Monoicous, paroicous or dioicous. Androecium intercallary, terminal or below the female inflorescence; antheridial bracts with a dorsal incurved lobe, often saccate at the base, similar to the leaves or distinctly smaller; antheridia solitary; perianth terminal mostly oblong-cylindrical, 3-angled above, the keels often winged, mouth wide with 3 large bifid and denticulate or denticulate-ciliate lobes; calyptra free; capsule long exserted, oval, dark brown, walls pleuristratose. Lophocolea, from Greek, lophos, crest, and koleos, a sheath; referring to the crested or toothed ridges of the perianth of certain species.

Terminal leaves (4–12) of the sterile stems entire and broadly rounded to truncate or merely emarginate; gemmae unknown; paroicous........................ ....1. *L. heterophylla*

All leaves more or less uniformly 2-lobed to the apex of the stem; gemmae usually abundant, sometimes the lobes of the upper leaves rendered erose or much reduced from the formation of gemmae; mostly dioicous. *L. minor*

1. *Lophocolea heterophylla* (Schrad.) Dumort., l. c.; 1835.

Jungermannia heterophylla Schrad., Jour. fur d. Bot. 5:66; 1801.

Plants in thin or dense, pale whitish-green mats or tufts; stems prostrate to ascending, usually closely creeping, 1–2 cm. long, irregularly branched, very soft and flaccid; leaves succubous, usually closely imbricated, about 1 mm. long, nearly horizontal, quadrate to shortly quadrate-oblong, the lower ones bilobed, the apices acute or obtuse, sinus broadly or narrowly rounded, upper leaves becoming progressively more entire upward; the upper leaves entire, rounded or truncate, usually larger, insertion nearly vertical, dorsal basal margin slightly decurrent; leaf cells rounded-quadrate to hexagonal, walls thin, trigones small, mostly 23–30 μ wide, up to 40 μ long. Underleaves rather large, deeply bifid, the lobes subulate-acuminate, 1–2 dentate below, occasionally with a cilium at the base.

Paroicous. Antheridia below the female inflorescence, bracts 2–3 pairs; perianth half exserted, oblong-cylindric, triangular-keeled above, mouth very wide, 3–lobed, each lobe coarsely dentate to sublobulate; involucral bracts larger than the leaves, oblong-cuneate, erect, shortly and irregularly 2–4–lobed, the tips sharply acute; bracteoles small, short, deeply bifid; capsule oval, dark brown; spores yellowish-brown, smooth 11–13 μ; elaters reddish-brown, 2-spiraled.

On wet or damp soil, humus or rotten logs. In Utah in the high Uintah and Wasatch mountains. United States and southern Canada, Europe and Asia.

Illustrations: Plate XI, 1–6.

Specimen examined: Flowers 8015. Duchesne County. Uintah Mountains, on damp humus in shade, near Mirror Lake, 10,300 feet.

The underleaves are rather large for this group of liverworts and easily observed both wet and dry. The leaves vary greatly as the name *heterophylla* indicates. Typically the lower ones are bifid, the upper ones entire, rounded to truncate, but some stems may have nearly all the leaves bifid and others nearly all more or less entire. Some very young branches may bear small distant leaves all of which are deeply bifid. These features together with the characteristic perianth make the species easily identified.

2. *Lophocolea minor* Nees, Naturg. Eur. Leberm. 2: 330; 1836.

Jungermannia crocata DeNot., Mem. Accad. Torino 2(1): 323; 1839.
Lophocolea crocata Ness, in G.L. & N., Syn. Hep. 160; 1845.
L. heterophylla var. *minor* Douin, Rev. Bryol. 34: 23; 1907.

Plants small, mostly prostrate in thin, yellowish-green to olivaceous mats; leafy shoots 1–2 mm. wide; stems slender, often weak, green, becoming olivaceous or purplish, freely branched, the branches lateral or ventral; rhizoids in tufts from the bases of the underleaves; leaves alternate, succubous, widely spreading to dorsally secund, distant to loosely imbricated, broadly ovate to nearly quadrate, 0.3–0.7 mm. long, widest in the middle and rather abruptly narrowed at the base or with a wide base of insertion, slightly dorsally decurrent, 2-lobed, the sinus ¼–⅓ the length of the leaf, rounded to widely angular, lobes more or less triangular, often unequal, the ventral one the largest, apices acute or blunt, often bearing abundant gemmae which render the margins erose and often reduce the whole lobe to a short, broadly rounded, ragged apical margin; median leaf cells isodiametric to slightly elongated, angular to slightly rounded, trigones lacking or very small, mostly 20–35 (46) μ across, those of the lobes smaller; gemmae nearly always present, abundant on the tips of the lobes, often on the lateral margins of the leaf, even on the bracts and perianth, at first 1-celled and spherical, often in 2-many-celled clusters or irregular filaments, pale yellowish-green, 23–30 μ in diameter, gemmiparous leaves becoming abnormal in shape; underleaves ovate, deeply lobed to cleft, sometimes with smaller lateral or basal lobes or teeth, main lobes triangular or lanceolate.

Usually autoicous, sometimes dioicous, fruit often rare. When autoicous male bracts below the female inflorescence, saccate and bearing a dorsal lobule at the base, antheridium single; female bracts larger than the stem leaves, shortly 2-lobed, closely investing the perianth; bracteoles small, about half the length of the bracts; perianth small, cylindric, 3-angled above, half emergent, mouth with three coarsely dentate lobes; seta up to 0.5 mm. long; capsule oval, light brown, about 0.5 mm. long; elaters reddish-brown with 2 spirals, 8–10 μ wide; spores about 10 μ. Type locality in Europe.

On damp or wet soil, rocks, humus, tree bases or rotten logs, usually in shaded places.

Nova Scotia to Virginia, westward across the northern United States to the Yukon and British Columbia; Iowa, Colorado and Utah; Europe and Asia.

Illustrations: Plate XI, 7–13.

Collection examined: Flowers 2710. Utah: San Juan County, La Sal Mountains, on damp soil under rotten log in shady woods, near Geyser pass, 9,900 feet; 8116, 8161. Grand County, La Sal Mountains, near Warner Ranger Station, on wet rotten logs and soil in shaded seepage area, 9,700 feet; 8136. Utah County, Mt. Timpanogos, wet soil, dripping cliffs, 7,600 feet; 8150, 8151. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, on damp soil, shaded brook banks, 7,500–7,700 feet; 8155. l. loc. Brighton, on moist soil under shaded granite rocks, in woods, 9,800 feet.

In most of the present specimens the stems are closely appressed to the substratum, freely branched, the leaves distant and widely spreading, of pale green color and delicate texture. In some the lobes of the leaves are largely consumed by the formation of gemmae but in others only the upper leaves bear gemmae freely while in a few instances they are lacking.

4. CHILOSCYPHUS Corda, in Opiz, Beitr. 651; 1828. Dumort., Syll. Jung. 67; 1831 emend.

Plants medium-sized to rather large, in loose masses or tufts in water or forming loose or compact mats or tufts on soil, pale yellowish-green to dark olivaceous-green; stems prostrate to erect, gently curved to flexuose, moderately branched; rhizoids often numerous but sometimes lacking; leaves alternate, succubous, mostly imbricated, sometimes approximate, mostly obliquely to nearly horizontally inserted, rounded-ovate, more or less rectangular to shortly oblong; apex broadly rounded, sometimes slightly retuse or emarginate but not lobed; margins entire, insertion broad, decurrent on the dorsal margin; leaf cells quadrate, oblong or 5–6-angled, walls thin, trigones lacking or small; underleaves present, mostly 2-lobed with a tooth on one or both basal margins; gemmae unknown or rare, except *C. gemmiparus* in which they are numerous.

Monoicous or dioicous. Sex organs mostly on short branches; in monoicous forms the male branch below the female; antheridia subterminal 1–2 in bracts similar to the stem leaves except that they have a small triangular lobule on the dorsal basal margin forming a little sac; archegonia terminal on short branches, bracts smaller than the stem leaves and 2–3-lobed, later becoming closely applied to the perianth; perianth cylindrical to campanulate or obovate to obconic, exserted ¾ or more beyond the bracts; mouth wide, 3-lobed; the lobes entire, toothed or lobed again; calyptra large, usually projecting from the perianth, thin and delicate, pyriform; seta long, capsule ovoid, dark, the walls composed of 3–4 layers of cells. Fruiting structures rarely formed. *Chiloscyphys* comes from the Greek *cheilos*, a lip, and *skyphos*, a cup; referring to the lip-like character of the perianth.

In the sterile condition the different species are often alike and may be difficult to separate. They have been variously treated as separate species or some regarded as varieties. Of the six species known in this country five of them occur in Utah.

Gemmae abundant on the tips of the upper leaves. ....5. *C. gemmiparus*

Gemmae unknown or rare.

Plants growing in running water, blackish-green or dark olivaceous; apical and marginal leaf cells small, 16–28 μ, medial cells mostly oblong, 20–50 μ, becoming conspicuously larger and inflated toward the base. ....2. *C. rivularis*

Plants growing in wet or damp places, sometimes in quiet water; green, brownish or very pale; apical leaf cells usually larger, medial and basal cells more uniformly isodiametric, not becoming greatly enlarged or inflated toward the base.

Plants green or brownish-green; all leaves entire.

Plants usually green; apical, and marginal leaf cells 16–27 μ, the medial 25–33 μ and the lower ones up to 40 μ long; underleaves 2-lobed. ....1. *C. polyanthus*

Plants usually olivaceous or brownish; apical and marginal leaf cells 24–30 μ, the medial cells 30–50 μ and the lower ones up to 60 μ long; underleaves bifid nearly to the base; perianth lobes spinulose ciliate. ....3. *C. fragilis*

Plant pale green to straw-colored, especially when dry; some of the leaves emarginate or slightly lobed; apical and marginal leaf cells 20–33 μ, the medial cells 30–50 μ and the lower ones up to 65 μ; perianth lobes sinuose-dentate. ....4. *C. pallescens*

1. *Chiloscyphus polyanthus* (L.) Corda l. c.

Jungermannia polyanthos L., Sp. Pl. ed. 2, 1597; 1762.

Plants medium sized, in loose or rather dense mats, green; stems prostrate to ascending, 1–5 cm. long, irregularly branched; rhizoids usually few; leaves subdistant to imbricated, succubous, about 1.5 mm. long and wide, rounded-quadrate, apex broadly rounded or truncate, concave or slightly convex, insertion nearly vertical, decurrent on the basal dorsal margin; medial leaf cells quadrate to hexagonal, mostly 26–33 μ wide or long and a few cells up to 40 μ long, in some plants quite uniform, in others quite variable in size, walls thin, trigones usually lacking (sometimes very small); underleaves small, oblong-ovate, bilobed, the lobes long and slender, lower margins 1–2 dentate.

Monoicous. Androecia intercallary, bracts saccate at the base and with a dorsal incurved basal lobe; perianth on a very short lateral branch, campanulate, rather deeply 3-lobed at the mouth; the lobes obtuse and entire; involucral bracts smaller than the leaves with short, acute or obtuse lobes; bracteoles still smaller, more deeply lobed; calyptra clavate, usually exserted from the mouth of the perianth; capsule ovoid, walls 4–5 cells thick; seta long and extending well beyond the perianth; spores globose, 12–16 μ, yellowish-brown, finely granular; elaters with 2 loose spirals, reddish-brown.

On damp or wet soil and rotten logs or among mosses. Wasatch and Uintah mountains. Nearly world wide in distribution.

Illustrations: Plate XII, 9–12.

Collections examined: Flowers 8014. Salt Lake County, Wasatch Mountains, Brighton, on wet soil and humus by rivulet, 8,600 feet; 2124. Duchesne County, Uintah Mountains, near Mirror Lake, on wet rocks by brook, 10,300 feet; 2709, 2712, 2722. San Juan County, La Sal Mountains, near Geyser Pass, on wet humus shady brook bank, 9,900 feet.

2. *Chiloscyphus rivularis* (Schrad.) Loeske, Abh. Bot. Verh. Prov. Brandenb. 172–174; 1904.

Jungermannia pallenscens var. *rivularis* Schrad., Syst. Samml. Crypt. Gewachse 2:7; 1797.

Chiloscyphus polyanthos var. *rivularis* (Schrad.) Nees, Naturg. Eur. Leberm. 2:374; 1836.

Plants in loose tufts or masses, blackish-green to olivaceous, submerged in slow streams or shallow lakes and ponds; attached to rocks and sticks; stems 2–10 cm. long, stiff, freely branched, the branches widely spreading; rhizoids few or lacking; leaves distant to closely imbricated, widely spreading to erecto-patent, convex or strongly concave-canaliculate, 1.5–2 mm. long, ovate to oblong, the apex more narrowly rounded or obtuse, frequently ragged; much shriveled when dry; apical leaf cells more or less isodiametric, quadrate, to hexagonal, often slightly enlongated, usually lax, walls thin and often flexuose; upper cells mostly oblong, 16–28 μ wide becoming larger and strongly inflated toward the base. Rarely fruiting.

Rather common in high mountains and canyons in Utah. Easily identified by the aquatic habitat, color, longer leaves, and smaller, variable leaf cells. United States and northward; Europe and Asia.

Illustrations: Plate XII, 13–15.

Collections examined: Flowers 2124, 2127, 2131. Duchesne County, Uintah Mountains, attached to rock in outflow of Mirror Lake, 10,300 feet.

3. *Chiloscyphus fragilis* (Roth) Schiffn., Krit. Bemerk. ueber, eur, Leberm. in Lotus 58; 1910.

Jungermannia fragilis Roth, Fl. Germ. 3:370; 1903.

Chiloscyphus polyanthus var. *fragilis* (Roth) K. Muell., Rabenh. Krypt.-Fl. 6(1):823; 1911.

Plants large, in loose tufts or mats in ponds, springs, on wet soil or in wet grassy places, brownish-green or sometimes yellowish-green; stems prostrate to ascending, long and lax, 2–8 cm. long, widely flexuose, freely branched; rhizoids few; leaves usually large, broader than long 2–2.5 mm. long, 2.5–3.5 mm. wide, oblong-quadrate to roundish-quadrate or subreniform; subdistant to slightly imbricated; apex broadly rounded to slightly emarginate, convex; dorsal margin strongly decurrent; medial leaf cells more or less uniform, mostly large, 28–60 μ, isodiametric to slightly elongated, quadrate to hexagonal, rather clear, walls thin, trigones small or lacking. Rarely fruiting.

In wet boggy areas on soil, among mosses, in springs or standing water mainly in high mountain valleys and canyons. North Carolina to California and northward; Iceland and Europe.

Illustrations: Plate XII, 1–4.

Collections examined: Flowers 8004, 8005. Juab County, Deep Creek Mountains, Birch Creek. Wet humus in seepage area, 5,300 feet; 8010. Kane County, Kanab Canyon, near Three Lakes, wet soil, seepage area at base of Sandstone cliff, 5,000 feet.

This is our largest form of *Chiloscyphus*. It is typically brownish-green but may be pale or yellowish-green. There is considerable variation in the size of the leaf cells and some plants fall within the cell range of other species; however, the large size and the very broad leaves make it fairly easy to distinguish.

4. *Chiloscyphus pallescens* (Ehrh.) Dumort., Syll. Jung. 67; 1831.

Jungermannia viticulosa L., p.p., Sp. Pl. 1597; 1753.

Jungermannia pallescens Ehrh., Pl. Crypt. Exs. 502; Hoffm. Deutsch. Fl. 2, 87; 1795.

Plants medium-sized, pale or yellowish-green (pale yellowish when dry), solitary or in thin mats on damp or wet soil, humus or rotten wood, often among mosses; stems prostrate to ascending, rather sparingly branched, rhizoids few; leaves 2 mm. long 1–1.7 mm. wide, quadrate-rounded to quadrate oblong, convex, apex broadly rounded to emarginate, on younger branches slightly bilobed; leaf cells more or less uniform to the base, isodiametric to elongated, quadrate to hexagonal, 28–60 μ, on the average larger than in the preceding species, usually thin-walled (occasionally slightly thickened) and quite clear and transparent; underleaves rather large, bifid, the lobes long and slender, margin 1–2 dentate.

Monoicous. Perianth campanulate or pyriform, lobes of the mouth spinulose dentate; involucral bracts fimbriate; capsule long exserted, ovoid; spores 14–18 μ, yellowish-brown, granular; elaters with 2 spirals.

Rather common on wet or damp soil and among mosses in high mountains and cool shaded canyons. Quebec, northwestward to Alaska; North Carolina, Missouri, New Mexico, Idaho and Oregon; Europe, Asia, Java.

Illustrations: Plate XII, 5–8.

Collections examined: Flowers 8000. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, on wet soil in seepage area, Spruces, 7,500 feet; 8143. L. loc. Mill D. Fork, on wet humus shady brook bank; 8152, 8134, 8144. L. loc., Brighton, wet soil, and humus, or among mosses, along rivulets, Lake Mary's trail, 8,900–9,200 feet; 8006. Salt Lake County, Wasatch Mountains, Lamb's Canyon, on wet soil, brook bank, 8,000 feet; 655. Utah County, Mt. Timpanogos, Stewart's Fork, on wet rotten log in spring, 6,100 feet; 8003. Duchesne County, Uintah Mountains, near Mirror Lake, on wet brook banks, 10,000 feet; 8005. Juab County, Deep Creek

Mountains, Trout Creek, in spring, 5,300 feet; 2716, 2717. San Juan County, La Sal Mountains, near Geyser Pass, wet porphyry rocks submerged in slow stream, 9,700 feet. 8087, 8096, 8166. Grand County, La Sal Mountains, Oowah Lake, on wet soil and humus often among mosses, banks of springs and rivulet, 8,800 feet.

The pale color, especially when dry, and some of the leaves distinctly emarginate or even bilobed serve to identify sterile plants. The size of the leaf cells is quite variable and less reliable, but on the whole they average larger than the other species. The ciliate dentate lobes of the perianth mouth is a good character but fruiting plants are rare.

5. *Chiloscyphus gemmiparus* Evans, Bryol. 41:50; 1938.

Plants of medium size, yellowish-brown, in caespitose mats; stems up to 1.5 cm. long, ascending to erect, sparingly branched at acute angles; rhizoids not seen; leaves imbricated, concave, oblong, 1.5–2 mm. long, 1.2–1.6 mm. wide; apex rounded, truncate or subemarginate; margins entire, oblique to widely spreading; upper and medial leaf cells mostly oblong, some isodiametric, 18 x 25 μ, becoming larger and longer toward the base, thin-walled, trigones lacking or very faint, underleaves small and irregular, difficult to demonstrate; gemmae on the margins of the upper leaves numerous, often in clusters, 1-many-celled, thin-walled and constricted at the cross-walls, 30–60 μ long, 25–40 μ wide. Sex organs and fruit unknown. (After Evans l. c.).

Known only from the type locality: Utah: Spirit Lake, near timberline, Uintah Mountains, Ashley National Forest, Arthur Svihla, August 18, 1928.

Illustrations: Plate XIII, 11–17.

The exact habitat is not given but Dr. Evans states that the plants "present the appearance of having grown in wet localities and may have been submersed."

Dr. Evans discusses the development of the gemmiparous cells in considerable detail. Part of his discussion is quoted here as follows: "These gemmae, which are exogenous in character, are developed in '*Brütbuschel*' or gemmiparous clusters, which were first adequately described by Buch. They are known in *Scapania, Lophozia,* in *Cephalozia,* and in several other genera of the Jungermanniales Acrogynae. Buch regards the Brutbuschel as specialized organs of vegetative reproduction, which invariably arise from embryonic leaf-tissue. According to his account each *Brutbuschel* owes its origin to a single embryonic cell, situated on or near the margin of the leaf. This cell acts as an apical cell with a single cutting face and gives rise by a few divisions to a short row of embryonic segments. In many cases the segments give off outgrowths, which act as the apical cells of branches, and in this way a more or less complicated branch-system composed entirely of embryonic cells is formed. The basal cell of the cluster, distinguished as a rule by its cylindrical form, is different from the others and acts as a stalk-cell. After the apical cells have ceased to cut off segments most of the cells of the *Brutbüschel* enlarge and become differentiated into gemmae."

5. Plagiochila Dumort., Rec. d'obs. 14; 1835.

Martinellia Sect. b. S.F. Gray, Nat. Arr. Brit. Pl. 1:692; 1821.

Plants mostly large, dark green to brownish, usually in dense mats or tufts; stems prostrate to suberect, from creeping rhizomes; rhizoids dense below, usually lacking above; leaves succubous, subdistant to imbricated; dorsal margin recurved, margins mostly dentate to spinulose-dentate, at least in the upper leaves, sometimes quite entire below; insertion strongly oblique, dorsal margin strongly decurrent, ventral margin arched, not or only slightly decurrent; underleaves usually lacking, but sometimes present and then small.

Mostly dioicous. Androecium spicate, terminal or intercallary, bracts usually smaller than the leaves, closely imbricated, saccate at the base, antheridia mostly 2 (1–10); perianth terminal, campanulate to cylindrical, more or less laterally compressed with a dorsal and sometimes a ventral wing, gibbous in the middle; apex truncate, mouth wide, dentate to ciliate; calyptra free; capsule oval-globose, on a rather short seta, the walls several cells thick; elaters with 2 spirals. The name *Plagiochila* comes from the Greek *plagios*, sloping, and *cheilos*, lip; referring to the sloping mouth of the perianth.

A large genus of more than 1000 species, mostly of the tropics and southern hemisphere.

Plagiochila asplenioides (L.) Dumort. l. c.

Jungermannia asplenioides L., Sp. Pl. 1131; 1753.

Plants in wide loose mats to dense erect tufts, dark-green to brownish-green, medium-sized to rather large; stems 2–6 cm. long, from deep trailing stolons, ascending or erect, simple or branched, often with leafless branches; rhizoids lacking on erect stems, present at the base and on the stolons, colorless; leaves variable, 2–4 mm. long, 1–3.5 mm. wide, small below, becoming larger upward, distant or approximate below, imbricated above, orbicular-ovate, erecto-patent to widely spreading; the margins usually weakly dentate to strongly spinulose-dentate all around, or entire toward the base, occasionally entire or subentire in the lower leaves, marginal teeth 2–4 cells long, 1–2 cells wide at the base; dorsal margin widely recurved, strongly decurrent at the base; ventral margin erect or widely recurved, shortly decurrent at the base; upper medial leaf cells 25–35 μ (sometimes larger — up to 50 μ), rounded polygonal, usually more or less equally thickened all around, trigones small or absent, oil bodies 6–12, small; underleaves lacking or small, subulate or bifid; gemmae unknown.

Dioicous. Antheridia usually 2, oval-globose, on a short stalk; perianth campanulate, more or less evenly tapering to the base, truncate, the mouth irregularly dentate to ciliate-dentate; involucral bracts larger than the leaves, usually more strongly spinose-dentate but irregularly so; capsule oval-cylindric, 1.5–2 mm. long, dark purplish-brown; spores reddish-brown, 12–16 μ, smooth; elaters purplish-brown.

On damp or wet rocks, soil or humus, often among mosses or on rotten wood; in many situations, stream bank, shaded cliffs, alpine meadows, on hillsides and rocky slopes. Newfoundland northwestward to Alaska; North Carolina, Tennessee, New Mexico and California; Mexico, Europe, Asia and Africa.

Illustrations: Plate XIII, 18–21.

An extremely variable plant both in size and leaf characters. Some forms have entire leaves, others weakly dentate while the typical form has rather strongly spinulose-dentate margins. Frequent in our high mountains.

6. Lophozia Dumort., Rec. d'obs., 17; 1835.

Jungermannia Sect. *Lophozia* Dumort., Syll. Jung. 53; 1831.

Plants small to large; stems prostrate, ascending or erect, mostly simple, sparingly branched; leaves succubous, widely spreading to erecto-spreading often dorsally secund; approximate to closely imbricated, nearly vertically, obliquely or nearly transversely inserted, often decurrent, mostly 2-lobed but 3–5-lobed in some species; underleaves present or lacking.

Mostly dioicous. Androecium terminal or intercallary; bracts like leaves but usually larger and saccate; perianth obovate to cylindrical, mostly plicate above; mouth contracted to a short beak; seta short or long; capsule ovoid to ovoid-cylindrical, dehiscent to the base by 4 valves; 2–6 cells thick; walls of the inner cell layer with semi-annular thickenings; elaters bispiral; spores 8–18 μ, verruculose or sometimes papillose. *Lophozia* comes from the Greek *lophos,* a crest or point, and *ozos,* a branch; referring to the branched or lobed leaves.

The older classification of this genus has been followed. More recently it has been divided into several smaller genera three of which are represented in our species as follows:

Lophozia alpestris, Lophozia ventricosa, Lophozia porphyroleuca and *Lophozia incisa.*

Liocolea bantriensis and *Liocolea heterocolpa.*

Barbilophozia lycopodioides and *Barbilophozia hatcheri.*

Middle stem leaves mostly 2-lobed (2–4 lobed in *L. incisa*), plants mostly small.
- Underleaves always present.
  - Ends of stems commonly attenuated and abruptly upturned, the terminal leaves deformed, erect and closely imbricated, always bearing gemmae at the truncated tips; perianth and fruit seldom formed. ....5. *L. heterocolpa*
  - Ends of stems not attenuated, terminal leaves normal, not deformed, not always bearing gemmae; commonly forming a perianth and fruit. ....6. *L. bantriensis*
- Underleaves lacking, rarely a few present.
  - Stems short, very thick and fleshy, plants usually bluish-green, leaves irregularly 2–4-lobed, usually broader than long, the upper ones coarsely dentate, perianth obovate, shortly emergent.....4. *L. incisa*
  - Stems long, slender; plants not bluish-green, leaves constantly 2-lobed, margins entire.
    - Leaves concave-canaliculate, the lobes incurved; sinus shallow, broadly crecentric; gemmae reddish. ....1. *L. alpestris*
    - Leaves generally not canaliculate, lobes more spreading, sinus deeper, mostly obtusely rounded or subacute; gemmae green or lacking.
      - Leaf cells with small trigones, perianth mouth merely dentate, not lobed. ....2. *L. ventricosa*
      - Leaf cells with large bulging trigones, perianth mouth lobed; the lobes dentate-ciliate. ....3. *L. porphyroleuca*

Middle stem leaves 3–5 lobed, plants larger.
- Leaves 3–4 lobed, the lobes more or less ovate, the sinuses rather deep and narrowly rounded. ....7. *L. hatcheri*
- Leaves 4–5 lobed, the lobes more or less broadly deltoid, the sinuses very wide and broadly rounded. ....8. *L. lycopodioides*

1. *Lophozia alpestris* (Schleich.) Evans, in Kennedy & Collins, Rhodora 3: 181, 1901.

Jungermannia alpestris Schleich., in Webb. Hist. Musc. Hep. Prodr. 80; 1815.

Plants yellowish-green to brown, in dense, compact tufts or more or less solitary among mosses; stems simple or sparingly branched, ascending to nearly erect, usually flexuose, 1.5–2.5 cm. long, mostly brownish, darker on the lower side; rhizoids pale brown to colorless, usually dense to the apex of the stem; leaves succubous and closely imbricated, widely spreading to horizontal, erecto-patent near stem apex, quadrate-rounded, very concave and canaliculate, 1/10–1/7 bilobed; apices mostly acute, or obtuse in a few leaves, incurved; sinus shallow, broad and rounded, insertion oblique, base very slightly decurrent on dorsal margin; medial leaf cells rounded to oval-oblong, 20–33 μ, walls thin or slightly thickened, trigones large; gemmae angular, 1–2-celled, brownish, borne on the tips of the leaves.

Dioicous. Perianth about ⅔ exserted, oblong-cylindrical, smooth below, plicate at the apex, mouth crenate-dentate; involucral bracts erect and appressed to the perianth, larger than the leaves, 2–3 lobed, very broad at the apex, sinus very shallow, often connate at the base; capsules shortly oval, dark reddish-brown; antheridial bracts more or less terminal, erecto-patent, very concave and saccate at the base; antheridia globose, mostly 2 in each bract (sometimes 3).

On damp or wet soil, humus or among mosses. Connecticut westward through Michigan and Colorado to California, northward to the Arctic; Iceland, northern Europe and Asia.

The leaves are usually more incurved than the illustration shows.

Illustrations: Plate XIV, 1–6.

Collections examined: Flowers 2119. Summit County, Uintah Mountains, near Bald Mountain, Upper Provo River, on boggy lake shore, 10,000 feet; 8104, 8114, 8163. Daggett County, Uintah Mountains, Spirit Lake, damp or wet soil and humus, often among mosses, 10,700 feet; 8149. Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, damp soil, stream bank, 7,500 feet; 8097. Grand County, La Sal Mountains, Oowah Lake, on wet rotten logs among mosses, 8,900 feet.

2. *Lophozia ventricosa* (Dicks.) Dumort., Rec. d'obs. 17; 1835.

Jungermannia ventricosa Dicks., Pl. Crypt. Fasc. 2, 14; 1790.

Plants in bright or yellowish-green mats or tufts or scattered among mosses; stems 0.5–2.5 cm. long, prostrate to ascending or suberect, simple to sparingly branched, ventral parts often tinged with violet or vinous-red; rhizoids colorless, long and often dense to the apex of the stem; leaves succubous, imbricated; quadrate-ovate or ovate, 0.7–1 mm. long, slightly unsymmetric, ¼–⅓-bilobed, the apices of the lobes acute to obtuse, sinuses usually wide and shallow, broadly rounded; insertion slightly oblique, half clasping the stem, slightly decurrent, spreading to erecto-patent concave; medial leaf cells rounded to rounded-polygonal, 26–33 μ, thin-walled, trigones small to medium; underleaves lacking; gemmae very often present, mostly 2-celled, 3–many-angled, pale or yellowish-green, borne on the apices of the leaf lobes.

Dioicous. Male plants smaller; androecium terminal, bracts erecto-patent, very concave and saccate at the base, antheridia 1–2, ovoid-globose, on a stalk about equal or half its length; perianth ⅓–⅔ exserted, rather shortly ovoid-oblong, contracted at the mouth, 4–5-plicate only at the apex, smooth below, mouth typically not lobed, but in many instances 2–4-lobed or with many small irregular lobes; margins mostly dentate, with 1-celled teeth; involucral bracts larger than the leaves, mostly 3-lobed (sometimes 2 or 4-lobed), more or less connate at the base; capsule oblong-ovoid, dark reddish-brown; seta equalling or slightly longer than the capsule; spores 10–14 μ, minutely papillose with small papillae, reddish-brown; elaters reddish-brown, flexuose, rather blunt, only slightly tapered to the ends.

On wet or damp soil, humus or rotten logs, often among mosses on banks of streams and ponds at high elevations. Pennsylvania westward through Iowa and Utah to Oregon, northward to the Arctic; Iceland, Europe and Asia.

Illustrations: Plate XIV, 7–19.

Collections examined: Flowers 8012, 8013. Wasatch County, Wolf Creek Summit, on humus and rotten wood, shady woods, 9,700 feet; 8093. Summit County, Uintah Mountains, Black's Fork, on wet soil, shaded banks, 9,200 feet; 8100, 8102, 8103, 8112, 8156. Daggett County, Uintah Mountains, Spirit Lake, damp soil, often among mosses, edges of wet meadows, brook banks and around seepage areas, 10,700 feet.

Lophozia ventricosa and *L. porphyroleuca* are often difficult to distinguish. The typical form of *ventricosa* shows a predominance of small trigones in the upper medial cells of the leaves and a shorter oblong-ovoid perianth, 4–5 plicate only at the mouth, not or only slightly lobed and with 1-celled dentations on the margin. *L. porphyroleuca* normally has a predominace of large bulging trigones in the upper medial leaf cells and a longer, cylindrical perianth about ½ exserted, usually ½–⅓ plicate above, 4–5-lobed at the mouth and dentate-ciliate, the dentations 2–5 cells long in a single series. Some plants show these differences in degree, often being more or less intermediate in character, and occasionally having the combinations of characters jumbled, such as the dentate-ciliate perianth mouth occurring on plants having leaf cells with small trigones, or the reverse situation where a dentate perianth mouth occurs with leaves having large bulging trigones.

Lophozia alpestris in its typical form is a distinctive species but its variations in our region lean strongly toward *L. ventricosa* and *L. porphyroleuca*. The features usually stressed for *L. alpestris* are the strongly concave-canaliculate leaves with a shallow sinus, smaller, rather thick-walled leaf cells, usually brownish in color, and with small trigones. These characters are often simulated by other species.

3. *Lophozia porphyroleuca* (Nees) Schiffn., Krit. Bemerk. in Lotos No. 7, 61; 1903.

Jungermannia prophyroleuca Nees, Eur. Leb. II, 78; 1836.

J. ventricosa var. *porphyroleuca* Husnot, Hep. Gall. 36; 1875.

Lophozia ventricosa var. *porphyroleuca* K. Mull., in Rabh., Krypt.Fl. I, 666; 1910.

Plants in dense tufts or mats, pale yellowish or brownish-green; stems prostrate, ascending or suberect, 1–1.5 cm. long, reddish or violet on underside, simple or branch, often with slender innovations; leaves oval-quadrate, ¼–⅓-bilobed; apices acute or obtuse; sinus wide, rounded; closely imbricated, often reddish at base; medial leaf cells mostly substellate or rounded-polygonal, with large conspicuous trigones, 20–33 μ.

Perianth ovoid-oblong, half exserted, plicate at the apex, contracted to the mouth; mouth lobed and unequally dentate-ciliate, base often reddish.

On wet or damp soil, humus or rotten wood often among mosses. Connecticut westward through Michigan and Colorado to California; northward to the Arctic, northern Europe and Asia.

Illustrations: Plate XIV, 20–25.

Collections examined: Flowers 2119A. Duchesne County, Uintah Mountains, near Mirror Lake, on humus and soil, boggy lake shore, 10,300 feet;

2721, 2723. San Juan County, La Sal Mountains, near Geyser Pass, on wet brook banks, shade, 9,700 feet; 8087, 8090, 8165. Grand County, La Sal Mountains, Oowah Lake, wet soil and humus, often among mosses, shaded banks of brooklet, 8,900 feet; 8161. L. loc. near Warner Ranger Station, on wet rotten logs, seepage area, in shade, 9,700 feet.

Closely resembling *Lophozia ventricosa* in appearance and habit but differing in the more brownish color, the more ovate leaves, the cells with very large trigones, stellate cells, the shorter and less exserted perianth with deeper plicae at the apex and longer ciliate-dentate margin of the mouth. The lobes of many leaves are unequal, one lobe being large and often rounded or obtuse while the other is much smaller and usually more acute. This species grades into *Lophozia ventricosa* and some plants will be difficult to place.

4. *Lophozia incisa* (Schrad.) Dumort. Rec. d'obs. 17; 1835.

Jungermannia incisa Schrad., Syst. Samml. Krypt. Gewache 2: 5; 1796. (Not of Taylor, Lond. Jour. Bot. 4:93; 1845).

Jungermannia viridissima Nees, Naturg. Eur. Leberm. 2:134; 1836.

Plants rather small, in rather compact mats or low tufts, green to bluish-green, often becoming brownish below; leafy stems, short, very thick and fleshy, 1.5–2.3 mm. wide, 0.5–1 cm. long, prostrate to ascending, sometimes suberect, mostly simple but often with very short branches; rhizoids usually numerous, pale to brownish, extending to the tips; leaves nearly transversely inserted, mostly erecto-patent to spreading horizontally, somewhat succubous, not or only slightly imbricated approximate to rather closely disposed, becoming crowded at the tip, more or less quadrate-rounded to reniform, often wider than long, rather small 0.6–0.8 mm. long; irregularly 2–4-lobed, usually unsymmetric and more or less oblique; lobes ovate to triangular, acute, apiculate or sometimes narrowly obtuse; sinuses narrowly to broadly rounded, often gibbous; basal half clasping the stem, not decurrent; margins entire to coarsely dentate; upper medial cells polygonal-rounded, about 30–38 μ, trigones small; gemmae often present on tips of leaf lobes, 1–2-celled, 3–5 angled, yellowish-green; underleaves lacking or a few at stem tips only.

Dioicous. Androecia terminal, bracts crowded at the tips of the stems broader than long, 3-lobed with a smaller, incurved basal lobe, irregularly dentate, saccate at the base; antheridia 1–2 globose on short stalks; perianth obovate to pyriform, shortly emergent, plicate above; mouth short, irregularly lobed and dentate or ciliate-dentate; capsule on a short seta, ovoid, reddish-brown; elaters slender, spores 12–16 μ, reddish-brown, finely roughened.

On wet or very damp soil, humus or rotten wood, at high altitudes. North Carolina westward through Colorado and New Mexico to California; northward to the Arctic; Mexico, Europe and Asia.

Illustrations: Plate XV, 1–5.

Collections examined: Flowers 2701A, 2708, 2714A, 2715. San Juan County, La Sal Mountains, near Geyser Pass, on wet soil and humus on brook banks, mostly in shade, 9,600–9,900 feet. 8153. Duchesne County, Uintah Mountains, near Mirror Lake, 10,300 feet; 8131. Summit County; Uintah Mountains, Henry's Fork; 8124, 8128. L. loc. Black's Fork, on wet banks, soil, humus or among mosses, 9,200–10,100 feet; 8102, 8106, 8108. Daggett County, near Spirit Lake, 10,700 feet.

The short, thick fleshy stems and broad, irregularly lobed leaves, mostly broader than long, widely spreading and crowded at the tips are characteristic of this species. The very short, emergent perianth, also is an outstanding feature.

5. *Lohpozia heterocolpa* (Thed.) Howe, Mem. Torr. Bot. Club 7, 108; 1899.

Jungermannia heterocolpa Thed., Kungl. Sv. Vet. Akad. Handl. 52; 1838.
Leiocolea heterocolpa (Thed.) Buch, Mem. Soc. Fauna Fl. Fennica 8(1932): 284; 1933.

Plants small, in dense or loose mats, green or yellowish-green, often solitary among mosses; stems simple or sparingly branched, prostrate, ascending or suberect, 1–1.5 cm. long; rhizoids numerous, pale or light brown, usually extending to apex of stem; leaves mostly dense, complanate, succubous and closely imbricated, ovate to orbicular, somewhat secund, insertion strongly oblique, dorsal margin slightly decurrent, ¼–⅓ bilobed, the dorsal lobe usually the larger; apices acute or obtuse; the sinus narrow, gibbous acute or rounded; medial leaf cells mostly 26–33 μ, rounded to oval-polygonal, walls thin, trigones medium to large; underleaves small, lanceolate to ovate-lanaceolate, simple to bifid, margins dentate to ciliate-dentate, 1–3 teeth or cilia on each side; gemmae always present, brown, ovate to obovate, 2-celled, borne on the apical portion of highly differentiated terminal leaves, the latter oblong to obovate-truncate, slightly bilobed, irregularly dentate; cells oblong to hexagonal or rhomboidal; the gemmiferous stem tips often attenuate, tipped with dull red.

Dioicous. Perianth exserted, oblong-ovate, smooth, apex slightly beaked; mouth crenulate; involucral bracts broad, ovate-orbicular, concave, insertion nearly transverse. Fruit rare, not known in North America.

On damp or wet soil, humus or rotten wood, often among mosses. Vermont westward through Michigan and Utah to California; northward to the Arctic; northern Europe and Asia.

Illustrations: Plate XV, 6–12.

Collections examined: Flowers 8015. Duchesne County, Uintah Mountains, near Mirror Lake, on damp humus, shade, 10,300 feet; 8031. Utah County, Wasatch Mountains, Mt. Timpanogos, above Aspen Grove at Columbine Falls, on damp shaded rocks and banks, 8,600 feet; 8168. Salt Lake County, Wasatch Mountains, Brighton, damp banks, 9,000 feet; 8162. Grand County, La Sal Mountains, near Oowah Lake, on wet soil and humus, banks of brooklet, 8,900 feet.

The gemmae are always present and the characteristic stem tips and gemmiferous leaves make it easy to identify.

6. *Lophozia bantriensis* (Hook.) Steph., Spec. Hep. II: 133; 1901.

Jungermannia bantriensis Hook., Brit. Jung. Pl. 41 in note; 1816.
Jungermannia bidentata var. Hook., Brit. Jung. Syn. p.16 and Suppl. pl.3; 1816.
Jungermannia hornschuchiana Nees, Eur. Leb. II: 153; 1836.
Leiocolea bantriensis (Hook.) Joerg., Burgens Mus. Skrift. 16:164; 1934.

Plants medium-sized to rather large, forming large tufts or mats, dark green to brownish, often with a reddish tint and a greasy lustre; leafy stems 1.4–4 mm. wide, 2–8 cm. long, prostrate to suberect, mostly simple; branches few, more or less flexuose, usually with dense rhizoids to the tip (except in erect habit), brownish to pale; leaves succubous, approximate to imbricated, horizontal to widely patent, often slightly curved toward posterior end, complanate or dorsally secund; bifid 1/6–¼, ovate-truncate or rounded-quadrate, more or less oblique and unsymmetrical, one lobe usually smaller; lobes triangular, apices sharply acute to obtuse; sinuses acute to broadly rounded; margins entire, dorsal margin slightly recurved and decurrent at the base; upper medial leaf cells rounded-polygonal, 30–35 μ, middle cells 35–50 μ, becoming larger and longer toward the base; walls thin, trigones small to rather large; underleaves small to rather large, variable in shape, mostly lanceolate, entire or with 1–2 lobes or teeth, apex often ciliate; gemmae not known.

Dioicous. Androecia spicate, bracts concave, dorsal margin with a large strongly incurved tooth, antheridia 1–2; perianth ⅔–¾ emergent, more or less cylindrical, smooth below, very slightly plicate at the apex; mouth shortly beaked, more or less unequally ciliate-dentate; involucral bracts similar to the leaves, erecto-patent, nearly transversely inserted; seta about 1 cm. long; capsule ovoid, blackish-brown, inner layer of cells with semi-annular thickenings; spores 12–16 μ, reddish-brown, finely roughened, elaters short and thick, bispiral. Type locality: near Brantry, Ireland.

On wet or damp soil and rocks, brook banks and cool shaded places. Colorado to California; British Columbia, Alberta, Greenland, Europe and Asia.

Illustrations: Plate XV, 13–18.

Collections examined: Flowers 2720. San Juan County, La Sal Mountains, near Geyser Pass, on damp soil and humus, 9,900 feet; 8107. Duchesne County, Uintah Mountains, near Mirror Lake, damp banks, 10,300 feet.

7. *Lophozia hatcheri* (Evans) Steph., Sp. Hep. 2:159; 1902.

Jungermannia hatcheri Evans, Bull. Torr. Club 25:417; 1898.

Barbilophozia hatcheri (Evans) Loeske, Verh. Bot. Ver. Brandenburg 49:37; 1907.

Plants rather large, in loose mats, dark green, reddish-brown or brownish-black; leafy stems 2–3 mm. wide, 1–5 cm. long, prostrate to suberect, straight or flexuose, simple or sparingly branched; rhizoids numerous, pale; leaves succubous, approximate to imbricated, horizontal, flat or concave to erecto-patent, about 1.5 mm. long, rounded, rhomboidal or reniform in outline, 3–4 lobed; the lobes ovate, the tips mostly acute or apiculate, a few obtuse; the sinuses rounded to acute, often narrowly so, more or less gibbous; margin slightly decurrent, anterior ventral margin with 1–3 long cilia at the base; upper medial leaf cells mostly 20–28 μ, rounded polygonal, smaller at the margins, becoming slightly larger and longer toward the base, walls thin or slightly thickened, trigones small; gemmae common, 1–2-celled, irregularly angled, obtuse at tips; underleaves small to rather large, deeply and irregularly cleft into narrow segments, often ciliate near base, or lobes with terminal cilia.

Dioicous. Androecia terminal or intercallary, bracts similar to the leaves but more concave and unsymmetrical, strongly imbricated, saccate at the base; perianth ovoid-cylindric, plicate above, mouth contracted, lobed or toothed. Fruit unknown in our region. New Hampshire westward through Michigan and Colorado to California; northward to the Arctic; South America, Antarctica and Europe.

Illustrations: Plate XIII, 1–5.

Collection examined: Flowers 2720. San Juan County, La Sal Mountains, near Geyser Pass, on damp soil, shady woods, 9,900 feet; 8107. Daggett County, Uintah Mountains, near Spirit Lake, wet soil, shady banks, 10,700 feet.

8. *Lophozia lycopodioides* (Wallr.) Cogn., Bull. Soc. Roy. Bot. Belg. 10:278; 1872.

Jungermannia lycopodioides Wallr., Fl. Crypt. Germ. 1:76; 1831.
Barbilophozia lycopodioides (Wallr.) Loeske, Verh. Bot. Ver. Brandenb. 49:37; 1907.

Plants medium-sized or rather large, pale to yellowish-green, sometimes brown, forming coarse mats; stems prostrate to ascending, simple or sparingly branched, 1–5 cm. long; rhizoids pale, few to dense; leaves complanate, succubous and mostly closely imbricated, unsymmetrically ovate-reniform, broader than long, 1.5–2.5 mm. wide; dorsal margin much smaller and more decurrent than the broad, ciliated ventral margin, 4-lobed; lobes more or less triangular, tipped with a sharp point or sometimes obtuse; sinuses acute to narrowly rounded; margins ruffled or crisped; insertion strongly oblique; medial leaf cells quadrate-rounded to hexagonal-oval, 20–33 μ long, walls rather thin, trigones small but usually distinct; underleaves large, 0.5–0.7 mm. long, deeply bilobed or parted, lobes deltoid to elongated triangular; margins ciliate or fimbriate; gemmae 1–2-celled, reddish, 3–many-angled, borne on the leaf lobes at the apex of the stems, rare.

Dioicous. Male bracts closely imbricated, concave, saccate at the base; antheridia several, large, oval-globose; perianth oblong, plicate at the apex; the mouth shortly incised and longly ciliate; cilia 1–3 cells long; capsule dark brown, ovate-oval; spores 12–14 μ, muriculate, brown. Fruit rare.

On wet or damp soil, rocks or humus, on banks of ponds or streams or in grassy meadows, at high altitudes. Common in Utah in the Wasatch and Uintah Mountains at high altitudes and probably elsewhere. New Hampshire westward through Michigan to New Mexico, northward to the Arctic; northern Europe.

Illustrations: Plate XIII, 6–10.

Collections examined: Flowers 2083, 2136. Summit County, Uintah Mountains, near Bald Mountain, Upper Provo River, on wet brook banks in shade, 10,000; 8092. Summit County, Black's Fork, 9,200 feet; 8117, 8121, 8122, 8135. Duchesne County, Uintah Mountains, near Mirror Lake, wet or damp soil or humus, often among mosses, 10,000–10,600 feet; 8101. Daggett County, Uintah Mountains, near Spirit Lake, on humus, moist brook banks, 10,700 feet; 2702. San Juan County, La Sal Mountains, near Geyser Pass, on damp soil and rocks in shade, 9,900 feet.

Easily recognized by the characteristic leaves. The leaves are difficult to remove whole but can be observed sufficiently well while in place on the stem. The underleaves also are difficult to remove but may be scraped from the underside of the stem with a sharp razor. Dry stems frequently show both leaves and underleaves to better advantage than moist ones; however if the water is blown from wet stems the parts show up well in good strong light and against a white background.

7. BLEPHAROSTOMA Dumort., Rec. d'obs. 18; 1835.

Jungermannia sect. Blepharostoma Dumort., Syll. Jung. 65: 1831.
Chaetopsis Mitt., Journ. Linn. Soc. 8:53; 1865.

Plants small, stems slender with few branches, rhizoids scarce, often lacking; leaves divided nearly to the base into 2–5 filamentous segments consisting of cylindrical cells arranged end to end in a single series; basal cells joined side by side and attached to the stem, insertion nearly transverse; underleaves similar to the leaves but smaller and with fewer segments.

Autoicous or dioicous. Androecium terminal on stems or branches; bracts like the leaves but with segments more united at the base and sometimes branched; archegonia terminal; perianth oblong or cylindrical, emergent, triangular in cross-section above, one angle ventral, mouth narrowed, ciliate; involucral bracts larger than the leaves, segments broader at the base, often with a broad basal lamina; seta short; capsule globose or ovoid, immersed or emergent, dehiscent by 4 valves; elaters with 2 spirals, short. Name from the Greek *Blepharon*, an eyelash, and *stoma*, mouth, referring to the ciliated mouth of the perianth.

Blepharostoma trichophyllum (L.) Dumort. l. c.

Jungermannia trichophylla L., Sp. Pl. 1135; 1753.

Plants small, mostly scattered among mosses or other hepatics or locally forming mats or tufts among them, usually pale green to whitish; stems plumose, slender, prostrate ascending or nearly erect, 0.5–2 cm. long, more or less flexuose or irregularly curved, branches few, horizontal; rhizoids long and colorless when present, usually scarce or lacking; leaves widely spreading to erecto-patent, distant to rather closely disposed, often imbricated at the tips forming a tuft, mostly 3-divided nearly to the base, sometimes 4-divided on the older main stems; segments filamentous, mostly about 0.3 mm. long, stiff, very gradually attenuated; cells variable in length mostly 26–44 μ long, quadrate to shortly oblong, walls rather thick; underleaves smaller and shorter than the leaves, mostly 2-divided, (occasionally 3-divided).

Autoicous or paroicous. Antheridia solitary, small, globose or oval-globose, on a short stalk; perianth proportionately large, cylindrical, exserted, triangular above, angles rounded, slightly contracted at the mouth, ciliolate; capsule nearly globose, dark brownish or purplish-black, immersed to slightly emergent; spores 13–18 μ, globose, brown, finely echinulate; elaters short, bispiral.

Almost always found among mosses or other hepatics, either scattered or forming local tufts among them, mostly on damp or wet soil or humus. North Carolina westward to New Mexico and California; northward to the Arctic; Mexico, Europe and Asia.

Illustrations: Plate XVI, 1–4.

Collections examined: Flowers 2701, 2706. Summit County, Uintah Mountains, Upper Provo River, wet meadows and brook banks, 9,500–10,000 feet; 2072, 8131. Henry's Fork, on wet brook bank, 9,500 feet; 8088, 8090, 8092, 8100, 8124, 8128, Black's Fork, 9,200–10,000 feet. 2083A. Duchesne County, Uintah Mountains, near Mirror Lake, 10,300 feet; 2703, 2719, 2721, 8066, 8073, 8074. San Juan County, La Sal Mountains, various points near Geyser Pass, on wet brook banks, seepage areas and meadows, usually in shade, 9,600–9,800 feet.

Very common locally in the high mountains and frequently scattered among mosses and other liverworts in a wide variety of habitats. Fruits freely.

8. CEPHALOZIELLA (Spruce) Schiffn., in Engler & Prantl, Nat. Pflanzenfam. 1(3): 98; 1895; emend. K. Muell., in Rabenh., Krypt.-Fl. 6(2):786; 1916.

Cephalozia subgen. *Cephaloziella* Spruce, On Cephalozia 62, 1882.

Plants small to minute; leafy shoots 0.1–1 mm. wide; stems 0.2–10 mm. long, prostrate, ascending or erect; branches lacking to numerous, ventral or lateral in origin, subfloral innovations common in some species; rhizoids few to numerous; leaves alternate, transversely to somewhat succubously inserted, distant to imbricated, spreading to erect, ⅓–¾ 2-lobed; the lobes often unequal, 2–14 cells wide, smooth or coarsely papillose dorsally; margins entire to dentate; leaf cells 7–40 μ; walls thin to thickish; trigones lacking to rather large, not bulging; gemmae 1–2-celled, spherical to oval, smooth; not angular; underleaves present or lacking.

Autoicous, monoicous or dioicous. Female bracts mostly united with the bracteoles at the base, entire to coarsely dentate, sometimes with an extra lobe; perianth 4–5 angled, one angle dorsal, 2 lateral and 1–2 ventral; mouth entire to slightly lobed; seta composed of 4 large epidermal cells inclosing 4 small inner cells, the latter soon disappearing; capsule ellipsoidal, valves 4, with large hyaline cells at the base. *Cephaloziella* is the diminutive of *Cephalozia*.

Cephaloziella stellulifera (Tayl.) Schiffner, Oesterr. Bot. Zeitschr. 55; 1905.

Jungermannia stellulifera Tayl., in G.L. & N., Syn. Hep. 134; 1844.

Plants minute, usually in dense tufts, pale yellowish-green or brownish, some young parts bright green; stems 1–9 mm. long, often short, straight or geniculate, simple or sparingly branched below, slender subfloral branches often abundant; rhizoids numerous, especially on the geniculations, often few here and there, hyaline to brownish; leaves alternate, distant to imbricated, mostly transversely inserted, widely spreading to erecto-spreading, 0.10–0.17 mm. long, mostly 1.5–3 times as long as the diameter of the stem, wider than the stem, becoming larger toward the base of the female inflorescence, not decurrent, ovate, quadrate to obovate-cuneate; lobes triangular to ovate-lanceolate, spreading, 4–6 cells wide at the base, acute to blunt; cells quadrate to shortly oblong, 16–21 μ; walls moderately thick, trigones lacking; gemmae 1–2-celled, pale, oval, more or less short-stalked; underleaves present, usually disappearing early, usually to be found at the apex of the stem, pale or green, subulate or nearly ovate, below the female inflorescence, usually difficult to find.

Autoicious. Male bracts similar to the leaves, lower ones entire, the upper ones toothed on the margins; female inflorescence terminal, often becoming lateral by innovation, several perianths often occurring close together on what appears to be the dorsal side of a prostrate stem; perianth ellipsoid-cylindric about ½-emergent, deeply 4–5 plicate above, narrowed at the mouth; mouth 4–5-lobed, entire to crenulate-dentate; involucral bracts about 3 times larger than the leaves, 2–3-lobed, the lobes nearly entire to coarsely dentate, united at the bases and also united with the bracteoles, seta short to long; capsule often included, ellipsoidal, dark reddish-brown; spores and elaters about 7 μ wide, dark reddish.

On damp soil, rotten wood, or bases of trees.

Illustrations: Plate XVI, 15–20.

Collection examined: Flowers 8154, Salt Lake County, Wasatch Mountains, Big Cottonwood Canyon, on shaded rotten tree stump, ca. 6,000 feet.

9. Cephalozia Dumort., Rec. d'obs. 18; 1835.

Jungermannia Sect. *Cephalozia* Dumort., Syll. Jung. 60; 1831.
Trigonanthus Spruce, Trans. Bot. Soc. Edinb. 3:207; 1849.

Plants mostly small, and slender, pale whitish-green, often tinged with brown; stems prostrate to ascending, simple or sparingly branched, flagella often present; rhizoids mostly few or lacking; leaves succubous, distant to imbricated, 2-lobed, entire, flat or slightly concave, obliquely inserted; leaf cells large and pellucid, mostly hexagonal; underleaves present or lacking on main stem, often present in the involucre.

Monoicous or dioicous. Androecia spicate, terminal, rarely hypogenous; antheridia solitary; perianth terminal, only on branches, not on the main stem, oblong to cylindric or fusiform, 3-angled, one angle ventral; mouth more or less constricted, dentate to ciliate; female bracts and bracteoles united at the base, 2–5-lobed, larger than the stem leaves; capsule long exserted, mostly oval to oblong; the walls bistratose, the inner layer with semi-annular thickenings. The name, *Cephalozia*, comes from the Greek *cephale*, a head, and, *ozos*, a branch, referring to the fact that the perianth always occurs on a branch.

A genus of about 23 species, mostly in the north temperate zone.

Leaves ½–⅔-bilobed, not decurrent; perianth 1 cell thick to the base; monoicous.

Flagella present; medial leaf cells 33–40 μ; perianth borne on a short branch. .... 1. *C. bicuspidata*

Flagella lacking; medial leaf cells 43–60 μ; perianth borne on a long branch. .... 2. *C. lammersiana*

Leaves ⅓–½ bilobed; perianth borne on a short branch, 2–3 cells thick from base to above middle.

Flagella present; leaves ⅓–½ bilobed, not decurrent, medial leaf cells 30–60 μ; monoicous. .... 3. *C. pleniceps*

Flagella lacking; leaves ⅓-bilobed, dorsally decurrent; medial leaf cells 22–30 μ; dioicous. .... 4. *C. media*

1. *Cephalozia bicuspidata* (L.) Dumort., l. c.

Jungermannia bicuspidata L., Sp. Pl. 1132; 1753.

Plants small, green to whitish-green, mostly scattered among mosses, occasionally in small mats; stems mostly creeping or ascending, usually flexuose, simple or irregularly branched, the branches few and ventral in origin, subfloral innovations and flagella frequent, main shoots 0.5–2 cm. long, 0.5–1 mm. wide; rhizoids pale, few and scattered, often lacking; leaves small, 0.4–0.7 mm. long, 12–14 cells wide, distant and small below, becoming subimbricated to imbricated and larger above, erecto-spreading to spreading, alternate, succubous and obliquely inserted to nearly transverse, not decurrent, ovate to quadrate-oval, ½–⅔ bifid; lobes slightly unequal, the ventral one the larger, lanceolate to triangular, apex acute or acuminate, usually ending in 2 cells, entire, sinus acute to narrowly rounded; branch leaves usually much smaller, often cleft nearly to the base, very widely spreading; medial leaf cells of normal sterile stems 33–42 μ, quadrate to hexagonal or irregular, pellucid, walls slightly thickened, trigones lacking; gemmae rare, in clusters at the tips of terminal leaves, 1-celled, spherical to ovoid, about 25 μ long, pale whitish-green.

Monoicous. Male organs borne on a separate branch, often arising from the female branch, antheridial bracts usually slightly larger than the leaves, terminal or intercallary; perianth borne on rather short ventral branches, cylindric to fusiform, ¾ exserted, triangular in cross section, unistratose, contracted and plicate above, mouth dentate to ciliate; bracts and bracteoles united at the base, about 3 times larger than the leaves, deeply lobed, the lobes 1–2 dentate; capsule dark brown or blackish, oval-oblong; spores brown, papillose, 12–16 μ.

Frequent among mosses and other species of liverworts growing in canyons and high mountains. North America, Europe, Asia and Africa.

Illustrations: Plate XVI, 6–7.

Collection examined: Flowers 2075. Summit County, Uintah Mountains, near Bald Mountain, wet soil on brook banks, 10,000 feet.

2. *Cephalozia lammersiana* (Heub.) Spruce, On Cephalozia 43. 1882.

Jungermannia lammersiana Heub., Flora 15:306; 1832.

Cephalozia bicuspidata var. *lammersiana* (Heub.) Nees, Naturg. Eur. Leberm. 2:254; 1836.

Plants usually in dense tufts, sometimes in spreading mats or scattered among mosses, pale or dark green often becoming reddish-brown or darker; stems usually ascending, less commonly prostrate, 0.5–3 cm. long, branches usually few, flagella rarely formed; rhizoids numerous arising from the stem and often the bases of the leaves; leaves alternate, succubous, distant to slightly imbricated, spreading to erecto-spreading, often slightly dorsally secund, obliquely inserted, not decurrent, ovate to rounded-ovate, ½–⅔ bilobed; lobes unequal, the ventral one largest, triangular-lanceolate, acute to acuminate; sinus rounded–obtuse to subacute; median leaf cells large for the genus, 38–60 μ, in the lobes 35–40 μ, pellucid, walls slightly thickened, trigones lacking; gemmae unknown.

Monoicous. Androecia spicate, on a ventral branch; antheridial bracts similar to the leaves but slightly larger, often with a tooth on the dorsal margin at base; perianth usually on an elongated ventral branch, more or less cylindric, ½–¾ emergent, with 5–6 plicae above, bluntly triangular above, 1 cell thick to the base, usually becoming purplish with age, gradually contracted above, mouth dentate, teeth 2–3 cells long; female bracts and bracteoles united at the base, ovate to oblong, 2-lobed, entire or sinuate, 2–3 times larger than the leaves; capsule ovoid; spores 12–15 μ, brown, densely papillose.

On damp or wet soil, humus or rotten logs; often among mosses.

Collected at Cedar Breaks National Monument by L. Rakestraw, cited in Frye and Clark, Hepaticae N.A. p. 485.

3. *Cephalozia pleniceps* (Aust.) Lindb., Medd. Soc. Fauna Fl. Fennica 9: 158; 1883.

Jungermannia pleniceps Aust., Proc. Acad. Nat. Sci. Philadelphia 21 (1869): 222; 1870.

Cephalozia macrantha Kaal. & Nichols, Jour. Bot. 49: 105; 1911.

C. pleniceps var. *macrantha* (Kaal. & Nich.) K. Muell., in Rabenh., Krypt.–Fl 6(2): 31; 1912.

Plants in tufts or mats, less commonly scattered, pale green or yellowish, becoming brownish with age; well developed shoots 1–1.5 mm. wide, prostrate to suberect; branches few; flagella common, often numerous, fleshy, beset with small leaves or sometimes nearly leafless; cross section of stem with large epidermal cells on dorsal side, ventral epidermal cells and inner cells smaller; rhizoids numerous; leaves alternate, succubous, distant to imbricated, spreading to erecto-spreading, often dorsally secund, obliquely to nearly transversely inserted, not or only slightly decurrent, rotund-ovate, often slightly broader than long, up to 0.5 mm. long, 16–25 cells wide, rather thick, ⅓–½ bilobed; lobes unequal, the ventral one largest, triangular-ovate, straight or somewhat connivent, acute, apex ending in 1–2 cells; sinus obtuse or rounded; median leaf cells variable, in some plants 30–45 μ, in others 42–60 μ, walls slightly thickened, trigones lacking; gemmae in globose clusters on the tips of the upper leaves, ovoid to pyriform, 1-celled.

Monoicous. Androecia terminal spicate, on a ventral branch, or sometimes intercallary on the main stem; antheridial bracts similar to the leaves but with an incurved tooth near the base of the dorsal margin; perianth on a short ventral branch, often numerous, cylindrical, ½–⅔-emergent, bluntly triangular above, 2–3 cells thick from the base to above the middle, becoming pale brownish with age, rather abruptly contracted at the mouth; the mouth crenulate dentate; capsule oblong-ovoid to subcylindric; spores 12–18 μ, reddish-brown, densely and finely papillose.

Commonly in tufts or mats on wet soil or humus, frequent among mosses, especially *Sphagnum*.

Illustrations: Plate XVI, 10–14.

Specimen examined: Flowers 8139. Summit County, Uintah Mountains, Henry's Fork, on damp humus among mosses, 8,900 feet.

4. *Cephalozia media* Lindb., Medd. Soc. F. Fl. Fenn. 6:242; 1881.

Jungermannia connivens forma *symbolica* Gottsche in Gott. & Rabh. Hep. Eurs. exs. No. 624; 1877.

Cephalozia multiflora Spruce, On Cephalozia 37; 1882.

C. symbolica Breidl., Die Leberm. Steiermark. 330; 1893.

C. lunulaefolia Pears., Hep. Brit. Isles 147; 1901.

Plants dark green to yellowish-green, often pale, mostly scattered among mosses, sometimes forming compact mats; stems slender 0.5–2 cm. long, simple or branched, prostrate to ascending; flagella lacking; rhizoids very few or lacking; leaves small, 0.3–0.6 mm. long, 7–14 cells wide, distant to imbricated, succubous and obliquely inserted to nearly transverse, distinctly decurrent, widely spreading, often dorsally secund, rounded to ovate, ⅓ bifid; sinuses rounded; lobes straight, incurved or connivent, acute, the apices terminated by 1–2 cells; medial leaf cells 22–32 μ, quadrate to hexagonal, pellucid, rather thick-walled, trigones lacking, underleaves lacking except among the female bracts; gemmae rare, in clusters at the tips of the apical leaves, oblong, pyriform or angular, 1-celled, pale greenish or yellowish, 15–20 μ.

Dioicous. Androecia on short ventral branches or intercallary on the main stem; bracts closely imbricated, much like the stem leaves but more or less saccate at the base, usually ½ bilobed and often with a third lobe on the dorsal margin; antheridium solitary; perianth terminal on a short ventral branch, cylindric to fusiform, usually 2 cells thick to the middle, 3-plicate above, only slightly contracted to the mouth; mouth wide, crenulate-denticulate, teeth 1–2 cells long; female bracts and bracteoles united at the base, larger than the leaves, mainly 2-lobed but often with additional teeth or lobes on the margins; seta short; capsule oblong-oval to oblong-cylindric, reddish-brown; spores 10–12 μ, finely papillose; elaters 7–9 μ thick, reddish-brown.

Frequent among mosses, especially *Sphagnum* and *Aulacomnium* in high mountains. United States and Canada; Europe and Asia.

Illustrations: Plate XVI, 8–9.

Collection examined: Flower 8015. Summit County, Uintah Mountains, Upper Provo River, on wet soil and humus, often among mosses, 10,000 feet.

10. CALYPOGEIA Raddi, Mem. Soc. Ital. d. Sci. in Modena 18:42; 1818.

Stems prostrate to ascending, sparingly branched or simple; rhizoids colorless, long, from the base of the underleaves; leaves incubous, mostly imbricated, more or less alternate in 2 opposite rows, flat to convex, ovate, subrhomboidal or oblong, entire; apex obtuse, broadly rounded or sometimes acute, occasionally bidentate; underleaves always present, small 1/5–1/2 as long as the leaves, broadly ovate, orbicular or reniform; apex usually bilobed; the sinus deep; margin entire or with a single tooth.

Paroicous, monoicous or dioicous. Male branches short, arising from the axils of the underleaves; antheridia solitary or 2–3, surrounded by 3–5 pairs of small leaf-like bracts; female branches short, from axils of underleaves; archegonia 4–12, surrounded by 2–3 pairs of small leaf-like bracts; after fertilization and during sporophyte development the gametophyte tissue surrounding the foot grows rapidly and gives rise to a fleshy sac-like body called a perigynium which may completely surround the young sporophyte. The perigynium becomes large, cylindrical, ventral to the stem and burrows into the ground, the outer surface covered with rhizoids, the mouth with scale-like bracts, internally lined with clavate, papillae-like cells; seta long at maturity extending through the mouth of the perigynium; calyptra adnate to the perigynium for ¾ its length, the free portion bearing unfertilized archegonia. Capsule cylindrical, the walls bistratose, inner walls with semiannular thickenings, dehiscent by 4 spirally twisted valves; spores globose; elaters with 2 spirals. *Calypogeia* comes from the Greek *Kalyx*, a husk or covering, *hypo*, under, and *ge*, the earth, referring to the subterranean cup- or urn-shaped perigynium from which the sporophyte arises.

A genus of 12 species.

Calypogeia trichomanis (L.) Corda in Opiz. Beitr. 653; 1828.

Mnium trichomanis L., Sp. Pl. 1114; 1753, in part.
Jungermannia trichomanis Dicks., Pl. Crypt. Brit. Fasc. 3, pl. 8, f. 5. 1793.

Plants forming thin mats, often more or less solitary among mosses, light green or glaucous, sometimes brownish-green; stems prostrate to ascending, 1–4 cm. long, sparingly branched; rhizoids long and colorless from the base of the underleaves; leaves broadly ovate to subcordate, obliquely inserted, incubously imbricated; margins entire, more or less decurrent, surface plane or slightly undulate; apex broadly rounded to obtusely pointed, occasionally bluntly bidentate; medial leaf cells mostly hexagonal, thin-walled, without trigones, 26–50 μ long, mostly about 43 μ, clear, chloroplasts parietal; underleaves orbicular to broadly ovate, broader than the stem, slightly decurrent, distant or approximate, ¼–½ bilobed; the sinus acute and narrow; tips of lobes obtuse to bluntly pointed; margins entire; gemmae 1–2-celled, in clusters on small leaves at the stem tips.

Paroicous. Antheridial branches short, less than 1 mm. long, capitate, in the axil of the female branch; antheridia solitary, ovoid, short-stalked; female branch short, soon forming the perigynium, the latter 2–2.5 mm. long, 0.6–0.9 mm. thick; seta 1–2.5 mm. long; capsule 1–2 mm. long; spores globose, 12–16 μ, minutely punctate; elaters 150–350 μ long, blunt at the ends.

On damp or wet soil and humus, often among mosses. In Utah it is found only in the higher mountains. It occurs in the Uintah Mountains at 9,000 feet or higher. North America, West Indies, Europe and Asia.

Illustrations: Plate XVIII, 1–8.

Collection examined: Flowers 2075A. Summit County, Uintah Mountains, near Bald Mountain, Upper Provo River, wet soil brook bank, shade, 10,000 feet.

11. Scapania Dumort., Rec. d'obs. 14. 1835.

Plants medium-sized to large; stems prostrate to erect from creeping rhizomes simple or sparingly branched; rhizoids pale, numerous below, none above; leaves complicate bilobed, the dorsal lobe usually much smaller but sometimes nearly equal to the ventral lobe, mostly keeled but sometimes rounded; underleaves lacking; gemmae usually present.

Mostly dioicous. Male plants usually smaller and more slender than the female; androecium mostly terminal and spicate, occasionally hypogenous; bracts usually similar to the leaves but ventricose and with nearly equal lobes; the margins usually entire; antheridia 1–6; paraphyses various or lacking; perianth terminal, rather large, mostly obovate to shortly oblong, wide-mouthed and broadly truncate, dorso-ventrally flattened, smooth or sometimes subplicate above, mouth usually dentate; capsule long exserted, globose to oval, wall of several layers, the inner layer with semi-annular thickenings; elaters bispiral. The name *Scapania* comes from the Greek *skapanion,* a spade or hoe, referring to the flattened perianth.

A genus of about 37 species, mostly of the northern hemisphere in temperate regions. Our specimens are often not typical in all respects and are difficult to key.

Dorsal leaf lobes mostly acute or obtusely pointed, rhomboidal to rectangularly ovate, arching half way across the stem or to the opposite edge; ventral lobe mostly rounded to obtuse, often obtusely pointed, rarely acute, oval to obovate; margins of both lobes entire or denticulate only toward the apex, not decurrent. ....3. *S. curta*

Leaves mostly rounded at the apex, at most obtusely pointed in a few; ventral lobe mostly long decurrent, sometimes not at all; dorsal lobe mostly arching beyond the opposite edge of the stem.

Rhizoids numerous; 2–3 rows of marginal leaf cells thick-walled; areolation sometimes thick-walled throughout; leafy shoots 1.5–2.7 mm. wide. ....2. *S. subalpina*

Rhizoids few or lacking; marginal leaf cells and areolation in general thin-walled; leafy shoots 2.5–5 mm. wide; wing of the keel present or lacking.

Wing entire to lobed, sometimes double; ventral lobe entire to strongly denticulate; dorsal lobe mostly entire, a few weakly denticulate; stems 2–20 cm. long. ....1. *S. undulata*

Wing entire, or in larger leaves with recurved teeth, single; ventral lobe denticulate; dorsal lobe mostly denticulate, a few entire; stems 1–2.5 mm. long. ....1a. var. *oakesii*

1. *Scapania undulata* (L.) Dumort., Rec. d'obs. 14; 1835.

Jungermannia undulata L., Sp. Pl. 1598; 1753, in part.

Scapania dentata Dumort., l. c.

S. resupinata Dumort., l. c.

S. intermedia Lamy, Rev. Bryol. 2: 54; 1876.

S. splendens Steph., Bull. Herb. Boissier 6: 107; 1897.

S. evansii Bryhn. Bryologist 4: 45; 1901.

S. purpurascens Tayl., in Pearson, Hep. Brit. Isles 1: 225; 1902.

S. speciosa Lett., List Spec. Hep. Brit. Isles 70; 1902.

And, many other synonyms as species or varieties in combination with the genera *Scapania, Jungermannia, Radula, Martinellia* and *Plagiochila.*

Plants extremely variable, green, yellowish-green, brownish, purplish-red, or blackish-green, in loose or compact mats or tufts, on damp substrata or floating in water; leafy shoots 3–5 mm. wide; stems prostrate, ascending or erect; stems simple to freely branched, 2–20 cm. long the lower portion often denuded or with ragged leaves, brown or black; rhizoids lacking.

few or sometimes numerous; leaves quite uniform from base of stem to apex, often slightly smaller below, distant to imbricated, widely spreading; keel slightly dorsally recurved or concave, often straight; wing single or double, often weak; 1–10 cells wide, entire to slightly lobed; ventral half of the leaf incubous, or nearly so, insertion arching around the stem and ending below the level of the keel, usually strongly and broadly decurrent but sometimes not at all decurrent, broadly obovate, 1.2–2.4 mm. long, 0.9–1.8 mm. wide, 1.5–2.5 times longer than the dorsal lobe, more or less undulate; apex broadly rounded to obtuse, rarely bluntly pointed; margin entire throughout to variably dentate, either in part or throughout; teeth short and blunt to long and sharp, 1–3 cells long; median leaf cells 20–30 μ, apical cells 15–20 μ, marginal cells 15–25 μ, basal cells ranging upward to 45 μ, a few in the center of the lobe much longer; areolation variable, uniformly angular or angles slightly rounded, isodiametric to slightly elongated; walls usually uniformly thin or slightly thickened; trigones lacking or small, rarely rather large; dorsal half of leaf transversely inserted, not decurrent, appressed and arching to the middle of the stem or half the width of the stem beyond the further edge, rounded to obtuse, entire to denticulate to the base; gemmae rare, 1–2 celled, spherical to ovoid, 12 x 25 μ, pale green to whitish.

Dioicous. Androecium terminal or on a branch; antheridial bracts more or less saccate, the lobes almost equal, antheridia 2–6; paraphyllia numerous, lanceolate; 2–3 cells wide below; 1 cell wide above; perianth oblong, about 6 mm. long, 2–2.5 mm. wide, ⅓–⅔ emergent, often ventrally curved and dorsiventrally compressed, not narrowed, mouth wide, entire to irregularly denticulate; capsule ovoid; elaters 9–10 μ thick, bispiral; spores 15–20 μ, smooth, reddish-brown.

On wet or damp soil, rocks or rotten wood, often submerged in springs or rivulets.

Illustrations: Plate XVII, 8–12.

Collections examined: Flowers 8099, 8105, 8109, 8110, 8111. Daggett County, Uintah Mountains, Spirit Lake, on wet humus, 10,700 feet; 8141. Summit County, Henry's Fork; 8127, Black's Fork; 8129. On damp or wet soil and humus; 8129. Shingle Creek, submerged and on banks of shallow ponds and rivulets, ca. 9,000 feet; 8118, 8119, 8125, 7001. Duchesne County, Uintah Mountains, near Mirror Lake, on brook banks, 10,300 feet; 8041. Salt Lake County, Wasatch Mountains, Lake Blanche, on rocks in rivulet, 9,000 feet.

Exceedingly variable. Numerous segregates have been proposed but recent experimental studies by Buch have shown that plants grown under varying conditions of moisture and light vary widely in the traits customarily cited in distinguishing species and varieties.

1a. Var. *Oaksei* (Aust.) Buch, Soc. Sci. Fennica, Comm. Biol. 3(1):-139. 1928.

S. oakesi Austin, Bull. Torr. Bot. Club 3:10; 1872.

Stem shorter than the last; 1–2.5 cm. long, simple or sparingly branched; keel the leaf straight to slightly recurved or convex; wing lacking or present, entire or, in large leaves, with recurved teeth; ventral leaf lobe coarsely dentate, dorsal lobe less strongly dentate to entire.

On wet or damp soil and humus.

Illustrations: Plate XVII, 13–16.

Collection examined: Flowers 2017A. Summit County, Upper Provo River, near Bald Mountain, on wet brook banks, 10,000 feet.

The leaves are quite constantly toothed well toward the base and in some instances the apex is nearly entire while the lower margins are strongly serrate-dentate. The winged, dentate keel is a character stressed but often it is very narrow or even lacking. The upper leaves show it the best.

2. *Scapania subalpina* (Nees) Dumort., Rec. d'obs. 14; 1835.

Jungermannia subalpina Nees, in Lindenb., Syn. Hep. Eur. 55; 1829.

Plant small to medium sized, in compact tufts or mats, pale to dark green, sometimes reddish tinted; stems ascending to erect, 1–3 cm. long, simple to sparingly branched, lower portion often denuded of leaves; rhizoids usually numerous below, lacking above; leaves subdistant to closely imbricated, patent to recurved-spreading, usually with the dorsal and ventral lobes about equal and about ½ divided, but variable, often the dorsal lobe much smaller, always arching across and beyond the stem, not decurrent at the base, rounded to quadrate-rounded; apex rounded to obtuse; margins entire to slightly dentate in the upper part; commisure keeled; ventral lobe appressed, 1–1.5 mm. long, broadly obovate; the apex broadly rounded to obtuse, margins usually sharply dentate above, but often entire, base long decurrent; upper medial leaf cells polygonal, isodiametric to slightly elongated, 16–25 μ, becoming smaller toward the margins and larger and more elongated toward the base; walls thin or rather thick, usually thick-walled on the margins for 2–4 cells wide, trigones small.

Dioicous. Perinath oblong, about 2.5 mm. long and 1 mm. wide, widest at the mouth, truncate, dentate or sinuate.

On wet soil and rocks along brook banks and shores of lakes and ponds. New York westward and southward to Oklahoma and California, northward to the Arctic; Iceland, Europe and Asia.

Illustrations: Plate XVII, 5–7.

Collections examined: Flowers 8091. Summit County, Uintah Mountains, Black's Fork, on wet banks, 9,200 feet; 8133. Henry's Fork, on wet humus, seepage area, 8,900 feet; 8001, 8120, 8125, 8138. Duchesne County, Uintah Mountains, near Mirror Lake, on damp or wet soil or humus, often on rotten wood or among mosses, 10,300 feet.

The leaf lobes sometimes are nearly the same size, but many forms have the dorsal lobe much smaller. The apices, however, are predominantly broadly rounded, seldom subacute, and the margins range from entire to moderately dentate; the basal margin is usually strongly decurrent and the two lobes appressed. The thick-walled marginal cells of the leaves are quite constant.

3. *Scapania curta* (Mart.) Dumort., Rec. d'obs. 14; 1835.

Jungermannia curta Mart., Fl. Crypt. Erlang., 148; 1817.

Plants small to medium sized, pale or yellowish-green, in loose or rather dense tufts; leafy shoots 1.5–3 mm. wide; stems prostrate to erect, usually short and fleshy, 1–2 cm. long, simple or sparingly branched, mostly flexuous; rhizoids pale, numerous below, lacking above; leaves approximate or imbricated ⅓–½ divided, the dorsal lobe ½–⅔ as large as the ventral one, usually not strongly conduplicate, erecto-patent, usually not keeled, rounded at the back; ventral lobe 1–1.5 mm. long, mostly rhomboidal ovate to obovate-oblong (the upper ones often rounded); the apex rounded, obtuse or acute, usually all three types present on one stem; margins entire or slightly to strongly dentate in upper half, or at the apex, not decurrent;

dorsal lobe rhomboidal-ovate or oblong-ovate, usually not arching across the stem, often spreading, not appressed, not decurrent, apex mostly acute, often rounded; upper medial leaf cells 16–25 μ, quadrate to polygonal, mostly isodiametric, becoming smaller toward margin, thin or thick-walled, trigones small; basal cells elongated thin-walled and inflated; gemmae mostly 2-celled variable in shape.

Dioicous. Male plants smaller and more slender than the female plants, often tinged with reddish-brown, bracts 4–6-paired, the lobes nearly equal, broadly saccate at the base, closely imbricated, antheridia 2–3, oval; perianth shortly oblong, truncate, the wide mouth denticulate to denticulate-ciliate, flattened, subplicate above, smooth below; involucral bracts larger than the leaves, the lobes almost equal, acute or broadly rounded, entire to strongly dentate-serrate at apex; capsule oval.

On shaded brook banks and around alpine lakes. Delaware westward through Indiana and Colorado to California; northward to the Arctic. Europe, Asia and Africa.

Illustrations: Plate XVII, 1–4.

Collections examined: Flowers 8030. Duchesne County, Uintah Mountains, near Mirror Lake, on wet brook bank, 10,300 feet; 2075. Summit County, Uintah Mountains, Upper Provo River, near Bald Mountain, in seepage area, 9,900 feet.

S. curta has a predominance of acute or narrowly obtuse leaves which are not decurrent, the margins entire to dentate, occasionally strongly so in a few leaves, but mostly the teeth are low, blunt and quite widely spaced. The line of junction of the lobes is weakly keeled to rounded so that the dorsal one stands out from the stem, the two not being very strongly conduplicate.

12. RADULA Dumort., p. p. Comm. Bot. 112; 1822; Rec. d'obs. 14; 1835.

Martinellus S. F. Gray p.p., Nat. Arr. Brit. Pl. 1, 691; 1821.

Stephanina O. Kuntze, Rev. Gen. Pl. 839; 1891; Schiffn. in Engl. and Prantl, Nat. Pflanz. 1-3, 113; 1895.

Plants medium-sized to rather large, in thin or compact mats or tufts; stems prostrate, ascending or suberect, pinnately, subpinnately or irregularly branched; rhizoids dense at the base, few above or lacking; leaves incubous, complicately 2-lobed, the ventral lobe about $\frac{1}{4}$ as large as the dorsal one, quadrate, rhomboidal or ovate, the free margin appressed to the underside of the stem and dorsal lobe, mostly obtuse; margin entire (in ours); the dorsal lobe broadly rounded, mostly obovate, leaf cells rounded-quadrate to hexagonal, trigones small or lacking; underleaves always lacking; gemmae discoid, many-celled, borne on the distal margins of the leaves.

Dioicous or paroicous. Androecia terminal; antheridial bracts similar to the leaves but strongly saccate at the base; antheridia solitary, globose; archegonia terminal, seldom on a short branch; perianth usually large and dorso-ventrally compressed, oblong to linear; apex mostly truncate, 2-lobed or 2-lipped, often subtended by small innovations; capsules on short stout setae, oval-cylindrical; walls bistratose, dehiscent by 4 valves; spores globose; elaters long and slender, with 2 close spirals, ends blunt. *Radula* (Latin), a scraper or scraping iron, referring to the flattened apex of the perianth which resembles such an instrument.

Radula complanata (L.) Dumort., Comm. Bot. 112, 1822.

Jungermannia complanata L., Sp. Pl. 1133, 1753.

Plants yellowish-green in thin but compact mats, often among mosses; stems 1–5 cm. long, prostrate to ascending, subpinnate to irregularly branched, more or less flexuose; rhizoids restricted to the underside of the ventral lobes of the leaves, colorless; leaves incubous, closely imbricated above, distant below; the dorsal lobe broadly rounded or obovate, 0.8–1 mm. long often broader than long, entire, crossing the stem, mostly patent, flat; ventral lobe about ¼ as large as the dorsal one, quadrate or subrhomboidal, not crossing the width of the stem, outer angle obtuse; leaf cells rounded-polygonal, isodiametric or slightly elongated, mostly 18–25 μ, walls thin, trigones small or lacking; underleaves absent; gemmae large, multicellular and discoid.

Paroicous. Antheridia globose, solitary, in saccate bracts subtending the archegonia; perianth large, terminal, oblong and flattened compressed at the tip; mouth wide, 2-lipped, truncate; involucral bracts resembling leaves, but slightly longer, ventral lobe about 1.5 times longer than the dorsal one; seta short; capsule oval, brown; inner layer of cells with nodular thickenings; spores globose, pale yellowish-brown, densely papillose, 25–36 μ; elaters bispiral, yellowish-brown.

On rocks or trees usually in rather dry or damp shaded places; among shaded cliffs. Nearly world wide in distribution.

Illustrations: Plate XVIII, 9–16.

Collection examined: Flowers 8021. Kane County, Kanab Canyon near Three Lakes, on damp sandstone at mouth of cave, 5,600 feet.

Reported from the Uintah Mountains, 9,000 feet. King, Clarence, U.S. Geol. Expl. 40th Parallel 5: 411. 1871.

13. PORELLA L., Sp. Pl. 2: 1106; 1753.

Bellincinia Raddi, Mem. Soc. Ital. Modena 18: 18; 1818.
Antoiria Raddi, l.c. p. 19 .
Cavendishia S. F. Gray, Nat. Arr. Brit. Pl. 689; 1821.
Madotheca Dumort., Comm. Bot. 111; 1822.

Plants large, dark green, blackish-green or brownish, usually in dense mats; stems prostrate to ascending, regularly or irregularly 1–3 times pinnately branched; branches lateral, widely spreading; rhizoids few, pale to brownish from the base of the underleaves; leaves imbricated, incubous, complicate-divided into a large, usually broadly ovate dorsal lobe, entire or dentate, obtuse, and a small ovate to linear ventral lobe, usually strongly decurrent, entire to dentate; underleaves always present, large and usually decurrent, mostly dentate, distant to imbricated.

Dioicous. Androecium on a very short lateral branch, terminal; bracts connate and adnate to the underleaves; antheridia solitary; archegonia terminal on very short lateral branches; bracts usually 1 pair, mostly dentate or ciliate; perianth short, ovate or ovate-truncate, triangular in cross-section, compressed dorso-ventrally, becoming 2-lipped and campanulate when the capsule pushes through; capsule on short seta, globose, dehiscent by 4 valves, often irregularly splitting; spores globose, several-celled; elaters with 2–3 spirals. Name from the Latin *porellus*, a little pore, of uncertain application to the plant.

A genus of about 77 species widely distributed throughout the world but mainly in the tropics.

Porella bolanderi (Aust.) Pears., List Canadian Hep. in Geol. & Nat. Hist. Survey Canada, 7, 1890.

Madotheca bolanderi Aust., Bull. Torr. Bot. Club 3: 14; 1872.

Plants dark green, often tinged with yellow, brownish below, in rather loose interwoven mats; stems prostrate, tips often ascending, 4–10 cm. long, 1–3 times irregularly pinnately branched, some of the branches long, often attenuated, and decurved; rhizoids few, whitish or pale brown; leaves rather closely imbricated, incubous, widely spreading; dorsal lobe about 2 mm. long, broadly ovate to ovate-triangular, rather broadly to somewhat narrowly obtuse; margins slightly undulate with a few large teeth on the side toward the stem, often with a broad cilium near the base; insertion slightly oblique and nearly crossing the stem; ventral lobe narrowly triangular to triangular-ovate, concave, often slightly lobed; margin toward the stem dentate-ciliate and very strongly decurrent on the stem, union with the dorsal lobe very narrow, upper medial leaf cells rounded-polygonal, 23–36 μ, some slightly elongated, mostly thin-walled, trigones small but distinct; underleaves distant or sometimes becoming imbricated, very strongly decurrent on both sides, upper ones often bifid, mostly obtuse; margins dentate to subentire, teeth few and large; gemmae unknown.

Dioicous. Male plants usually scarce; archegonial branches usually numerous, small, leaves few, outer bracts 2, ovate, narowly obtuse, entire or with 1–2 teeth; ventral lobe rather large about half as long as the dorsal one, the tips subacute to blunt, more or less connate at the base; inner bracteoles smaller, narrower with more or less acuminate tips; archegonia 4–8; perianth broadly ovoid from a short obconic base, more or less plicate, especially ventrally, narrowed at mouth; mouth about half as wide as the perianth, deeply 2-lipped, the lips ciliate; seta about $1\frac{1}{2}$ times as long as the perianth; capsule ovoid or ovoid-oblong; elaters 180–316 μ long, 10–12 μ thick, mostly 2-spiraled (rarely 3); spores 29–40 μ, minutely roughened. Rarely fruiting.

On dry or damp soil or rocks, often on the face of cliffs, or overhanging rocks, in well-shaded places in deep canyons, usually where it is cool. Common in the Wasatch Mountains. Utah and California.

Illustrations: Plate XI, 14–19 and Figures 15 and 26.

Collections examined: Flowers 1607. Salt Lake County, Wasatch Mountains, Little Cottonwood Canyon, on damp soil and granite rocks, 7,000 feet; 7196. City Creek Canyon, on limestone cliff in shade, 6,000 feet; 8018. Big Cottonwood Canyon, Stairs Fork, on shaded quartzite cliff, 6,100 feet.

Rather common in certain localities in the Wasatch Mountains and probably elsewhere. Of the numerous collections none has been found fruiting, the male plants have not been found but archegonia are numerous on the female plant.

14. FRULLANIA Raddi, Atti Soc. Ital. Sci. Modena 18: 20; 1818.

Plants small to large, green, reddish-brown or blackish-green, solitary, widely spreading or in low dense mats; stems irregularly to pinnatly branched; branches lateral from the axils of the stem leaves; rhizoids few, from the bases of the underleaves; leaves incubous, distant to imbricated, complicately bilobed; dorsal lobe larger, rounded to obliquely ovate, mostly concave, entire; ventral lobe small, concave, cucullate-saccate or helmet-shaped, distant from the stem, bearing at the base toward the stem a slender triangular process, the stylus; leaf cells rather thick-walled, with trigones and often with intermediate thickenings; underleaves always present, bifid.

Dioicous or autoicous. Androecia on short lateral branches; bracts densely crowded in a globose or oblong cluster, unequally bilobed, saccate;

antheridia 3–4; archegonia on short lateral branches; bracts 2–5 pairs, adnate, the inner ones connate, larger than the leaves, free from the perianth; lobes subentire, dentate, ciliate or laciniate; perianth usually large, emergent, triangular in cross section, often with intermediate folds, more or less dorso-ventrally compressed, one angle ventral; apex rounded to truncate with a short cylindrical beak, the latter torn by the emerging capsule; capsule globose on a rather short seta; walls bistratose, dihescent to the base by 4 valves; elaters few, mostly with 1 spiral, ends blunt or expanded, mostly attached to the inner face of the valves on their upper half; spores mostly large, variously roughened. Named in honor of Leonardo Frullani of Florence, Italy, Councilor of State, Finance and War, and Director of Finance and Savings in Tuscany.

A large family of about 300 species, mostly tropical.

Frullania inflata Gottsche in G.L.N., Syn. Hep. 424; 1845.

F. mexicana Lindenb. in G.L.N., Syn. Hep. 424; 1845.
F. saxicola Aust., Proc. Acad. Nat. Sci. Philadelphia 21 (1869): 225; 1870.
F. rappi Evans, Bryologist 15: 22, f. 1–9; 1912.

Plants small, in thin compact mats, dark green to blackish-green, becoming brownish when old; stems prostrate to ascending, 0.5–2 cm. long, irregularly branched, more or less flexuose; rhizoids few, pale; leaves small, 0.3–0.6 mm., usually increasing in size upward on the stem, subdistant to incubously imbricated; dorsal lobe rounded to obliquely ovate, concave with the dorsal side convex; ventral lobe ovate to obovate, concave, cucullate or saccate; stylus small, sometimes lacking; leaf cells rounded or polygonal, 16–23 μ, densely chlorophyllose, walls rather thick, trigones small; underleaves rather large, about 0.2 mm. long, ovate, deeply bifid, tips of the lobes acute or blunt.

Autoicous. Androecium on short branches, bracts densely imbricated, forming a globose or obovate cluster; perianth large, emergent, pyriform to obovate-oblong, with intermediate folds, apex broadly rounded, beak short, free and open; papillae on the inner surface of the mouth small, few or lacking; involucral bracts larger than the leaves, more or less elongated, erect, the inner ones connate and usually united to the smaller bracteoles; capsule globose, dark brown, on a short seta, shortly exserted from the perianth; calyptra shortly pyriform, becoming bilobed when the capsule pushes through it; spores 27–30 μ, pale brown, finely papillose; elaters 1-spiral, a few bispiral, apex expanded, reddish-brown.

On rather dry or damp rocks and bases of trees, sometimes on soil, often on the underside of overhanging rocks, bases of cliffs or among ledges in shaded canyons.

Illustrations: Plate XVIII, 17–24.

Collections examined: Flowers 8020, 8026, 8075. Kane County, Kanab Canyon at Three Lakes, on bases of tree trunks and on bases of sandstone cliffs, quite dry, 5,000 feet.

GLOSSARY

Acrogenous, having the archegonium originating from the apical cell and therefore the sporophyte is terminal on stems or branches. Characteristic of the leafy liverworts.

Acuminate, having the apex curving inward and then tapering outward to a slender tip.

Air chambers, cavities in the thallus or gametophores.

Anacrogynous, having the archegonium originating from a cell behind and dorsal to the apical cell, the sporophyte therefore being dorsal or only apparently terminal.

Annular, ring-like.

Antheridium, male sex organ.

Apiculate, having a short sharp point.

Appressed, lying close or flat against another part.

Approximate, close together, just touching or nearly so.

Archegonium, female sex organ.

Arcuate, curved like a bow.

Areolae, small areas on the surface of the thallus or spores.

Areolation, network of cells of a leaf.

Auricle, a small lobe or ear at the base.

Autoicous, having antheridia and archegonia on the same plant but on different branches.

Axil, the angle between the stem and leaf.

Bifid, cut into two divisions.

Bilabiate, two-lipped.

Biseriate, in two rows.

Bracts, modified leaves with antheridia or archegonia in their axils.

Caespitose, tufted.

Calyptra, a protective hood covering the capsule, originating from the base of old archegonium.

Campanulate, bell-shaped.

Canaliculate, channelled.

Carinate, keeled.

Chlorophyllose, rich in chlorophyll.

Chloroplasts, grains containing chlorophyll.

Ciliate, fringed with hair-like processes.

Circinnate, curved like a sickle.

Clavate, club-shaped.

Collenchymatous, having the cell walls thickened at the angles.

Columella, a central column of sterile cells extending through the capsule.

Commissure, the plane or line of junction of two parts, as in conduplicate leaves.

Complanate, compressed or flattened, in the same plane.

Complicate, folded together.

Complicate-bilobed, with one lobe folded against the other.

Compressed, flattened.

Costa, midrib of the thallus or leaves.

Cordate, heart-shaped.

Coriaceous, leathery.

Crenulate, scalloped or with rounded teeth on the margin.

Crisped, Crispate, curled or twisted.

Cruciate, like a cross.

Cucullate, hood-shaped.

Cuticle, outer layer of wall substance of cells.

Deciduous, falling off early.

Decurrent, basal margin of a leaf extending down the stem in wing-like fashion.

Deltoid, triangular.

Dehisce, Dehiscence, Dehiscent, splitting open at maturity.

Dentate, toothed.

Dichotomous, having forked branches.

Dioicous, having antheridia and archegonia on separate plants.

Disc, a more or less circular flattened structure; in hepatics a receptacle within which or upon which the sex organs are borne. Often used as a synonym for receptacle.

Discoid, like a small disc.

Dorsal, back, upper side; side away from stem.

Elaters, slender cells with spiral thickenings produced in rows alternating with the spores.

Endogenous, originating from within the tissues of an organ.

Exogenous, originating from superficial cells.

Exserted, projecting beyond surrounding structures.

Fimbriate, fringed.

Flagellum, a very slender filiform branch with reduced leaves.

Foot, basal part of the embryo or sporophyte forming an organ which absorbs food from the gametophyte.

Gametophyte, the generation of a plant reproducing gametes; bearing sex organs; haploid.

Gemmae, asexual buds, becoming detached and under favorable conditions growing into new plants.

Glaucous, bluish-gray or with a whitish caste.

Hyaline, transparent or without color.

Hypogenous, a structure inserted or located below the archegonia.

Imbricated, overlapping like shingles on a roof.

Immersed, not projecting beyond surrounding structures; included.

Incised, sharply cut.

Included, immersed; not projecting beyond the surrounding structures.

Incubous, position of the leaves when the anterior margin of a leaf overlaps the posterior margin of the leaf in front or above it on the same side of the stem. Applies only to the dorsal view.

Innovation, a new shoot arising from below the perianth.

Insertion, point of attachment of a structure as leaves on stems.

Intercallary, located between the base and apex.

Involucre, in thallose liverworts a short tube-like or elongated pair of valves derived from the thallus and forming a protective covering of the archegonia. At maturity it is the outermost sheath and may enclose the entire sporophyte or only the base of the seta. In leafy liverworts the upper pair of bracts just below the perianth.

Laciniate, much cut, fringed.

Lamella, a plate or sheet of tissue.

Lamina, the flat expanded portion of the thallus or leaf.

Lanceolate, like a lance head, broadest at the base and tapering to a rather long apex.

Lateral, attached to the side.

Lumen, cavity within a cell.

Midrib, thickened middle portion of the thallus or leaf.

Monoicous, having both antheridia and archegonia on the same plant but on different branches.

Obcordate, reversed heart-shaped.

Obconical, reversed cone-shaped.

Obovate, reversed ovate.

Obtuse, with apex or tips, or sinuses rounded.

Ostiole, a tubular neck of the antheridial cavities.

Ovate, egg-shaped or nearly so, base broadest.

Papillae, minute protuberances.

Papillose, covered with papillae.

Paraphyses, scales or hairs subtending or mixed with the antheridia.

Parenchyma, short, thin-walled cells.

Paroicous, having the antheridia below the archegonia on the same stem or branch.

Patent, spreading at about a 45° angle.

Perianth, a tubular sheath forming an inner protective envelope surrounding the archegonia. Originating in hepatics by the nondivergence of modified leaves immediately below the archegonia.

Plicate, folded, pleated.

Postical, belonging to the back or lower part of a leaf or stem.

Procumbent, prostrate, spreading on the ground.

Pseudoperianth, a sheath arising from the base of the venter. When mature it is just outside of the calyptra.

Pyriform, pear-shaped.

Quadrate, more or less square in outline.

Radial, radiating or spreading from a common center or axis.

Receptacle, an outgrowth of the thallus or a modified branch, often with a stalk, having an expanded structure within which or upon which the sex organs are borne. Also applied to the gemmae cups. The term disc is often used synonymously.

Recurved, curving backwards from the main plane or away from another structure.

Reniform, kidney-shaped.

Reticulate, forming a net-work.

Retuse, a truncate apex with a notch.

Revolute, margins rolled backwards.

Rhizoids, hair-like organs arising from the underside of the thalluus or from the stem and sometimes the leaves.

Rhizoid furrow, a furrow in the stalk of the gametophores containing rhizoids.

Saccate, like a sac, bulged at the base.

Scale, a thin, flat, more or less transparent outgrowth.

Sclerenchyma, hard thick-walled cells.

Secund, turned to one side.

Serrate margin with teeth like a saw.

Serrulate, finely serrate.

Sessile, sitting, without an apparent stalk.

Sinus, the space between two projecting parts.

Spathulate, broad at the apex and narrowed at the base like a spatula or spoon.

Sporogonium, sporophyte, a spore sac.

Sporophyte, asexual generation producing tetraspores in the capsule. Diploid generation. In hepatics mostly consisting of foot, seta and capsule.

Squarrose, abruptly spreading at right angles to the stem.

Stellate, star-like, radiating from a common center.

Stolon, a creeping stem, usually without leaves or with small ones.

Striate, with streaks or shallow furrows, usually parallel.

Stylus, a small slender lobe of a leaf.

Subulate, long and narrowly tapering like an awl.

Succubous, the position of leaves when the posterior margin of a leaf overlaps the anterior margin of the leaf back of or below it on the same side of the stem. Applies only to the dorsal veiw.

Synoicous, having antheridia and archegonia mixed together in the same involucre.

Terete, round or cylindrical.

Tetrad, spores grouped in 4's until fully mature.

Thallus, the flat leaf-like body of a liverwort not differentiated into stem and leaves.

Trigones, the thickened angles where 3 or 4 cells converge.

Truncate, abruptly cut off at the apex.

Tuberculate, surface beset with warts.

Turbinate, top-shaped.

Underleaves, a third row of leaves on the underside of the stem in leafy liverworts; mostly very small.

Undulate, wavy on the margin or surface.

Unistratose, having the cells in a single layer.

Vaginate, sheathing.

Valve, (valves) the divisions of a capsule wall after it has opened.

Venter, the more or less swollen base of the archegonium containing the egg.

Ventricose, bulging, usually at the base.

Vermicule, Vermiculate, like a little worm.

BIBLIOGRAPHY

CLARK, L.

1957. Hepaticae collected in Nevada by Elva Lawton in 1955. Bryologist, 60: 32–35.

CLARK, L. and T. C. FRYE

1928. The liverworts of the northwest. Pub. Puget Sound Biol. Sta., 6: 1-194.

1931a. Hepaticae new to some northwestern states. Bryologist, 34: 54–55.

1931b. Liverworts new to Wyoming and Washington. Bryologist, 34: 82–83.

1936. Some Hepaticae from California. Bryologist, 39: 91–95.

CLARK, L. and L. RAKESTRAW

1938. Hepaticae of the Wallowa Mountains (NW Oregon). Bryologist, 41: 137-139.

EVANS, A. W.

1915. Preliminary list of Colorado Hepaticae. Bryologist, 18: 44–47.

1923. Targioniaceae in N. Amer. Flora (New York Bot. Gard.), 14: 31–33.

1923a. Reboutiaceae in N. Amer. Flora (New York Bot. Gard.), 14: 39–56.

1923b. Marchantiaceae in N. Amer. Flora (New York Bot. Gard.), 14: 57-66.

1938. A new species of Chiloscyphus from Utah. Bryologist, 41: 50-57.

FLOWERS, S.

1936. Bryophytes of Utah. Bryologist, 39: 97–104.

1945. Utah Hepaticae. Bryologist, 48: 8–11.

1954. Liverworts of Utah. Proc. Utah Acad. Sci., Arts and Letters, 31: 93–100.

FOSTER, A. S.

1909. Bryophytes from Mount Hood region, Oregon. Bryologist, 12: 64.

FROST, C. C.

1871. Report on Hepaticae. In King, C., Rept. of the Survey of the Fortieth Parallel, 5: 411.

FRYE, T. C. and L. CLARK

1937-47. Hepaticae of North America, Univ. of Wash. Publ. Biol., 6: (pts. 1–5) 1–1018.

FULFORD, M.

1936. Some Hepaticae from Oregon, Washington and Idaho collected by Arthur Svihla. Bryologist, 39: 105–111.

HAYNES, C. C.

1909. An enumeration of the Washington and Oregon Hepaticae collected by Mr. A. S. Foster, 1904-1909. Bryologist, 12: 65–71.

KINGMAN, C. C.

1911. Notes on Hepaticae of southern California. Bryologist, 14: 33–34.

LITTLE, E. L., JR.

1939. Hepaticae of Sierra Ancha, Arizona. Bryologist, 42: 23–27.

1942a. Notes on the genus Riccia in New Mexico. Bryologist, 45: 147–148.

1942b. Liverworts at Rainbow Bridge National Monument, Utah, 45: 148–149.

MACVICAR, S. M.

1926. The student's handbook of British hepatics, Ed. II. I–XXXI and pp. 1–464. Eastbourne.

PEARSON, W. H.

1921. Notes on a small collection of hepatics from Oregon. Bryologist, 24: 21.

PORTER, C. L.

1933. The Bryophytes of Wyoming, Part I. Hepaticae. Bryologist, 36: 5–8.

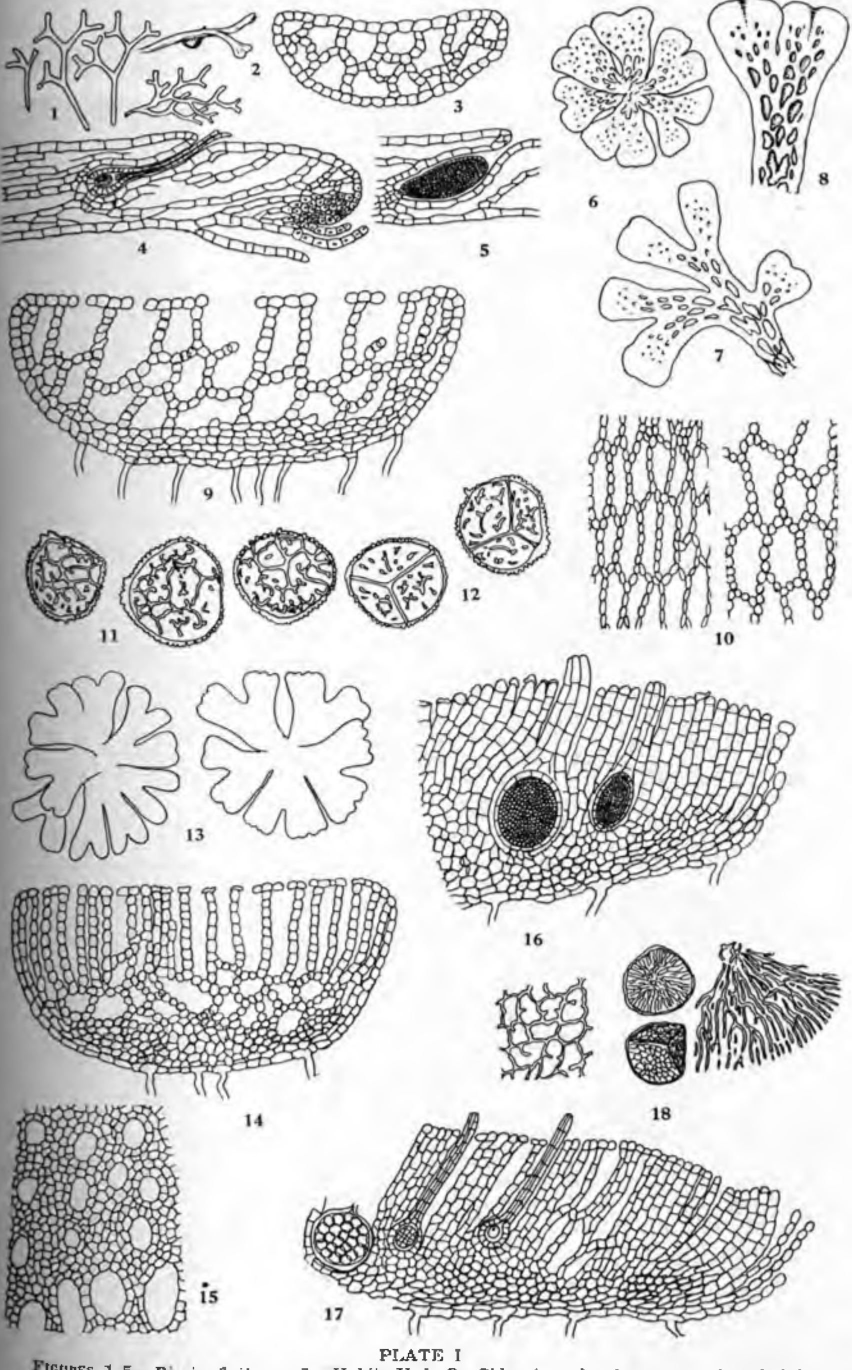


PLATE I

FIGURES 1–5. *Riccia fluitans.* 1. Habit, X 4; 2. Side view showing sporangium bulging on lower side, X 8; 3. Cross section of the thallus, X 40; 4. Longitudinal section of the thallus showing an archegonium, X 40; 5. Same showing an antheridium, X 40.

FIGURES 6–10. *Riccia crystallina.* 6. Rosette habit, X 4; 7. Habit, X 8; 8. A segment showing the progressive enlargement of the lacunae, X 16; 9. Cross section of the thallus in the younger part, X 60; 10. Surface configuration of the thallus, the epidermis largely disintegrated, X 30; 11. Three spores, outer surface; 12. Two spores, inner surfaces, X 160.

FIGURES 13–18. *Riccia frostii.* 13. Rosette habit, X 4; 14. Cross section of the thallus, X 40 (note: the vertical air chambers are often much narrower and approach the condition of *Riccia glauca*); 15. Surface view of the epidermis showing enlargement of the lacunae, X 40; 16. Longitudinal section of the thallus showing antheridia, X 40; 17. Same showing two archegonia and a young sporangium, X 40; 18. Spores with surface markings enlarged, X 160.

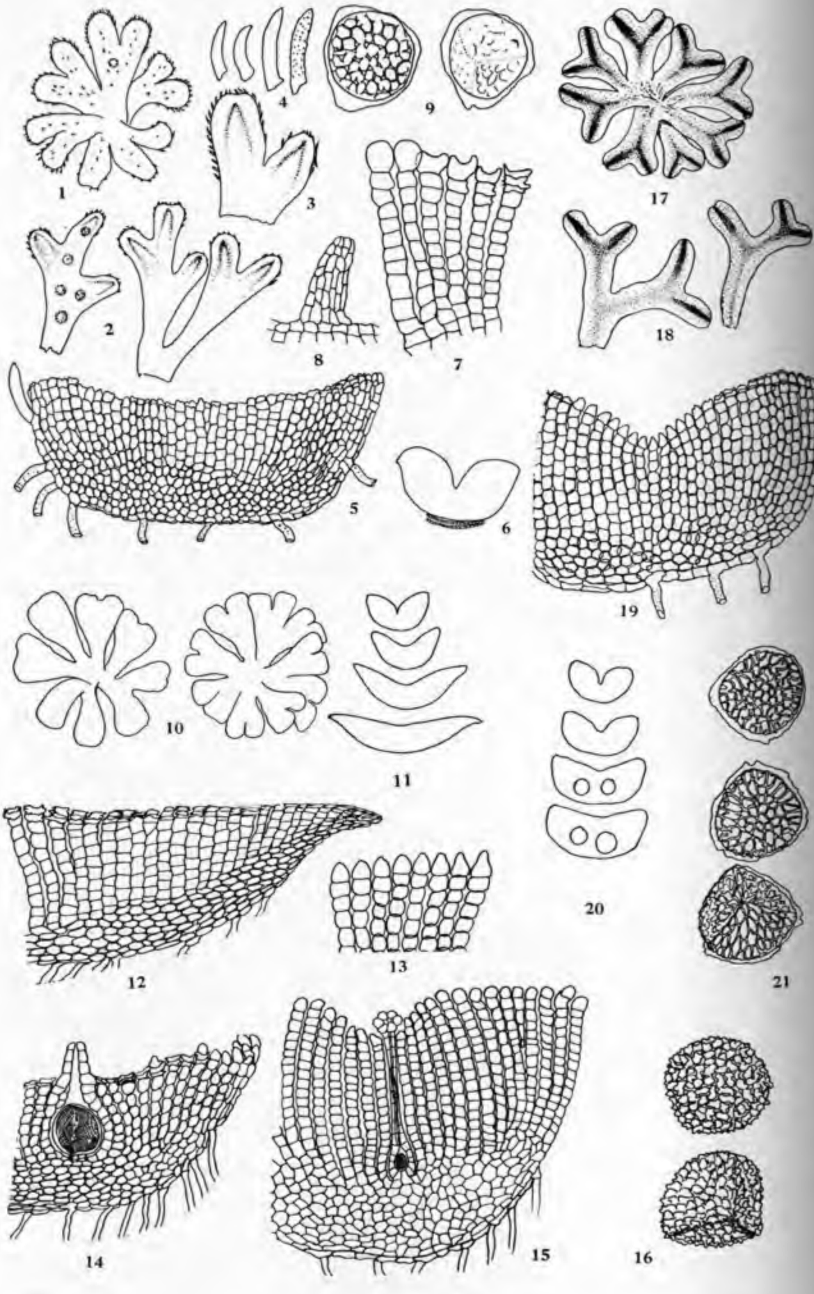


PLATE II

FIGURES 1–9. *Riccia beyrichiana.* 1. Rosette habit, X 4; 2. Habit, X 4; 3. Segments showing setae, X 8; 4. Setae, X 75; 5. Cross section of the thallus, X 40; 6. Outline of cross section of the thallus near the apex of a segment, X 16; 7. Detail of the vertical plates of cells showing the epidermal cells and their collapse, X 80; 8. Ostiole of antheridial chamber, X 75; 9. Spores, X 160.

FIGURES 10–16. *Riccia glauca.* 10. Rosette habit, X 4; 11. Successive cross sections of a segment from apex to the base, X 8; 12. Cross section of the thallus, X 40; 13. Detail of the vertical plates of cells showing the epidermal cells before collapsing, X 75; 14–15. Cross sections of the thallus showing an antheridium and archegonium respectively, X 40; 16. Spores, X 160.

FIGURES 17–21. *Riccia sorocarpa.* 17. Rosette habit, X 4; 18. Habit, X 4; 19. Cross section of the thallus in younger part showing the epidermal cells and their collapse, X 40; 20. Successive cross sections of a segment from apex to base, X 8; 21. Spores, X 160.

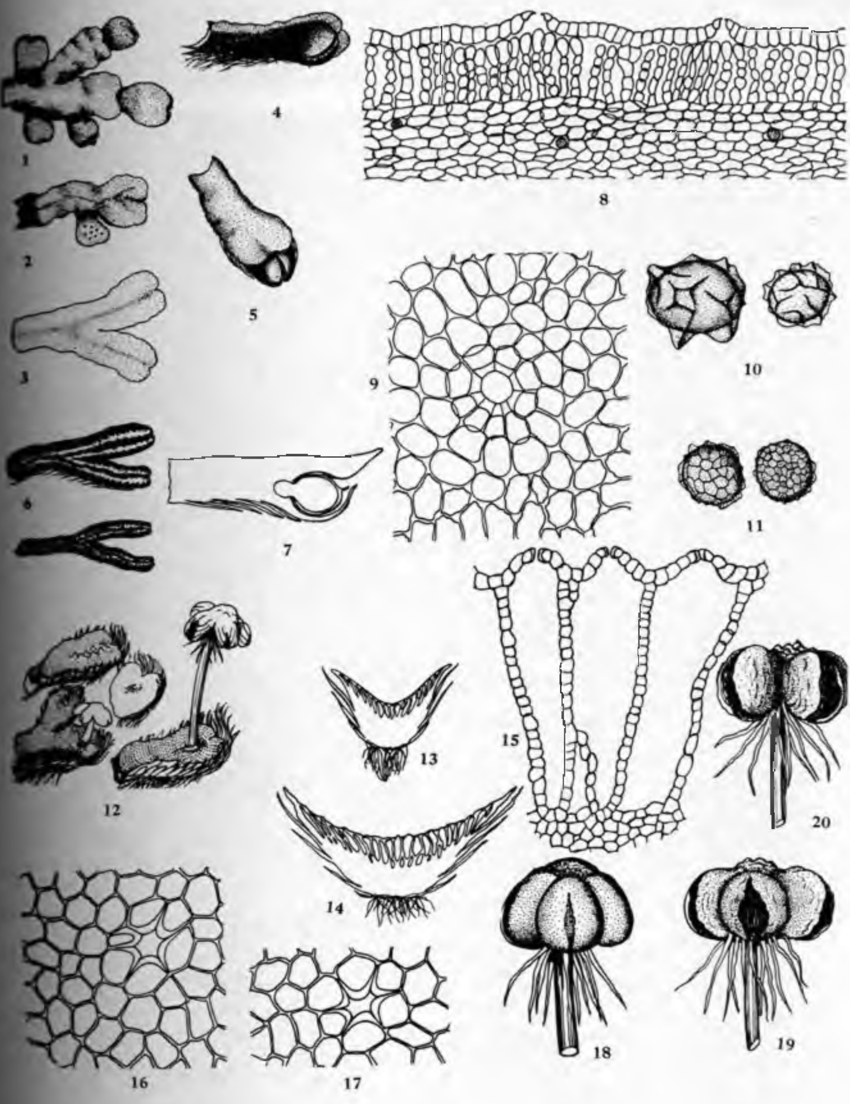


PLATE III

FIGURES 1–11. *Targionia hypophylla.* 1–3. Habit sketches, X 2; 4–5. Two views of the fertile branch showing the bilabiate involucre, X 4; 6. Dorsal view of the dry thallus showing the strongly incurved wings and black ventral scales, X 2; 7. Longitudinal section of a fertile branch showing the position of the sporophyte, X 6; 8. Cross section of the upper part of the thallus X 50; 9. Surface view of the epidermis with a pore, X 160; 10. Large spore and 11. Small spores from same capsule, X 160.

FIGURES 12–20. *Clevea hyalina.* 12. Habit sketches, X 2; 13–14. Cross sections of the thallus at different points showing the form, and position of the air chambers, X 10; 15. Vertical section through the dorsal part of the thallus showing air chambers and pores, X 50; 16–17. Surface views of the epidermis showing pores, X 160; 18–20. Archegonial receptacles, moist and dry, X 6.

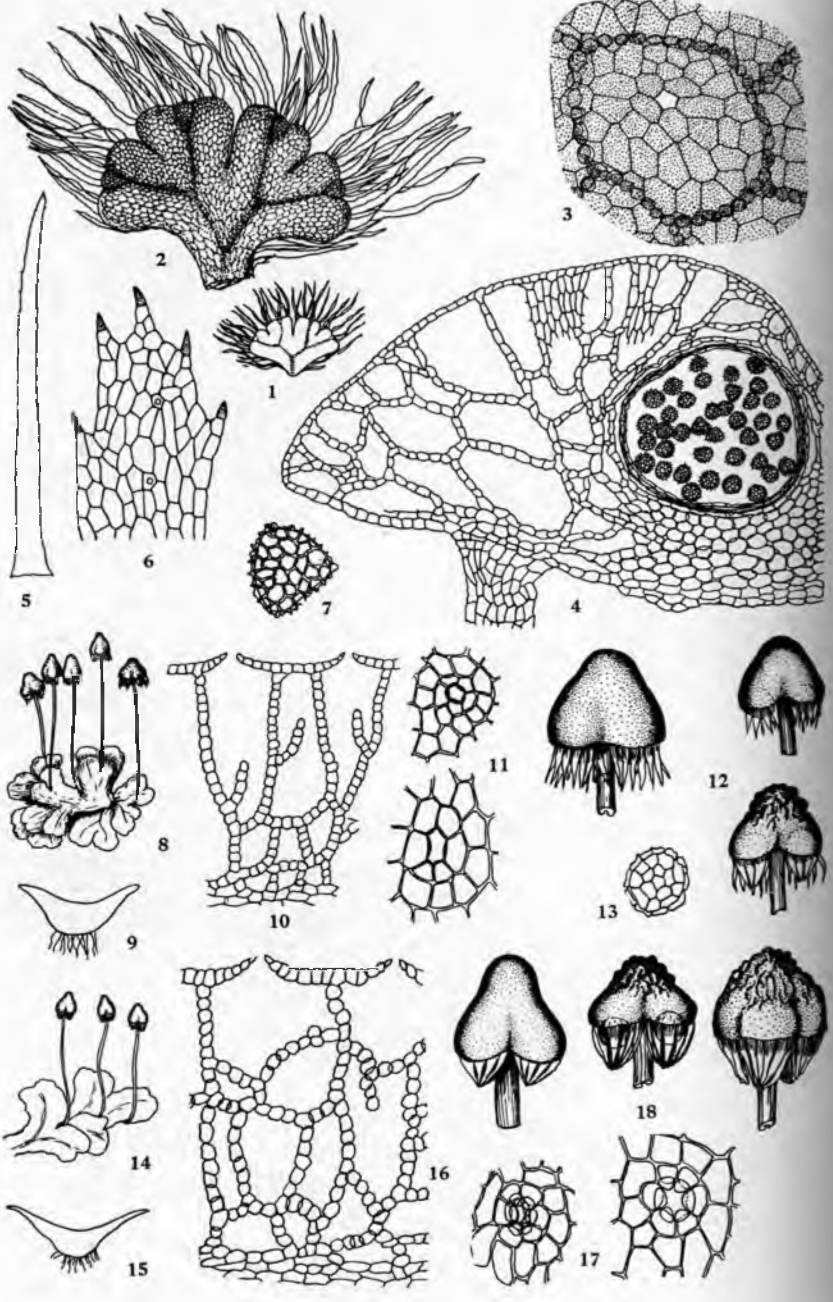


PLATE IV

FIGURES 1–7. *Ricciocarpus natans*. 1. Habit, X 2; 2. Habit in detail, X 6; 3. Surface view of the epidermis showing air pore and areolae, X 125; 4. Cross section of the thallus showing air chambers and a sporophyte, X 60; 5. Ventral scale, X 20; 6. Apex of a ventral scale, X 125; 7. A spore, X 125.

FIGURES 8–13. *Asterella ludwigii*. 8. Habit, X 2; 9. Outline of cross section of the thallus, X 10; 10. Vertical section through the upper part of the thallus showing simple air chambers, X 60; 11. Two examples of the air pores and surrounding epidermal cells, X 125; 12. Three female receptacles showing prominent whitish pseudoperianth free at tips, X 8; 13. a spore, X 125.

FIGURES 14–18. *Asterella lindenbergiana*. 14. Habit, X 2; 15. Outline of cross section of the thallus, X 10; 16. Vertical section through the upper part of the thallus showing supplementary portions of the air chambers, X 80; 17. Examples of two air pores and surrounding cells in radial rows, X 125; 18. Three female receptacles with prominent reddish-purple pseudoperianth, united at the tips, X 8.

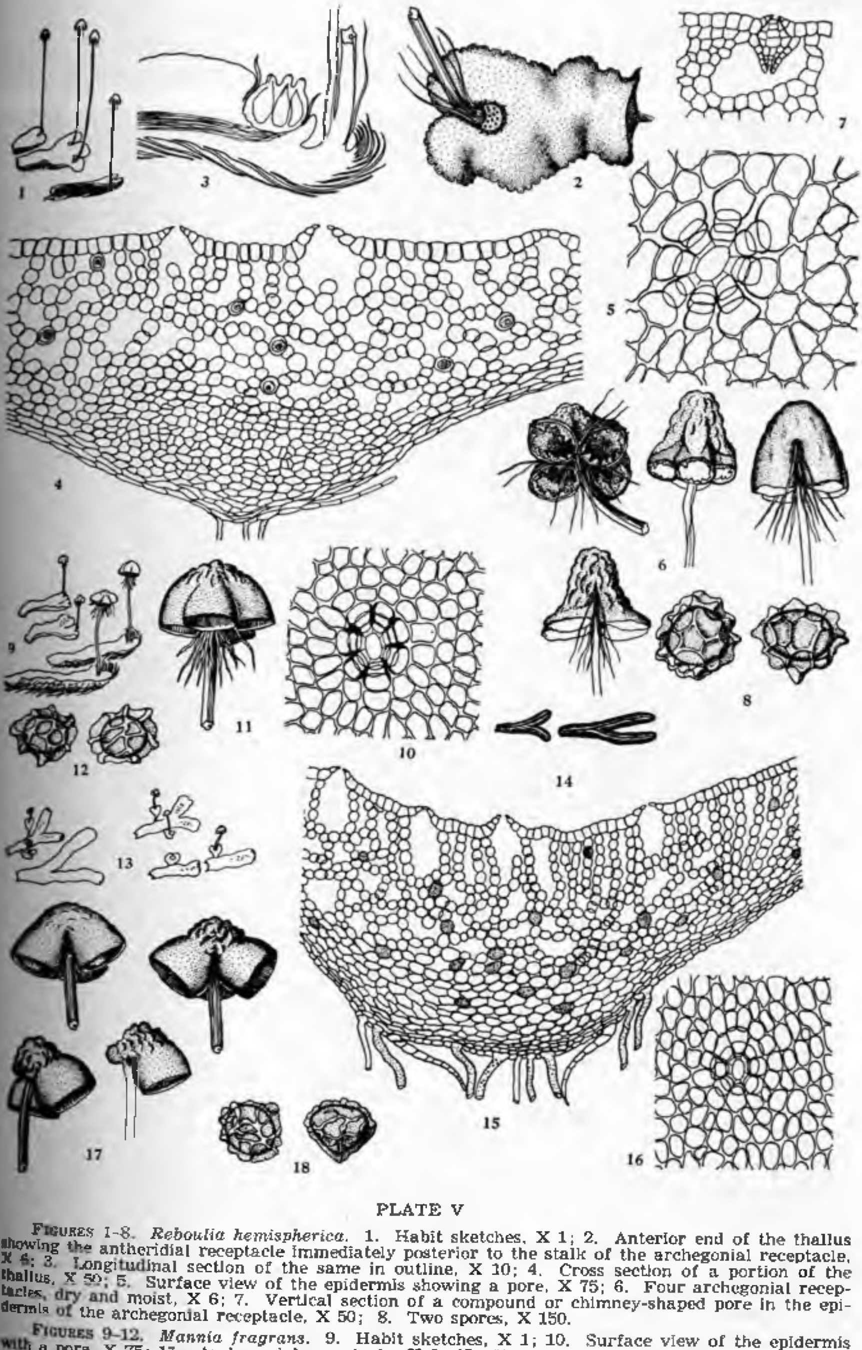


PLATE V

FIGURES 1–8. *Reboulia hemispherica*. 1. Habit sketches, X 1; 2. Anterior end of the thallus showing the antheridial receptacle immediately posterior to the stalk of the archegonial receptacle, X 6; 3. Longitudinal section of the same in outline, X 10; 4. Cross section of a portion of the thallus, X 50; 5. Surface view of the epidermis showing a pore, X 75; 6. Four archegonial receptacles, dry and moist, X 6; 7. Vertical section of a compound or chimney-shaped pore in the epidermis of the archegonial receptacle, X 50; 8. Two spores, X 150.

FIGURES 9–12. *Mannia fragrans*. 9. Habit sketches, X 1; 10. Surface view of the epidermis with a pore, X 75; 11. Archegonial receptacle, X 6; 12. Two spores, X 150.

FIGURES 13–16. *Mannia californica*. 13. Habit sketches, X 1; 14. Habit sketch dry, X 2; 15. Cross section of a part of the thallus, X 50; 16. Surface view of the epidermis showing a pore, X 75; 17. Four archegonial receptacles, X 6; 18. Two spores, X 150.

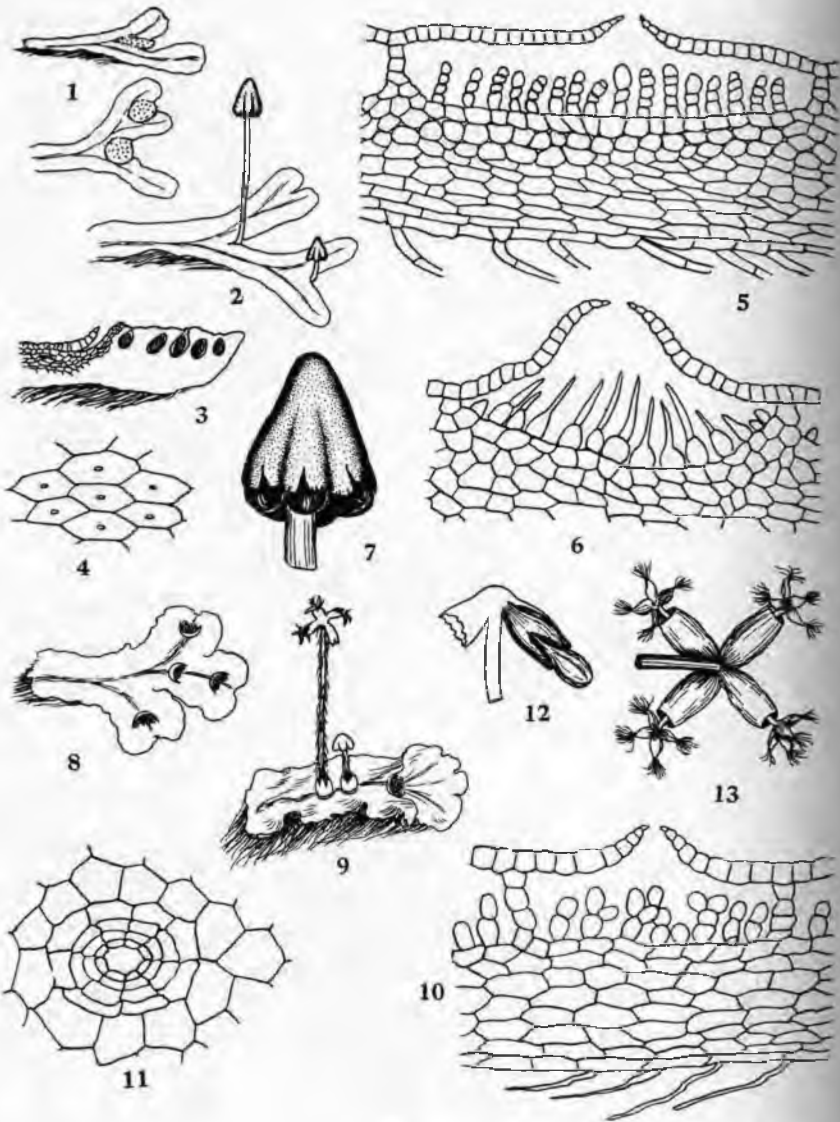


PLATE VI

FIGURES 1-7. *Conocephalum conicum.* 1. Male plants, X 1; Female plant, X 1; 3. Longitudinal section through the antheridial disc, X 6; 4. Surface view of areolae, X 10; 5. Longitudinal section through an older part of the thallus, X 60; 6. Same through the younger part, X 50; 7. Mature female gametophore, X 6.

FIGURES 8-13. *Lunularia cruciata.* 8. Habit showing cupules, X 1; 9. Habit with gametophores, X 1; 10. Cross section through the thallus, X 50; 11. Surface of the epidermis showing a pore, X 75; 12. Dissection of a lobe of the female gametophore showing the outer involucre and sporophyte, 13. Ventral view showing dehised capsules; (9, 12 and 13, after Bischoff.)

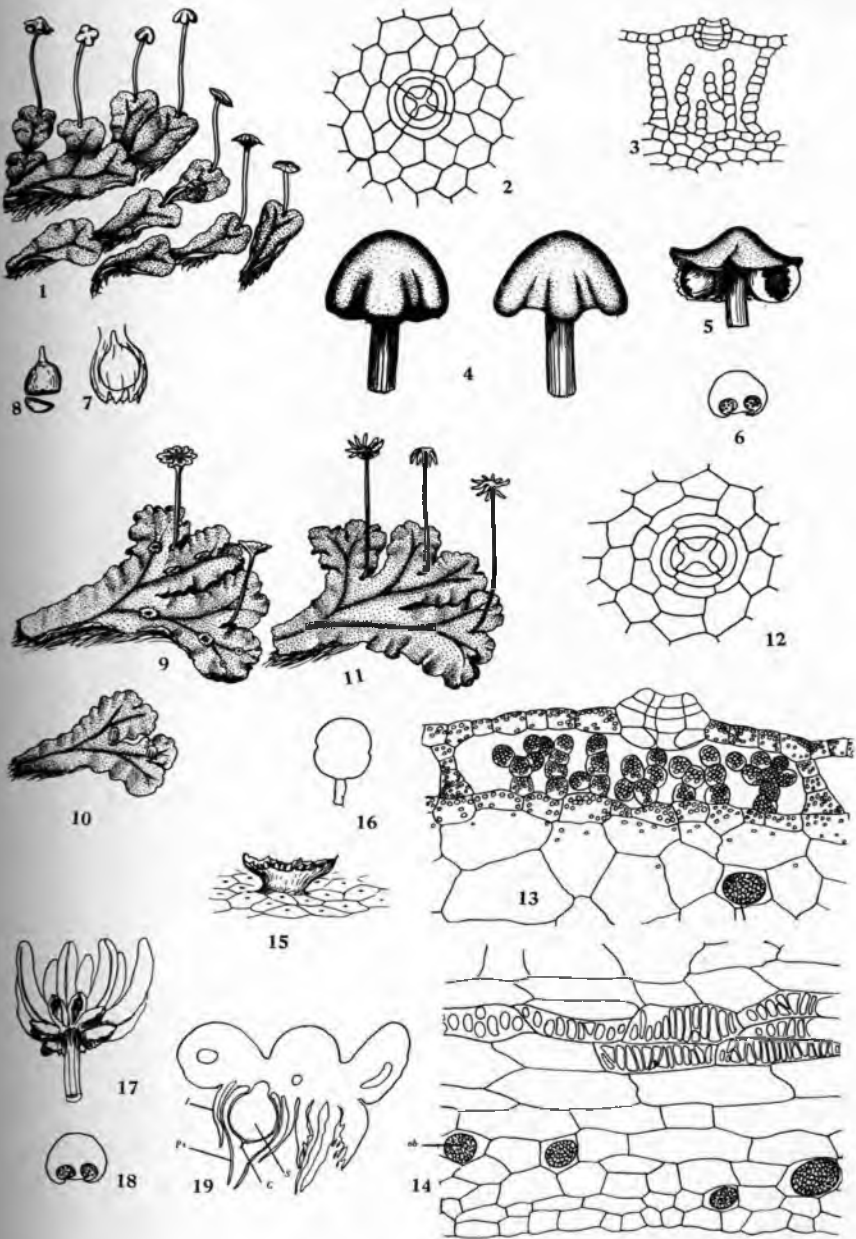


PLATE VII

FIGURES 1–8. *Preissia quadrata*. 1. Habit sketches of female and male plants, X 1; 2. Surface view of the epidermis showing an air pore, X 150; 3. Vertical section of the upper part of the thallus showing an air chamber with pore, X 50; 4. Two female receptacles, X 10; 5. Female receptacle at maturity showing involucres inclosing sporophytes, X 10; 6. Cross section of the stalk showing two rhizoidal furrows, X 30; 7. Sporophyte within the involucre, X 10; 8. Sporophyte, X 10.

FIGURES 9–19. *Marchantia polymorpha*. Male plant with gemmae cupules, X 1; 10. Female plant with young receptacles at time of fertilization, X 1; 11. Female plant with mature receptacles and sporophytes, X 1; 12. Surface view of the epidermis showing an air pore, X 150; 13. Vertical section through the upper part of the thallus showing an air chamber with photosynthetic filaments and an air pore, X 150; 14. Same through the lower part of the thallus showing pitted cells and oil bodies (ob), X 150; 15. A gemmae cupule, X 10; 16. A gemma, X 50; 17. Female receptacle at maturity showing upturned rays, elongated involucres inclosing sporophytes, X 10; 18. Cross section of the stalk showing two rhizoidal furrows, X 50; 19. Tangential section through a mature female receptacle showing the position of the sporophyte (S), calyptra (C), Pseudoperianth (Ps) and involucre (I), X 20.

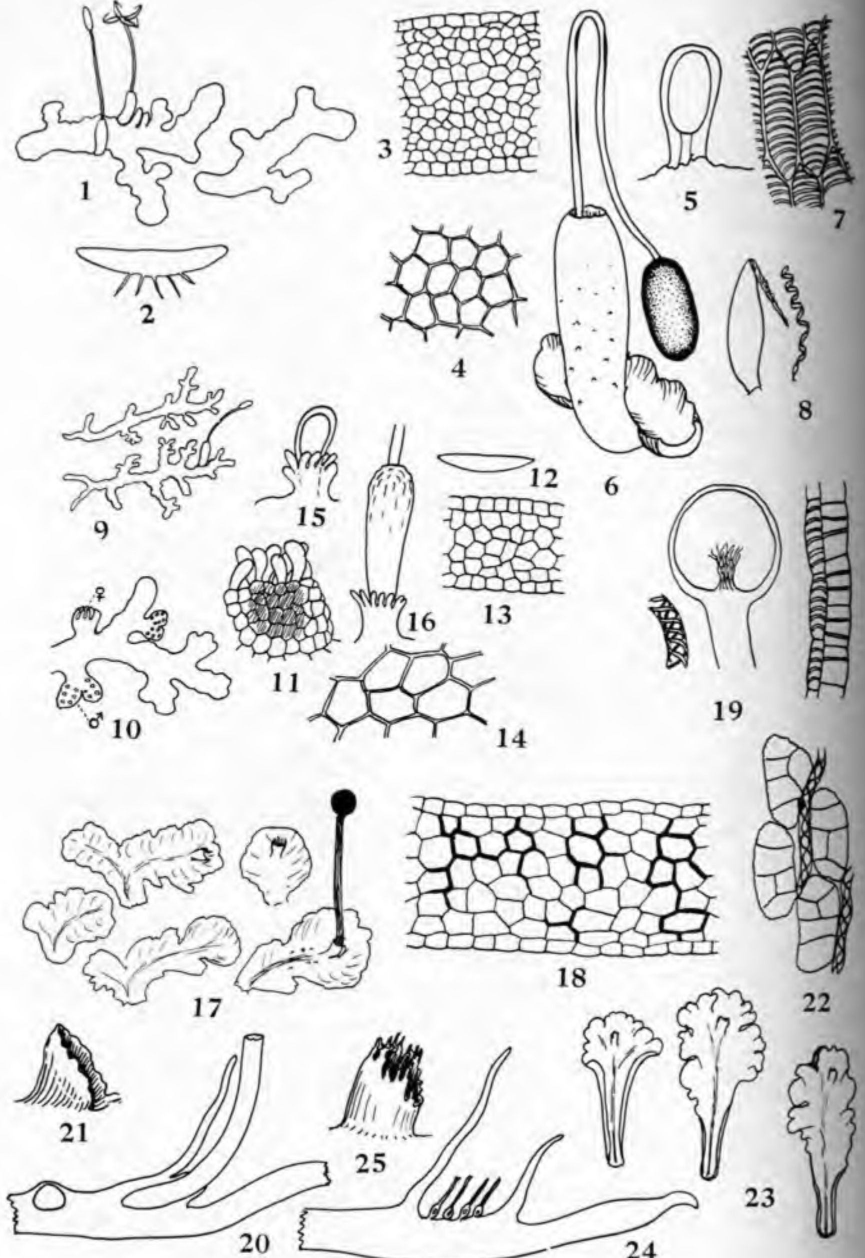


PLATE VIII

FIGURES 1–8. *Riccardia pinguis.* 1. Habit sketches, X 1; 2. Cross section of the thallus in outline, X 6; 3. Cross section showing solid thallus, X 20; 4. Dorsal epidermis, X 50; 5. Young sporophyte inclosed within the large calyptra, X 4; 6. Mature sporophyte with large calyptra, X 6; 7. Details of the cells of the wall of the capsule, X 75; 8. A single valve of a dehiscent capsule showing the apical elaterophore, X 10; with an elater, X 75.

FIGURES 9–16. *Riccardia latifrons.* 9. Habit sketches, X 1; 10. Plant enlarged showing short lateral male and female branches, X 10; 11. Detail of a female branch, X 40; 12. Cross section of the thallus in outline, X 12; 13. Cross section showing cells of the solid thallus, X 20; 14. Dorsal epidermis, X 75; 15. Young sporophyte within the enlarged calyptra, X 8; 16. Large calyptra, X 8.

FIGURES 17–22. *Pellia epiphylla.* 17. Habit sketches, X 1; 18. Oblique section of the thallus showing irregular band-like thickenings on some of the cells, X 90; 19. Diagram of a longitudinal section of a capsule showing the basal elaterophore, X 20; detail the cells forming the wall of the capsule, right, X 125; portion of an elater, X 125; 20. Longitudinal section through the thallus showing the seta arising within the one-sided involucre, X 40; 21. One-sided involucre, X 20; 22. Multicellular spores with elaters, X 75.

FIGURES 23–25. *Pellia neesiana.* 23. Habit sketches, X 1; 24. Longitudinal section of the thallus showing the short tubular involucre, with archegonia, X 40; 25. Tubular involucre, low at anterior side, X 20.

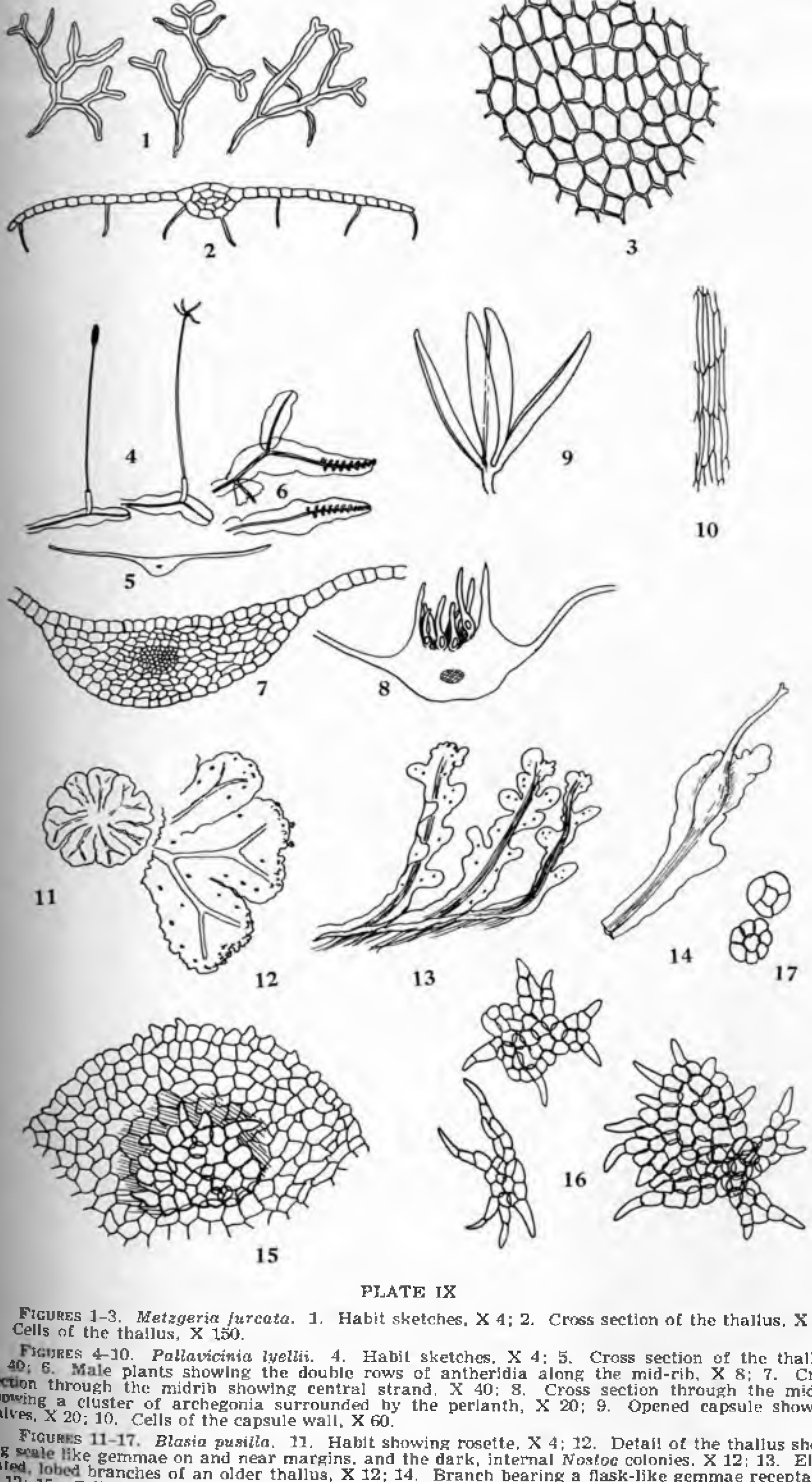


PLATE IX

FIGURES 1–3. *Metzgeria furcata*. 1. Habit sketches, X 4; 2. Cross section of the thallus, X 40; 3. Cells of the thallus, X 150.

FIGURES 4–10. *Pallavicinia lyellii*. 4. Habit sketches, X 4; 5. Cross section of the thallus, X 40; 6. Male plants showing the double rows of antheridia along the mid-rib, X 8; 7. Cross section through the midrib showing central strand, X 40; 8. Cross section through the midrib showing a cluster of archegonia surrounded by the perianth, X 20; 9. Opened capsule showing valves, X 20; 10. Cells of the capsule wall, X 60.

FIGURES 11–17. *Blasia pusilla*. 11. Habit showing rosette, X 4; 12. Detail of the thallus showing scale like gemmae on and near margins, and the dark, internal *Nostoc* colonies, X 12; 13. Elongated, lobed branches of an older thallus, X 12; 14. Branch bearing a flask-like gemmae receptacle, X 12; 15. Cellular detail of the apex of the thallus with a submarginal, scale-like gemmae, X 50; 16. Three scale-like, stellate gemmae, X 50; 17. Globose, multicellular gemmae from the receptacle above, X 50.

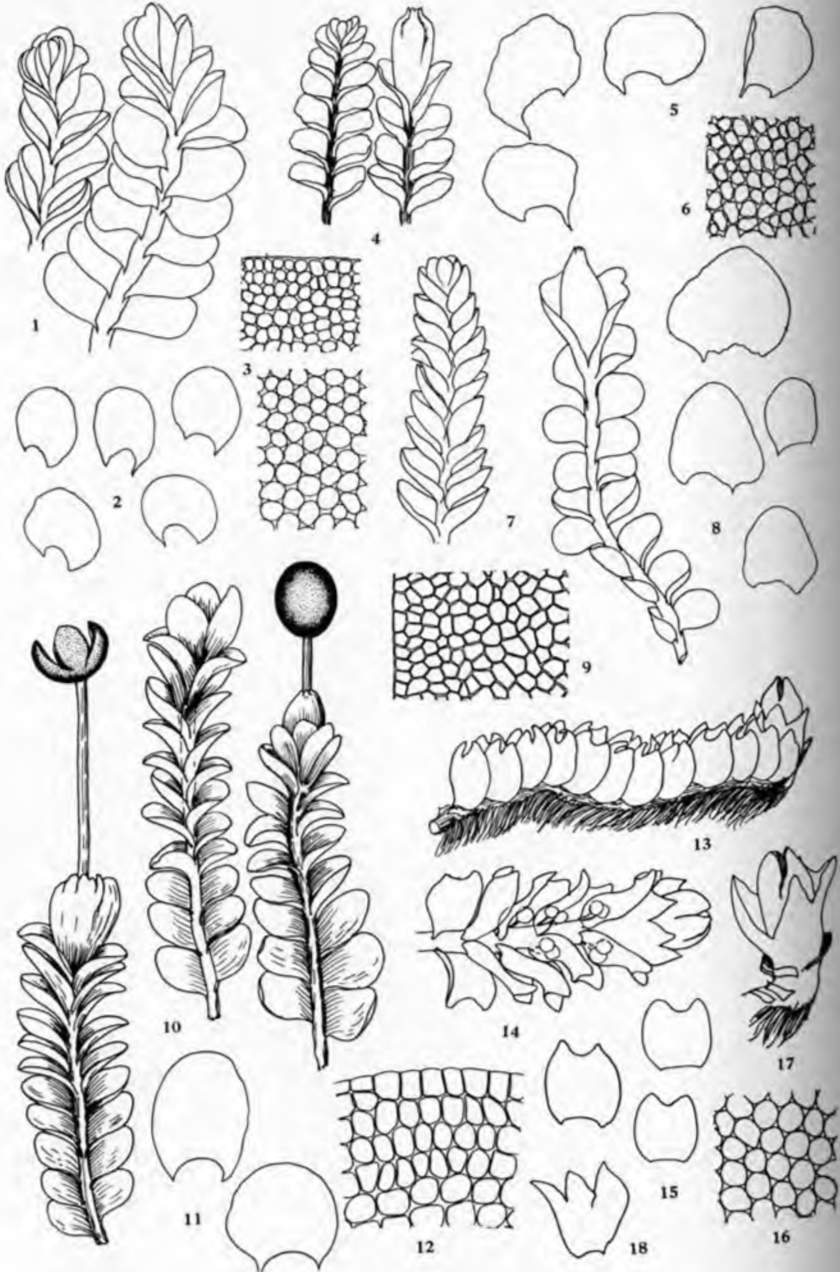


PLATE X

FIGURES 1–3. *Jungermannia lanceolata.* 1. Habit sketches, X 10; 2. Five leaves, X 10; 3. Marginal and upper medial leaf cells, X 125.

FIGURES 4–6. *Jungermannia sphaerocarpa.* 4. Habit sketches, X 4; 5. Five leaves, X 12; 6. Upper medial leaf cells, X 125.

FIGURES 7–9. *Jungermannia pumila.* 7. Habit sketches, X 10; 8. Four leaves, X 12; 9. Upper marginal and medial leaf cells, X 125.

FIGURES 10–12. *Jungermannia tristis.* (L.) 10. Habit sketches, X 10; 11. Two leaves, X 16; 12. Upper marginal and medial cells, X 125.

FIGURES 13–18. *Nardia geoscyphus.* 13. Habit sketches, X 10; 14. Dorsal view of a stem tip showing the antheridia, X 10; 15. Three leaves, X 14; 16. Upper medial leaf cells, X 125; 17. Involucre and subtending perigynium (lower bracts removed), X 16; 18. A female bract, X 14.

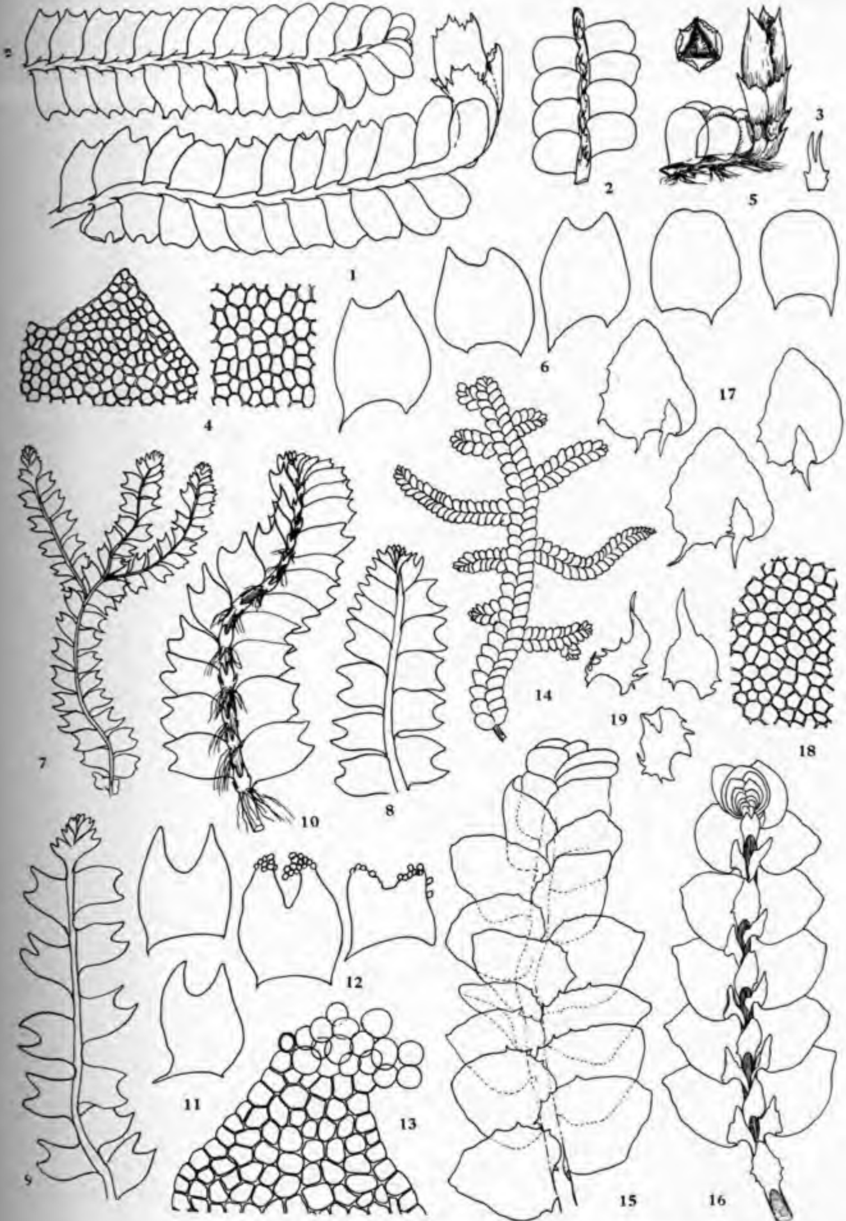


PLATE XI

FIGURES 1–6. *Lophocolea heterophylla*. 1. Habit sketches, dorsal view, X 8; 2. Portion of a stem showing underleaves, X 8; 3. An underleaf, X 16; 4. Upper marginal and medial leaf cells, X 125; 5. Stem tip with perianth, apical view left, X 4; 6. Five leaves, X 16.

FIGURES 7–13. *Lophocolea minor*. 7. Habit sketch, X 4; 8–9. Same, X 8; 10. Ventral view of stem showing underleaves, X 14; 11. Two normal leaves, X 16; 12. Two gemmiparous leaves, X 16; 13. Apex of a leaf lobe showing cells and gemmae, X 125.

FIGURES 14–19. *Porella bolanderi*. 14. Habit sketch, X 2; 15. Dorsal view of stem, X 8; 16. Ventral view of stem showing ventral leaf lobes and underleaves, X 6; 17. Three leaves, ventral view, X 8; 18. Upper medial leaf cells, X 125; 19. Three underleaves, X 12.

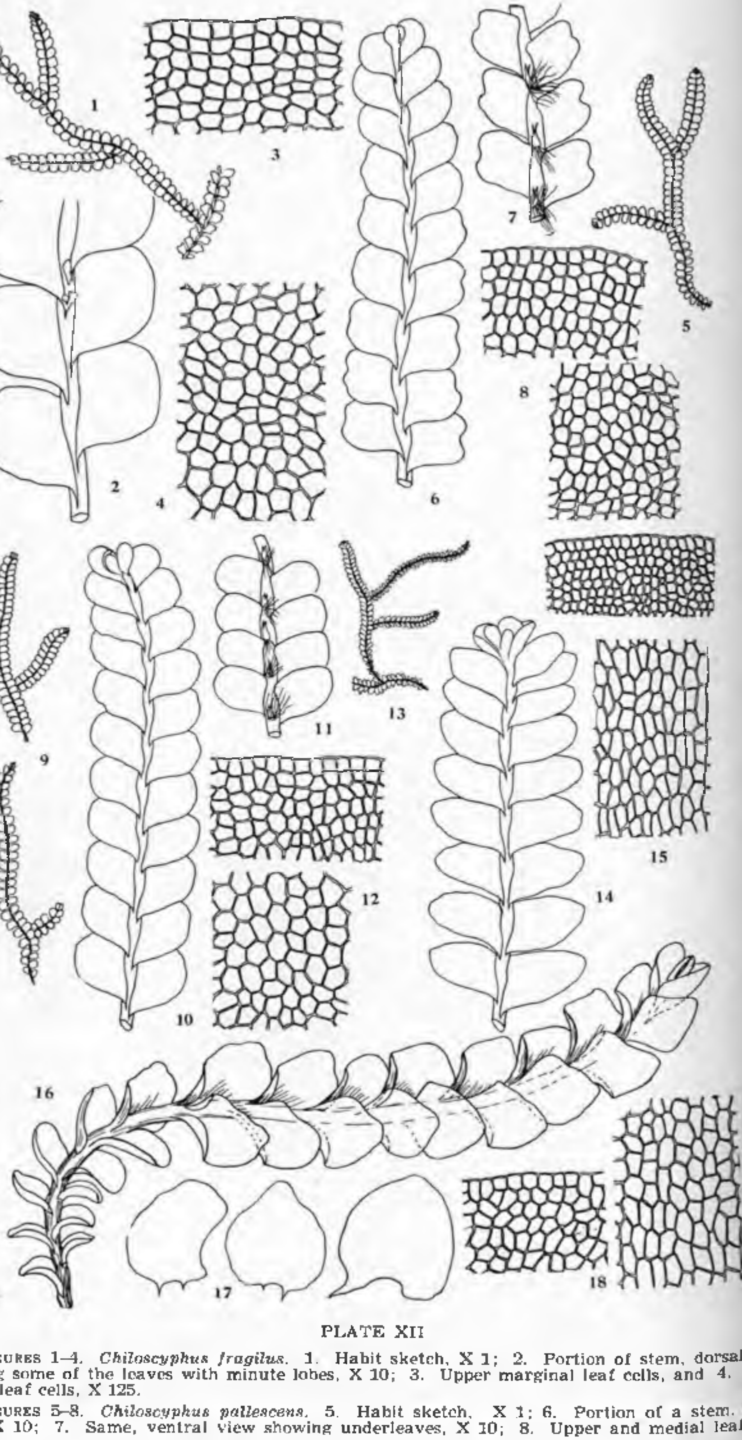


PLATE XII

FIGURES 1–4. *Chiloscyphus fragilus.* 1. Habit sketch, X 1; 2. Portion of stem, dorsal view, showing some of the leaves with minute lobes, X 10; 3. Upper marginal leaf cells, and 4. Upper medial leaf cells, X 125.

FIGURES 5–8. *Chiloscyphus pallescens.* 5. Habit sketch, X 1; 6. Portion of a stem, dorsal view, X 10; 7. Same, ventral view showing underleaves, X 10; 8. Upper and medial leaf cells, X 125.

FIGURES 9–12. *Chiloscyphus polyanthus.* 9. Habit sketch, X 1; 10. Portion of a stem, dorsal view, X 10; 11. Same, ventral view, X 10; 12. Upper marginal and medial leaf cells, X 125.

FIGURES 13–15. *Chiloscyphus rivularis.* 13. Habit sketch, X 1; 14. Portion of the stem, dorsal view, X 19; 15. Marginal and medial leaf cells, X 125.

FIGURES 16–18. *Jungermannia cordifolia.* 16. Habit sketch, X 6; 17. Three leaves, X 10; 18. Marginal and upper medial leaf cells, X 125.

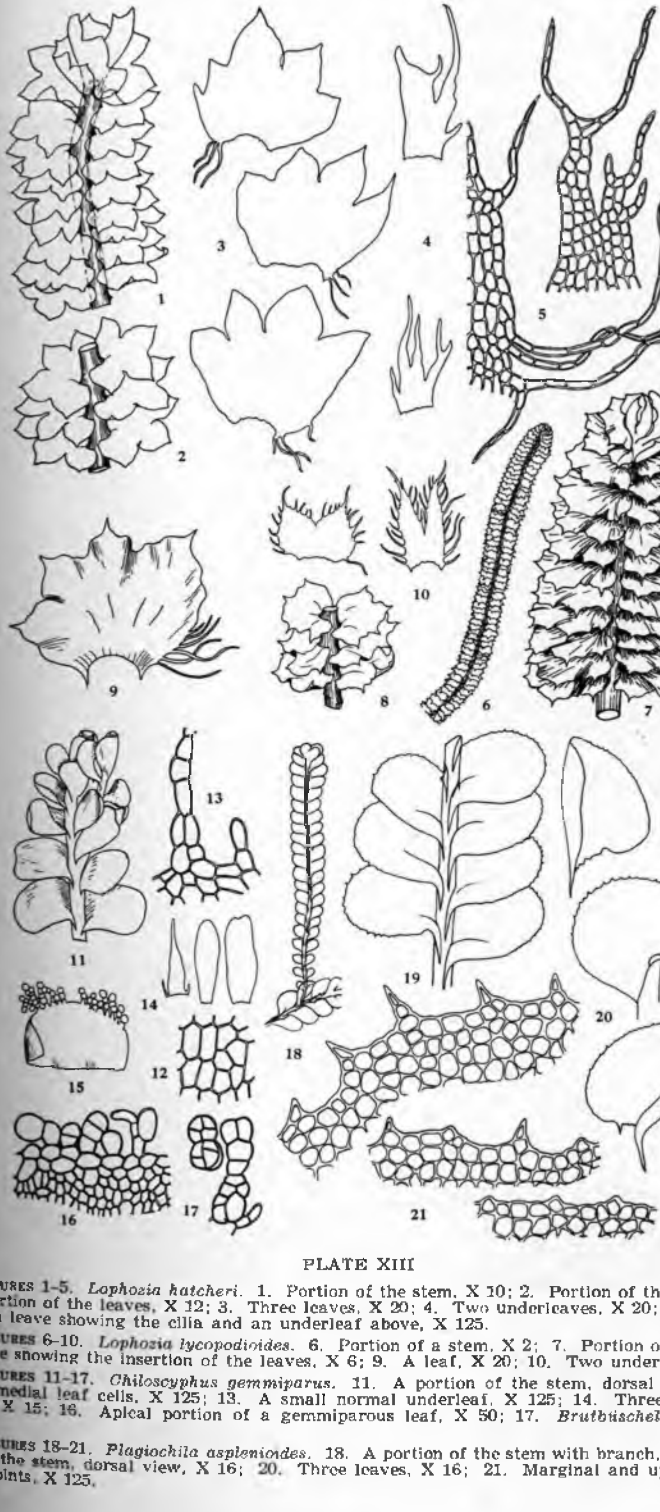


PLATE XIII

FIGURES 1–5. *Lophozia hatcheri*. 1. Portion of the stem, X 10; 2. Portion of the stem showing the insertion of the leaves, X 12; 3. Three leaves, X 20; 4. Two underleaves, X 20; 5. Basal margin of a leave showing the cilia and an underleaf above, X 125.

FIGURES 6–10. *Lophozia lycopodioides*. 6. Portion of a stem, X 2; 7. Portion of a stem X 10; 8. Same showing the insertion of the leaves, X 6; 9. A leaf, X 20; 10. Two underleaves, X 30.

FIGURES 11–17. *Chiloscyphus gemmiparus*. 11. A portion of the stem, dorsal view, X 6; 12. Upper medial leaf cells, X 125; 13. A small normal underleaf, X 125; 14. Three larger underleaves, X 15; 16. Apical portion of a gemmiparous leaf, X 50; 17. *Brutbüschel*, X 125 (after Evans).

FIGURES 18–21. *Plagiochila asplenioides*. 18. A portion of the stem with branch, X 2; 19. Portion of the stem, dorsal view, X 16; 20. Three leaves, X 16; 21. Marginal and upper cells from three points, X 125.

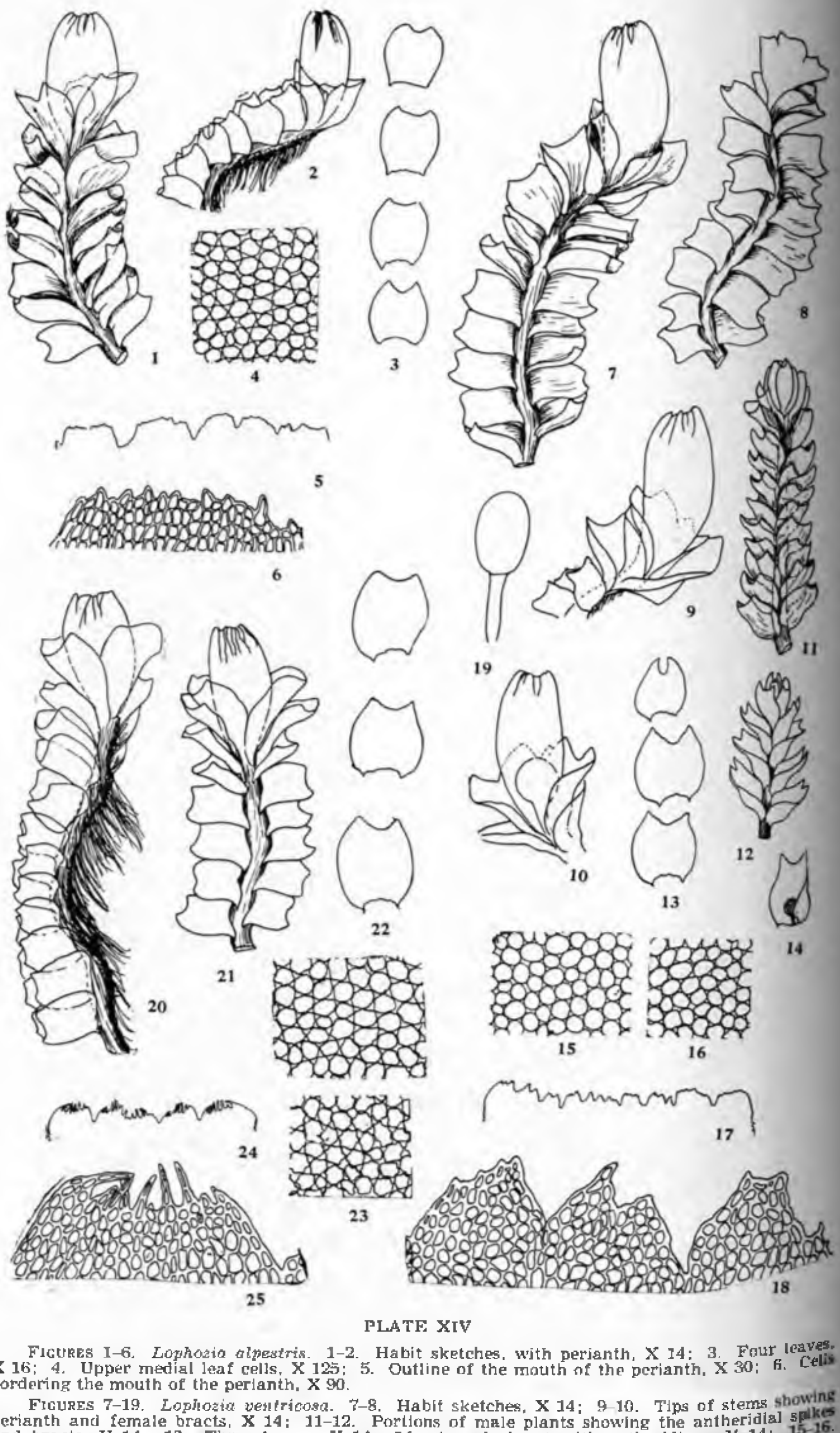


PLATE XIV

FIGURES 1–6. *Lophozia alpestris*. 1–2. Habit sketches, with perianth, X 14; 3. Four leaves, X 16; 4. Upper medial leaf cells, X 125; 5. Outline of the mouth of the perianth, X 30; 6. Cells bordering the mouth of the perianth, X 90.

FIGURES 7–19. *Lophozia ventricosa*. 7–8. Habit sketches, X 14; 9–10. Tips of stems showing perianth and female bracts, X 14; 11–12. Portions of male plants showing the antheridial spikes and bracts, X 14; 13. Three leaves, X 14; 14. A male bract with antheridium, X 14; 15–16. Upper medial leaf cells, X 125; 17. Outline of the mouth of the perianth, X 30; 18. Cells bordering the mouth of the perianth, X 90; 19. Young sporophyte, X 14.

FIGURES 20–25. *Lophozia porphyroleuca*. 20. Portion of a stem, lateral view, X 14; 21. Same, dorsal view, X 14; 22. Three leaves, X 16; 23. Upper medial leaf cells, X 125; 24. Outline of the mouth of the perianth, X 30; 25. Cell bordering the mouth of the perianth, X 90.

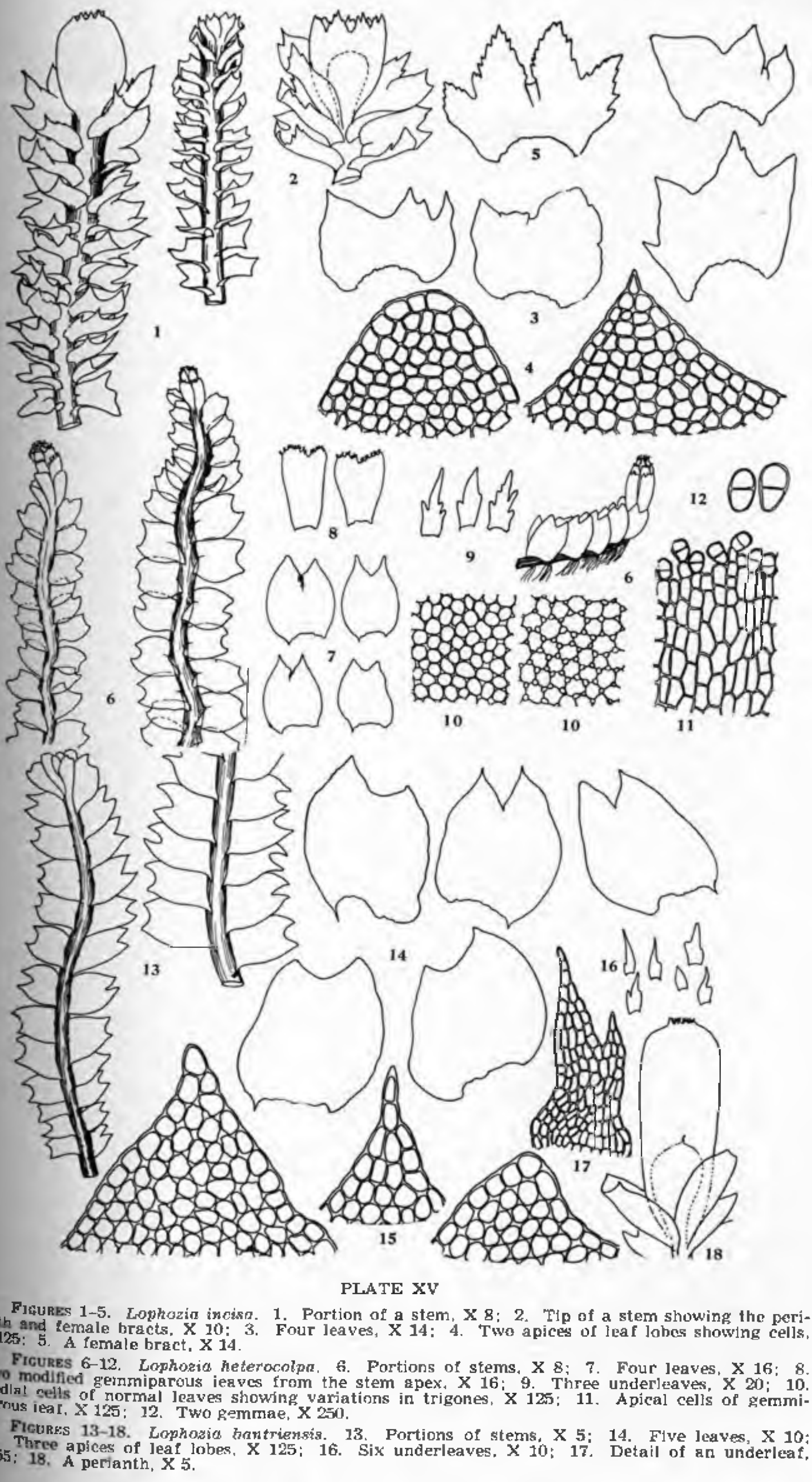


PLATE XV

FIGURES 1–5. *Lophozia incisa*. 1. Portion of a stem, X 8; 2. Tip of a stem showing the perianth and female bracts, X 10; 3. Four leaves, X 14; 4. Two apices of leaf lobes showing cells, X 125; 5. A female bract, X 14.

FIGURES 6–12. *Lophozia heterocolpa*. 6. Portions of stems, X 8; 7. Four leaves, X 16; 8. Two modified gemmiparous leaves from the stem apex, X 16; 9. Three underleaves, X 20; 10. Medial cells of normal leaves showing variations in trigones, X 125; 11. Apical cells of gemmiparous leaf, X 125; 12. Two gemmae, X 250.

FIGURES 13–18. *Lophozia bantriensis*. 13. Portions of stems, X 5; 14. Five leaves, X 10; 15. Three apices of leaf lobes, X 125; 16. Six underleaves, X 10; 17. Detail of an underleaf, X 55; 18. A perianth, X 5.

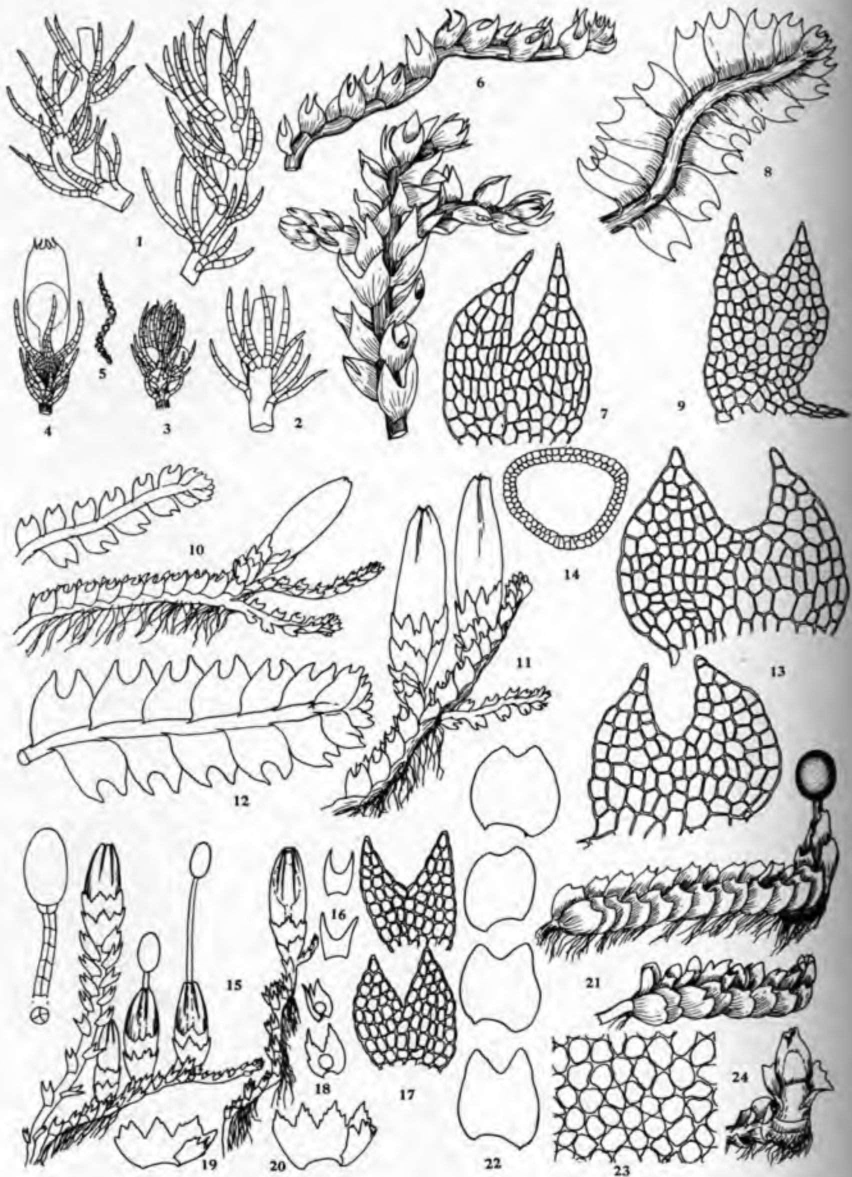


PLATE XVI

FIGURES 1–4. *Blepharostoma trichophyllum*. 1. Portions of the stem, X 16; 2. Ventral view of a stem showing underleaf, X 16; 3. Apex of a stem showing antheridia, X 8; 4. Apex of a stem showing the perianth and female bracts, X 8; 5. An elater, X 75.

FIGURES 6–7. *Cephalozia bicuspidata*. 6. Habit sketches, lateral view above, dorsal view below, X 16; 7. A leaf, X 100.

FIGURES 8–9. *Cephalozia media*. 8. Portion of a stem, dorsal view, X 30; 9. A leaf, X 100.

FIGURES 10–14. *Cephalozia pleniceps*. 10. Habit sketches, X 16; 11. Erect stem with perianth on short lateral branches, X 16; 12. Portion of the stem, X 30; 13. Two leaves, X 120; 14. Cross section of the perianth, X 40.

FIGURES 15–20. *Cephaloziella stellulifera*. 15. Habit sketches with perianths and sporophytes, X 16; capsule and seta at left, X 40; 16. Two leaves, X 40; 17. Two leaves, X 100; 18. Antheridial bracts, X 40; 19–20. Female bracts, X 40.

FIGURES 21–24. *Nardia geoscyphus*. 21. Habit sketches, X 6; 22. Four leaves, X 16; 23. Medial leaf cells, X 120; 24. Perigynium with leaves and lower female bracts removed, X 8. See also Figure 18.

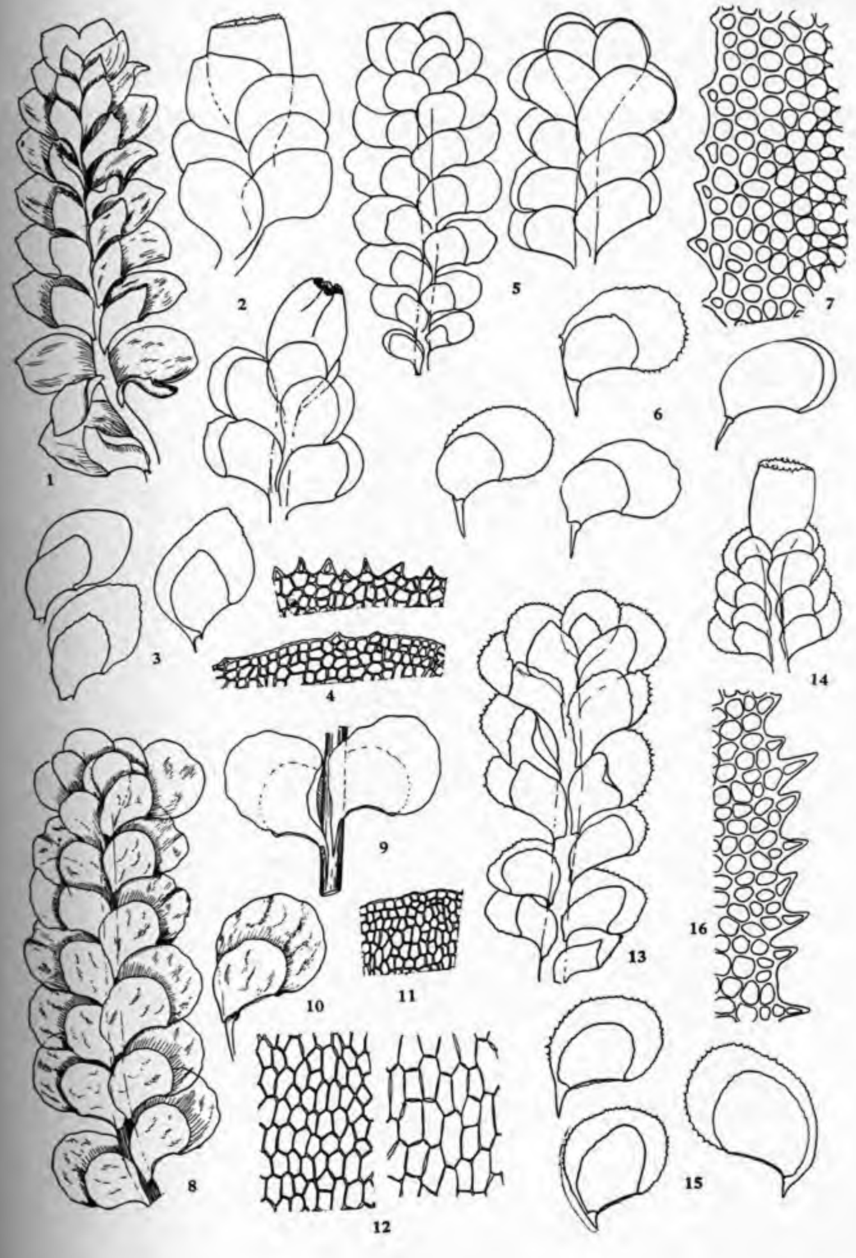


PLATE XVII

FIGURES 1–4. *Scapania curta.* 1. Habit sketch, dorsal view, X 8; 2. Apices of two stems with perianths, X 8; 3. Three leaves, X 10; 4. Marginal cells of different leaves, X 90.

FIGURES 5–7. *Scapania subalpina.* 5. Portions of different stems, dorsal view, X 8; 6. Four leaves, X 10; 7. Upper areolation showing thick-walled marginal cells, X 125.

FIGURES 8–12. *Scapania undulata.* 8. A portion of a stem, dorsal view, X 6; 9. Ventral view of two leaves on stem, X 10; 10. A leaf, X 10; 11. Marginal leaf cells, X 90; 12. Medial and basal leaf cells, X 90.

FIGURES. 13–16. *Scapania undulata var. oakesi.* 13. Portion of the stem, X6; 14. Apex of a stem with perianth, X6; 15. Three leaves, X10; 16. Marginal leaf cells, X125.

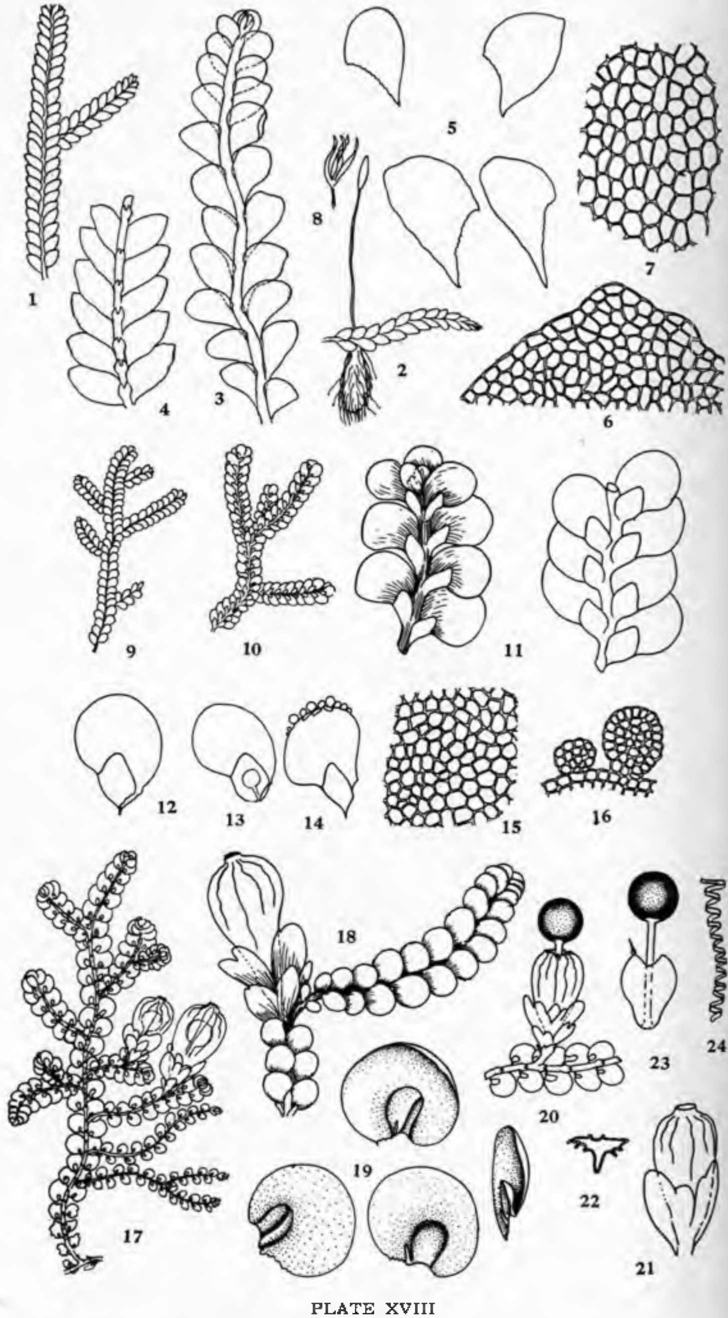


PLATE XVIII

FIGURES 1–8. *Calypogeia trichomanis*. 1. Habit sketch, X 2; 2. Portion of a plant bearing a sporophyte and showing the bulbous perigynium, X 2; 3. Dorsal view of a stem, X 8; 4. Ventral view of a stem showing underleaves, X 8; 5. Four leaves, X 10; 6. Upper and marginal leaf cells, X 125; 7. Medial leaf cells, X 125; 8. Dehiscent capsule, X 4.

FIGURES 9–16. *Radula complanata*. 9. Habit sketch, dorsal view, X 2; 10. Same, ventral view, X 3; 11. Apical and medial portions of a stem, ventral view, X 10; 12. A leaf, ventral view, X 15; 13. Antheridial bract, X 15; 14. A gemmiparous leaf, X 15; 15. Medial leaf cells, X 90; 16. Gemmae on leaf margin, X 90.

FIGURES 17–24. *Frullania inflata*. 17. Habit sketch, ventral view, X 6; 18. Dorsal view of stem with perianth, X 10; 19. Four leaves, ventral and lateral views, X 30; 20–21. Perianth and sporophyte, X 8; 22. Cross section of perianth, X 8; 23. Sporophyte with calyptra, X 12; 24. An elater, X 125.