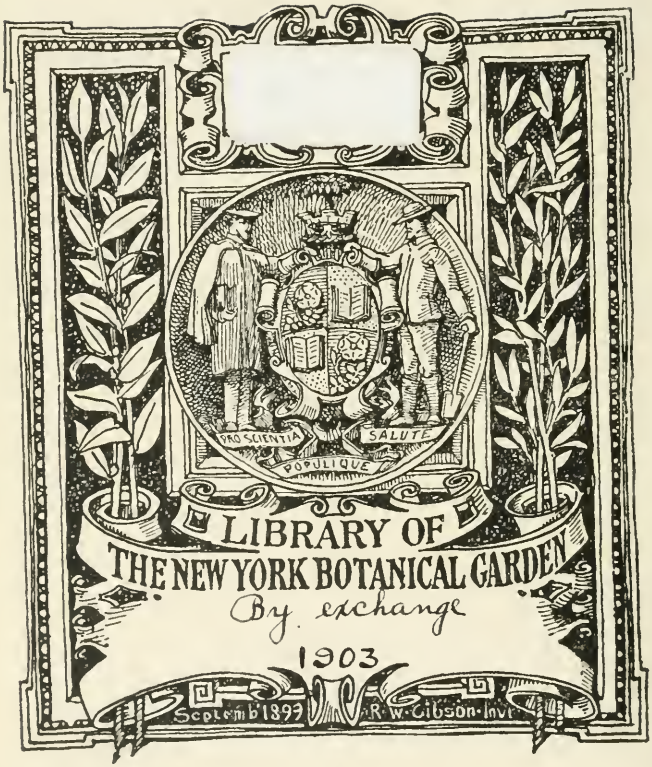

PRO SCIENTIA
SALUTE
POPULIQUE
LIBRARY OF
THE NEW YORK BOTANICAL GARDEN
By exchange
1903
Septemb 1899
R. W. Gibson. Invt.

BULLETIN

OF THE

UNIVERSITY OF WISCONSIN

SCIENCE SERIES

VOLUME I

(1894-1896)

WILLIAM HERBERT HOBBS, PH. D., *Editor*

Assistant Professor of Mineralogy and Petrology.

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF
THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
1896

DEMOCRAT PRINTING CO.
State Printer
MADISON, WIS.

CONTENTS OF VOLUME I.

INDEX TO PLATES.

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SCIENCE SERIES, VOL. 1, NO. 1, PP. 1—33.

ON THE SPEED OF THE LIBERATION OF IODINE IN MIXED SOLUTIONS OF POTASSIUM CHLORATE, POTASSIUM IODIDE, AND HYDROCHLORIC ACID

BY

HERMAN SCHLUNDT
Assistant in Chemistry.

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
DECEMBER, 1894

PRICE 35 CENTS

Democrat Printing Company, State Printer

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SCIENCE SERIES, VOL. 1, NO. 1, PP. 1-33, DECEMBER, 1894

ON THE SPEED OF THE LIBERATION OF IODINE IN MIXED SOLUTIONS OF POTASSIUM CHLORATE, POTASSIUM IODIDE, AND HYDROCHLORIC ACID.

BY HERMAN SCHLUNDT.[1]

Assistant in Chemistry.

A systematic study of the conditions of experimentation that determine the progress of a reaction has until of late years received very little attention. During the last two decades, the speed of various reactions as dependent upon modifying influences has been specially investigated, and to-day the subject of chemical dynamics furnishes many interesting problems for investigation. The present work has been undertaken with the view of collecting data for the solving of some of these problems.

Burchard[2] studied the speed of the liberation of iodine in mixtures of hydriodic and iodic acids in very dilute solutions. Similarly he investigated mixtures of hydriodic acid with bromic or chloric acids. Mixtures of the salts of hydriodic and chloric acids with hydrochloric acid, however, have never to my knowledge been investigated in this way. It is the purpose of this paper to study the speed of the liberation of iodine in such mixtures as are influenced: first, by temperature; second, by degree of concentration; third, by the presence of an excess of one or more of the components; and fourth, by the addition of an excess of other acids.

[1] A thesis submitted for the degree of Bachelor of Science in the General Science Course, University of Wisconsin, June, 1894.

[2] Ueber die Oxydation des Jodwasserstoffes durch die Sauerstoffsaüren der Salzbilder, Zeitschr. physik. Chem., 2; p. 796. (1888.)

Preliminary Experiments.— It is well known that when potassium iodide, potassium chlorate, and hydrochloric acid are mixed in solution, iodine is liberated according to this reaction,—

$$K\,Cl\,O_3 + 6\,H\,Cl + 6\,K\,I = 7\,K\,Cl + 3\,H_2\,O + I_6.$$

In order to ascertain the conditions favorable for studying the speed of the liberation of iodine in such mixtures, several preliminary experiments on the effects of temperature and concentration became necessary.

It was found that in mixtures containing equivalents[1] of the salts according to the foregoing reaction as deci-normal solutions at 0° C., iodine is liberated very slowly, a sample of twenty cubic centimeters of the mixture after twenty-four hours requiring only one-tenth cubic centimeter of a deci-normal solution of sodium thiosulphate to destroy the blue color produced by the addition of starch paste.

The same mixture at 100° C. proved well adapted for investigation, as the following table shows:—

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2\,S_2\,O_3$ used in each titration.	Per cent. of Iodine liberated
15	20	1.45	3.6
35	20	3.1	7.8
60	20	4.3	10.8
90	20	6.0	15.0

Preparation of Solutions.—The solutions used were prepared as follows: A normal solution of potassium iodide free from iodate served throughout the investigation. It

[1] Whenever this term is used it is understood to mean equivalents according to the reaction already given.

was prepared by dissolving 165.54 g. of the pulverized salt, dried at 100° C., and making it up to one liter. The normal hydrochloric acid was standardized on calcite. The potassium chlorate was tested for sulphates, nitrates, chlorides, the heavy metals, and the alkaline earths, and found to be pure. The solution of this salt was three times normal and was prepared by taking 61.25 g. of the dry crystallized salt to a liter. A twentieth normal solution of sodium thiosulphate served for titration. It was prepared by dissolving 12.4 g. of the pure crystallized salt per liter of water. The strength of this solution was verified by testing with deci-normal iodine solution. The starch paste used was quite dilute and was prepared by stirring up two to three grams of the fine starch with cold water. Three to four hundred cubic centimeters of boiling hot water were then added and the mixture well stirred. This paste was then filtered, and the filtrate used as indicator. A fresh solution was frequently prepared.

Conduct of Experiments.—The entire series of investigations was conducted at 100° C. The mixtures were prepared by measuring out the desired equivalents of the different components, cooling them to 0° C. in ice water, and then mixing them. Samples of 20 cc. of the mixture were then quickly taken out and put into ordinary six-inch test tubes. The tubes were quickly sealed, but all the time kept as cool as possible. The samples were then plunged into a large kettle of boiling water and kept at this temperature. At definite intervals samples were taken out and plunged into ice water, thus quickly checking the reaction. After one minute the test tubes were broken, washed with cold water, and the iodine determined by means of a twentieth normal solution of sodium thiosulphate.

The test tubes were sealed at about the same distance from the end, thus keeping the pressure nearly constant. Whenever it was found expedient to work with samples

of 10 cc., the tubes were used over again. As the test tubes were new, special precautions in cleaning had to be exercised. To remove the alkalies that are given off by new glassware, I followed the advice of Professor Ostwald and steamed the tubes for about five minutes by means of an apparatus figured on p. 295 of his "Hand- und Hilfsbuch zur Ausführung physico-chemischer Messungen."

In mixtures where the components enter in equivalent proportions it was found that the free iodine began to crystallize out when about 40 per cent. had been liberated. To get this iodine into solution a few cubic centimeters of a strong potassium iodide solution were added. But as this excess of potassium iodide might possibly enter into the reaction and so slightly increase the amount of sodium thiosulphate used, the iodine of several samples was shaken out with carbon bisulphide and determined. A comparison of results obtained by these two methods,[1] shows that the addition of a few cubic centimeters of cold potassium iodide during titration has little or no effect on the result.

The equation expressing the reaction shows that for every molecule of potassium iodide present one atom of iodine is liberated. In titrating the iodine with sodium thiosulphate the following reaction takes place,—

$$2\ Na_2\ S_2\ O_3 + I_2 = Na_2\ S_4\ O_6 + 2\ Na\ I.$$

Hence the per cent. of iodine liberated at any time from the given sample, originally containing 20 cc. of potassium iodide in deci-normal solution, is obtained by dividing by forty the number of cubic centimeters of sodium thiosulphate used, the thiosulphate being twentieth-normal.

Presentation of Results.—The results obtained are divided into five sections. Section A includes the results obtained from a mixture containing equivalents of the salts as deci-normal solutions. The effect of a definite excess of *one* of the several components upon the speed of the reaction

[1] Sec. B, III, series (1) and (3), and Sec. C, series (4).

is shown in section B. Section C, similar to B, gives the effect upon the speed when definite excesses of *both* potassium iodide and hydrochloric acid are used. Section D gives the results obtained from mixtures containing equivalents of the components in fifth normal and two-fifth normal solutions respectively. The acceleration in the speed by various organic and inorganic acids forms the fifth and last section of the results.

To facilitate comparison, the results obtained in similar series are graphically represented in the same figure. In plotting the curves the axis of abscissas was chosen to denote the time of the reaction, each space representing one hundred minutes, while the percentages of iodine liberated are plotted on the axis of ordinates.

SECTION A.

Series in which equivalents of K Cl O_3, H Cl, and K I enter in deci-normal solutions,[1] *according to the reaction,—*

$$K\,Cl\,O_3 + 6\,H\,Cl + 6\,K\,I = 7\,K\,Cl + 3\,H_2\,O + I_6.$$

A sample of 400 cc. of the mixture was prepared as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	306.7 cc.
	400.0 cc.

[1] Curve A, Figures 1, 2, 3, 5.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
15	20	1.45	3.6
35	20	3.1	7.8
35	20	3.0	7.5
60	20	4.3	10.8
70	20	4.6	11.5
90	20	6.0	15.0
110	20	6.6	16.5
150	20	7.85	19.6
210	20	9.4	23.5
300	20	12.05	30.1
300	20	12.25	30.6
360	20	13.55	33.9
440	20	14.55	36.4
520	20	15.55	38.9
585	20	16.0	40.0
730	20	17.0	42.5
830	20	18.4	46.0
1250	20	21.3	53.3
1400	20	21.7	54 3
1830	20	23.2	58.0
2000	20	24.1	60.3

SECTION B.

Series in which an excess of one of the three components enters, both of the other components remaining tenth normal.

I. Potassium chlorate in excess. (1) An excess of *one* molecule of $KClO_3$ enters,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + KClO_3 \quad \text{Excess.}$$

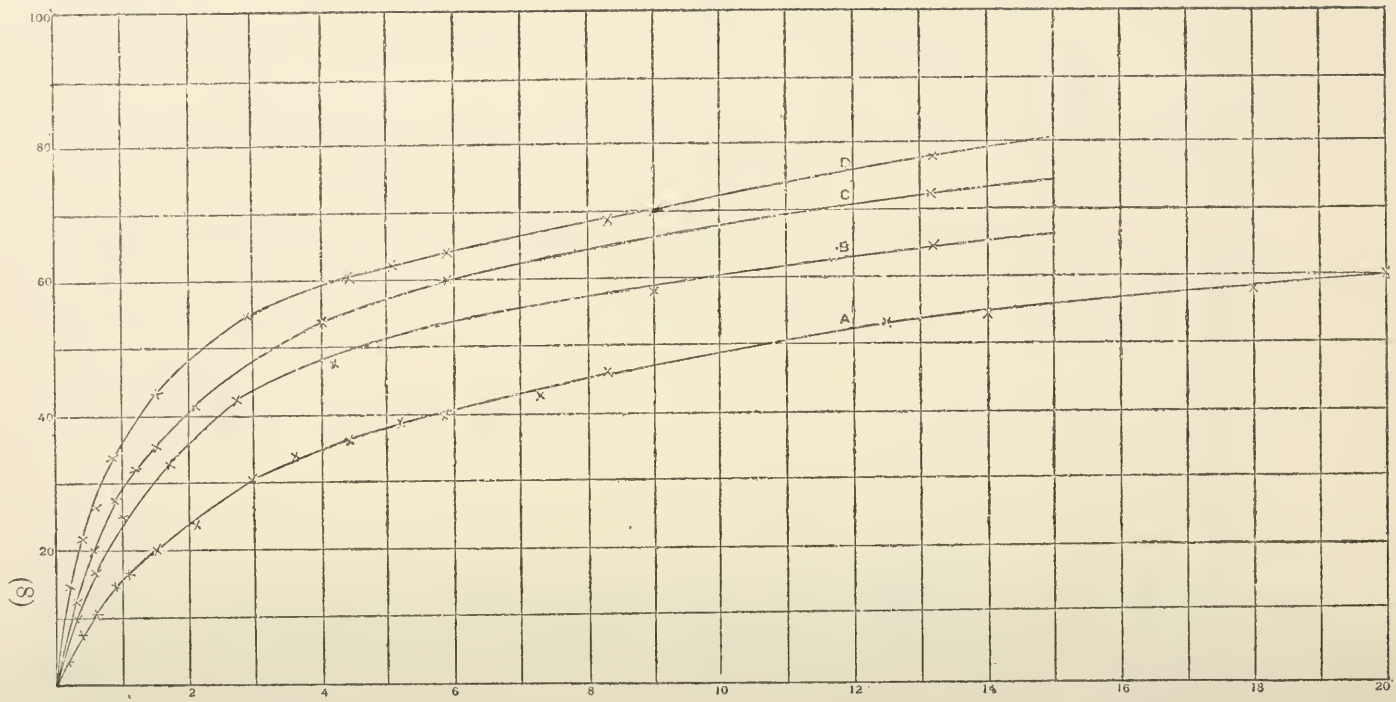
A sample of 400 cc. of the mixture was prepared as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	26.7 cc.
Water	293.3 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	1.35	3.4
20	20	2.85	7.1
30	20	3.95	9.9
30	20	3.9	9.8
60	20	6.6	16.5
60	20	6.7	16.8
100	20	9.9	24.8
170	20	13.0	32.5
270	20	16.9	42.3
420	20	18.95	47.4
590	20	21.2	53.0
1320	20	25.85	64.6

[1] Curve B, Figure 1.

I



(2) An excess of *two* molecules of $KClO_3$ enters,[1]—

$$KClO_3 + 6\ HCl + 6\ KI + 2\ KClO_3 \text{ Excess.}$$

A sample of 400 cc. of the mixture was prepared as follows:

Normal Hydrochloric Acid	40 cc.
Normal Potassium Iodide	40 cc.
Three times normal Potassium Chlorate	40 cc.
Water	280 cc.
	400 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
15	20	2.8	7.0
30	20	5.0	12.5
55	20	8.0	20.0
85	20	10.95	27.4
120	20	12.7	31.8
150	20	14.25	35.6
210	20	16.65	41.6
400	20	21.45	53.6
590	20	23.9	59.8
1320	20	28.95	72.4

After keeping 48 hours at the ordinary temperature of the laboratory 20 cc. of this mixture required 0.4 cc. of twentieth normal sodium thiosulphate solution.

[1] Curve C, Figure 1.

(3) An excess of *three* molecules of $KClO_3$ enters,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 3\,KClO_3 \text{ Excess.}$$

A sample of 400 cc. of the solution was made up as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	53.3 cc.
Water	266.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	2.8	7.0
20	20	5.0	12.5
40	20	8.25	20.6
60	20	10.6	26.5
85	20	13.5	33.8
110	20	15.4	38.5
150	20	17.35	43.4
180	20	19.25	48.1
210	20	20.25	50.6
230	20	21.4	53.5
290	20	21.85	54.6
440	20	24.2	60.5
510	20	24.75	61.9
590	20	25.6	64.0
830	20	27.4	68.5
900	20	27.8	69.5
1320	20	31.3	78.3

[1] Curve D, Figure 1.

II. Potassium iodide enters in an excess, both the hydrochloric acid and potassium chlorate remaining constant and tenth normal.

(1) Series in which the K I is *doubled*,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 6\,KI \text{ Excess.}$$

A sample of 400 cc. was prepared as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	80.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	266.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
15	20	2.4	6.0
30	20	4.7	11.8
50	20	6.35	15.9
85	20	9.65	24.1
110	20	11.45	28.6
160	20	13.85	34.6
230	20	16.7	41.8
315	20	18.55	46.4
430	20	19.9	49.8
530	20	21.4	53.5
640	20	22.9	57.3
760	20	23.65	59.1
1360	20	27.2	68.0

[1]Curve B, Figure 2.

(2) Series in which K I is *tripled*,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 12\,KI \text{ Excess.}$$

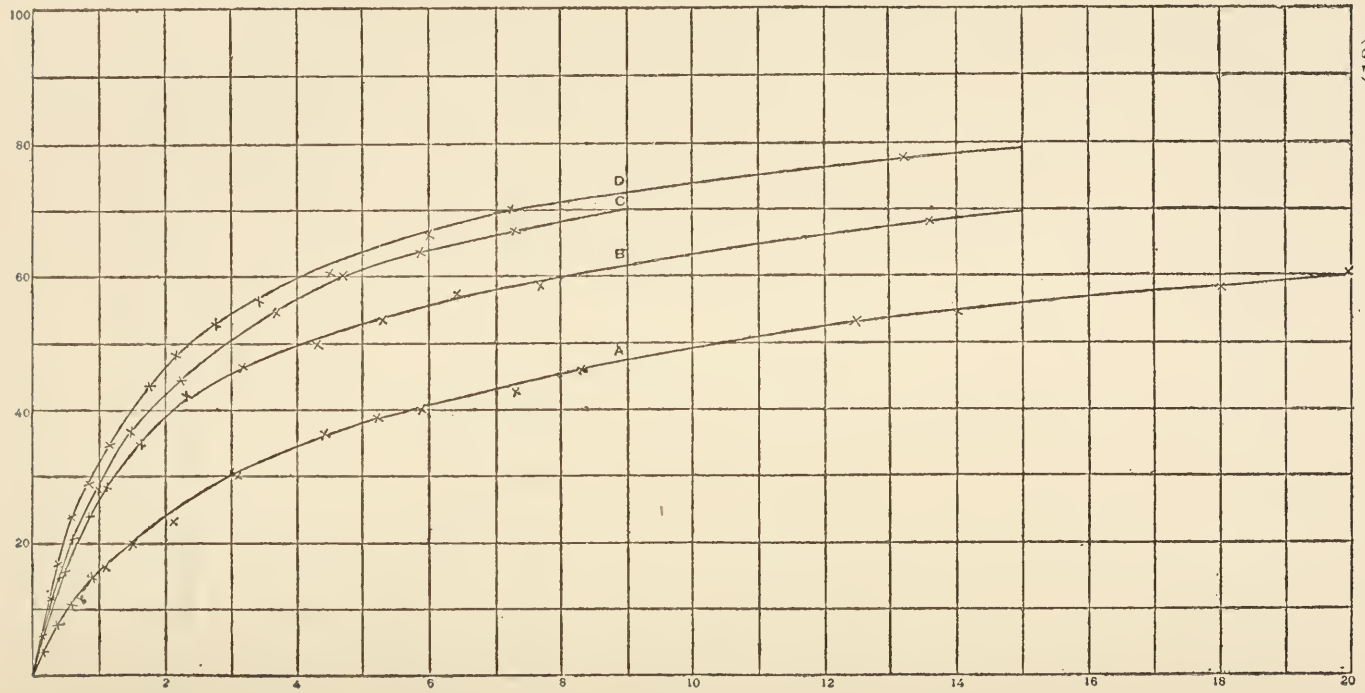
A sample of 400 cc. was made up as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	120.0 cc.
Three times normal Potassium chlorate	13.3 cc.
Water	226.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	1.8	4.5
20	20	3.25	8.1
40	20	5.9	14.8
65	20	8.25	20.6
100	20	11.05	27.6
150	20	14.6	36.5
225	20	17.8	44.5
370	20	21.7	54.3
470	20	24.0	60.0
585	20	25.35	63.4
720	20	26.65	66.6

[1] Curve C, Figure 2.

II.



(3) Series in which the K I is *quadrupled*,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 18\,KI \text{ Excess.}$$

A sample of 400 cc. was prepared as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	160.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	186.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	1.9	4.8
25	20	4.6	11.5
40	20	6.7	16.8
60	20	9.5	23.8
85	20	11.5	28.8
115	20	13.75	34.4
150	20	17.1	42.8
175	20	17.4	43.5
215	20	18.3	45.8
275	20	21.15	52.9
340	20	22.6	56.5
450	20	24.2	60.5
600	20	26.3	65.8
720	20	28.0	70.0
1320	20	31.0	77.5

[1] Curve D, Figure 2.

III. Hydrochloric acid enters in an excess, both the other components remaining constant and tenth normal.

(1) Series in which the original amount of H Cl is *doubled*,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 6\,HCl \text{ Excess.}$$

A sample of 400 cc. was prepared as follows:

Normal Hydrochloric Acid	80.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	266.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
17	20	4.3	10.8
30	20	7.25	18.1
50	20	10.45	26.1
70	20	12.7	31.8
105	20	16.2	40.5
105	20 (CS_2)	16.35	40.9
150	20	18.95	47.4
220	20	22.3	57.5
300	20	24.85	62.1
450	20	27.55	68.9
720	20	30.95	77.4

[1] Curve B, Figure 3.

(2) Series in which the original amount of HC is *tripled*,[1]—

$$KClO_3 + 6\,HCl + 6\,KI + 12\,HCl \text{ Excess.}$$

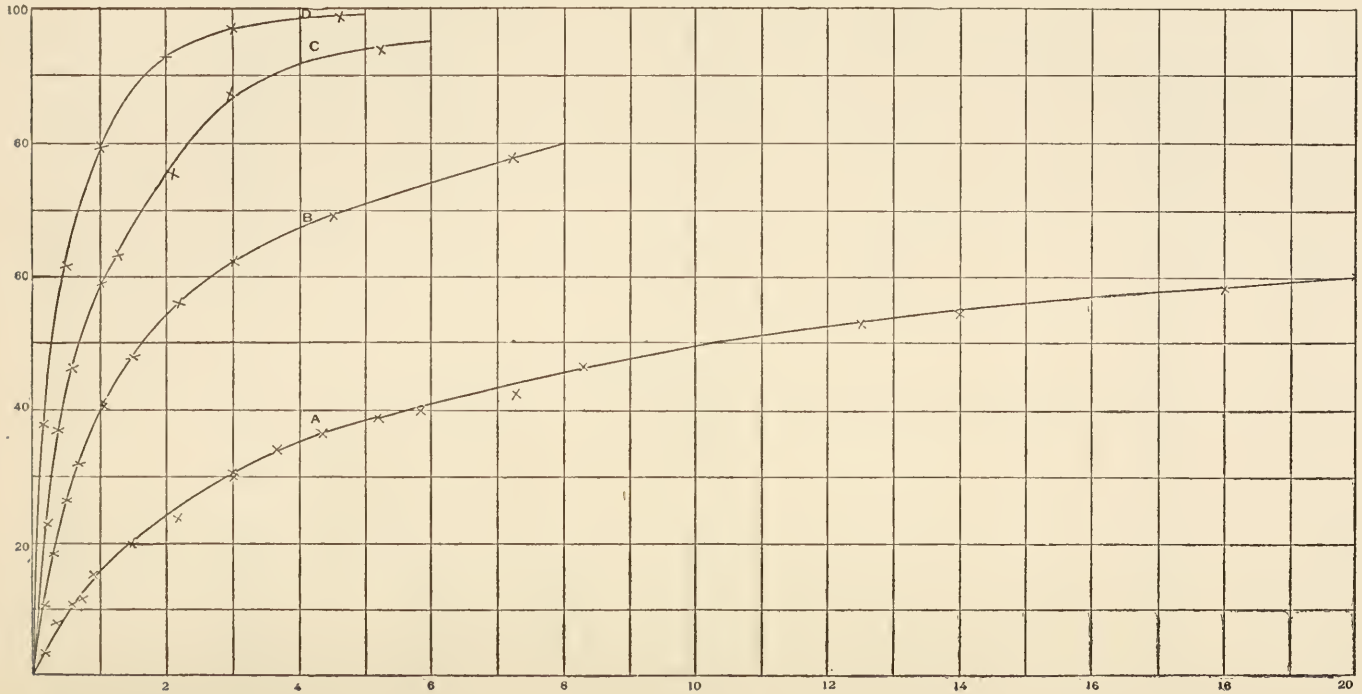
A sample of 400 cc. was prepared as follows:

Normal Hydrochloric Acid	120.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	12.3 cc.
Water	226.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	4.6	11.5
20	20	9.05	22.6
40	20	14.75	36.9
60	20	18.75	46.4
100	20	23.6	59.0
130	20	25.35	63.4
210	20	30.1	75.3
295	20	34.95	87.4
525	20	37.5	93.8

[1] Curve C, Figure 3.

III



(3) Series in which the original amount of H Cl is *quadrupled*,[1]—

$$K\,Cl\,O_3 + 6\,H\,Cl + 6\,K\,I + 18\,H\,Cl \text{ Excess.}$$

A sample of 400 cc. was prepared as follows:

Normal Hydrochloric Acid	160.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	186.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2\,S_2\,O_3$ used in each titration.	Per cent. of Iodine liberated.
20	20	15.3	38.3
50	20	24.55	61.4
100	20 ($C\,S_2$)	31.7	79.3
100	20	31.8	79.5
200	20	37.15	92.9
300	20	38.85	97.1
460	20	39.55	98.9

After 24 hours 20 cc. of this mixture kept at the ordinary temperature of the laboratory required 0.5 cc. of twentieth normal sodium thiosulphate.

[1] Curve D, Figure 3.

SECTION C.

This section embraces a series of experiments in which excesses of both the hydrochloric acid and potassium iodide enter, the amount of potassium chlorate remaining constant. The results obtained have a direct bearing upon analytical methods as these are the conditions under which chlorates are estimated.

(1) Series in which *both* the H Cl and K I are *doubled*, the K Cl O_3 remaining constant and tenth normal,[1]—

$$KClO_3 + 6\,KI + 6\,HCl + \overbrace{6\,HCl + 6\,KI}^{\text{Excess}}.$$

A sample of 400 cc. was made up as follows:

Normal Hydrochloric Acid	80.0 cc.
Normal Potassium Iodide	80.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	226.7 cc.
	400.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	20	3.75	9.4
35	20	11.35	28.4
60	20	16.5	41.3
100	20	21.3	53.3
170	20	25.75	64.4
280	20	30.4	76.0
415	20	33.6	84.0

[1] Curve A, Figure 4.

(2) Series in which *both* the H Cl and K I are *tripled*,—

$$KClO_3 + 6\,HCl + 6\,KI + \overbrace{12\,KI + 12\,HCl}^{\text{Excess.}}$$

A sample of 200 cc. was prepared as follows:

Normal Hydrochloric Acid	60.0 cc.
Normal Potassium Iodide	60.0 cc.
Three times normal Potassium Chlorate	6.7 cc.
Water	73.3 cc.
	200.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
5	10	2.6	13.0
10	10	5.05	25.3
20	10	8.75	43.8
35	10	12.0	60.0
50	10	14.15	70.8
70	10	16.25	81.3
95	10	17.85	89.3
160	10	19.8	99.0

[1] Curve B, Figure 4.

(3) Series in which *both* the H Cl and K I are *quadrupled*, —

$$KClO_3 + 6\,HCl + 6\,KI + \overbrace{18\,HCl + 18\,KI}^{\text{Excess}}.$$

A sample of 200 cc. was prepared thus:

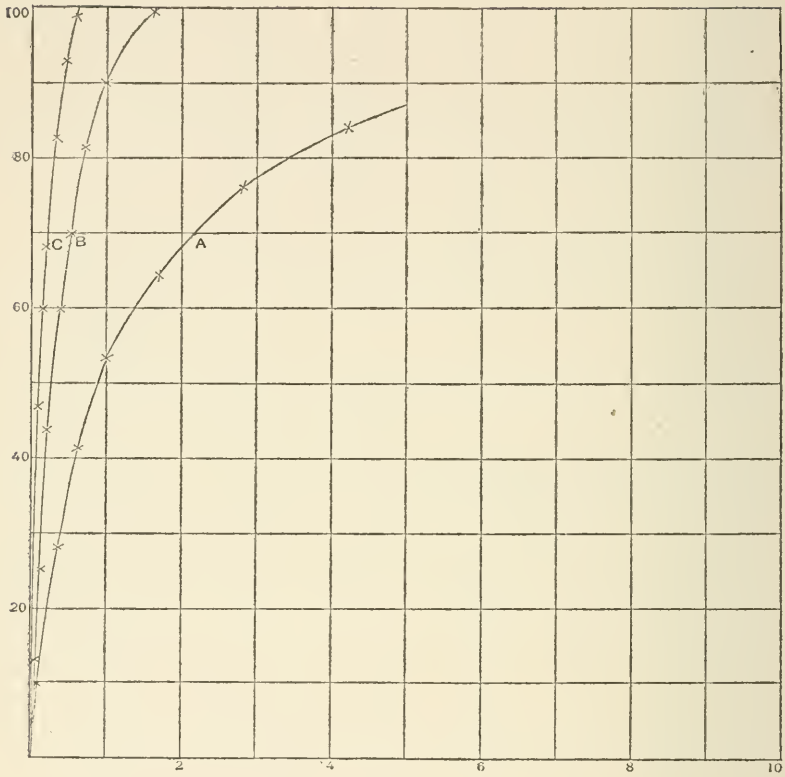
Normal Hydrochloric Acid	80.0 cc.
Normal Potassium Iodide	80.0 cc.
Three times normal Potassium Chlorate	6.7 cc.
Water	33.3 cc.
	200.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodide liberated.
5	10	5.4	27.0
10	10	9.4	47.0
15	10	12.0	60.0
20	10	13.7	68.5
25	10	15.3	76.5
30	10	16.5	82.5
35	10	17.3	86.5
45	10	18.6	93.0
55	10	19.75	98.8
60	10	19.95	99.8
80	10	19.9	99.5
105	10	20.1	100.5

It is to be observed here that the entire amount of iodine is liberated in an hour.

[1] Curve C, Figure 4.

IV.



(4) Series in which the K I is *doubled* and the H Cl *sextupled.*

$$KClO_3 + 6\,KI + 6\,HCl + \overbrace{6\,KI + 30\,HCl}^{\text{Excess.}}$$

A sample of 200 cc. was made up as follows:

Normal Hydrochloric Acid	120.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	6 7 cc.
Water	33.3 cc.
	200.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
5	10 (CS_2)	7.3	36.5
10	10	11.6	58.0
20	10 (CS_2)	15.4	77.0
20	10	15.45	77.3
31	10	17.65	88.3
35	10 (CS_2)	18.1	90.5
45	10	19.0	95.0
60	10 (CS_2)	19.9	99.5
85	10	19.9	99.5

Here too it is to be noticed that the entire amount of iodine is liberated at the end of an hour.

SECTION D.

Effect of Concentration on the Speed.

A comparison of the results in section B with those in A shows that there is an increase in the speed of the iodine liberation as one of the components enters in an excess; i. e., there is an increase in speed when *one* of the components exists in the mixture in a more concentrated form than the others. The results in section C show that there is a greater increase in the speed of the reaction when *both* the hydrochloric acid and potassium iodide enter in an excess. One would also expect an increase in speed as the component solutions became more concentrated, although none of the components entered in an excess. A mixture containing equivalents of the salts as fifth normal solutions, and another containing them as two-fifths normal were investigated. The results are graphically represented by curves B and C, Figure 5. The curve marked A represents the speed in a mixture containing the salts as tenth normal solutions.

V.
100
80
60
40
20
2
4
6
8
10
12
14
16
18
20
A
B
C

(1) Series containing equivalents of the components as *fifth* normal solutions,[1]—

$$KClO_3 + 6KI + 6HCl.$$

A sample of 200 cc. was made up as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	106.7 cc.
	200.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated
10	10	4.45	11.1
20	10	6.7	16.8
50	10	11.95	29.9
115	10	17.3	43.3
190	10	20.1	50.3
310	10	22.5	56.3
410	10	23.9	59.8
530	10	25.15	62.9
780	10	26.65	66.6
1380	10	29.2	73.0
1980	10	30.4	76.0

[1] Curve B, Figure 5.

(2) Series containing equivalents of the components as *two-fifth* normal solutions,[1]—

A sample of 100 cc. was made up as follows:

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Water	6.7 cc.
	100.0 cc.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	24.25	30.3
20	10	33.7	42.1
30	10	38.4	48.0
50	10	43.3	54.1
100	10	50.55	63.2
180	10	55.6	69.5
280	10	58.7	73.4
410	10	61.75	77.2
660	10	65.0	81.25

[1] Curve C, Figure 5.

SECTION E.

Acceleration of Speed by Other Acids.

The presence of an excess of hydrochloric acid accelerates the reaction. Will the presence of other acids have a similar influence, and if so what is their comparative influence on the speed of the reaction? Various acids, organic and inorganic, were tested.

Normal solutions of the following acids were prepared,—hydrobromic, nitric, sulphuric, boric, formic, acetic, propionic, butyric, tartaric, malic, lactic, succinic, and oxalic.

A mixture containing equivalents of the components as *fifth* normal solutions served as a basis throughout the investigations. The following is a general sample mixture of 200 cc.—

Normal Hydrochloric Acid	40.0 cc.
Normal Potassium Iodide	40.0 cc.
Three times normal Potassium Chlorate	13.3 cc.
Normal acid used as accelerator	20.0 cc.
Water	86.7 cc.
	200.0 cc.

It was found that none of the organic acids mentioned increased the speed of the reaction. On the contrary they all slightly retarded the liberation of iodine. [Boric acid also shows a slight retardation of the speed.] This is easily accounted for by the fact that some of the acids are oxidized by potassium chlorate. It is also possible that some of the halogens present go to form substitution products of the acid.

The results obtained by using hydrobromic, hydrochloric, nitric, and sulphuric acids respectively as accelerators are graphically represented in figure 6. Curve A represents the speed when no accelerating acid is present.

(1) Hydrobromic acid is the accelerator.[1]

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2 S_2 O_3$ used in each titration	Per cent. of Iodine liberated.
10	10	8.0	20.0
20	10	12.6	31.5
50	10	19.6	49.0
110	10	26.1	65.3
185	10	28.9	72.3
360	10	32.1	80.3
430	10	33.15	82.9
690	10	35.3	88.3

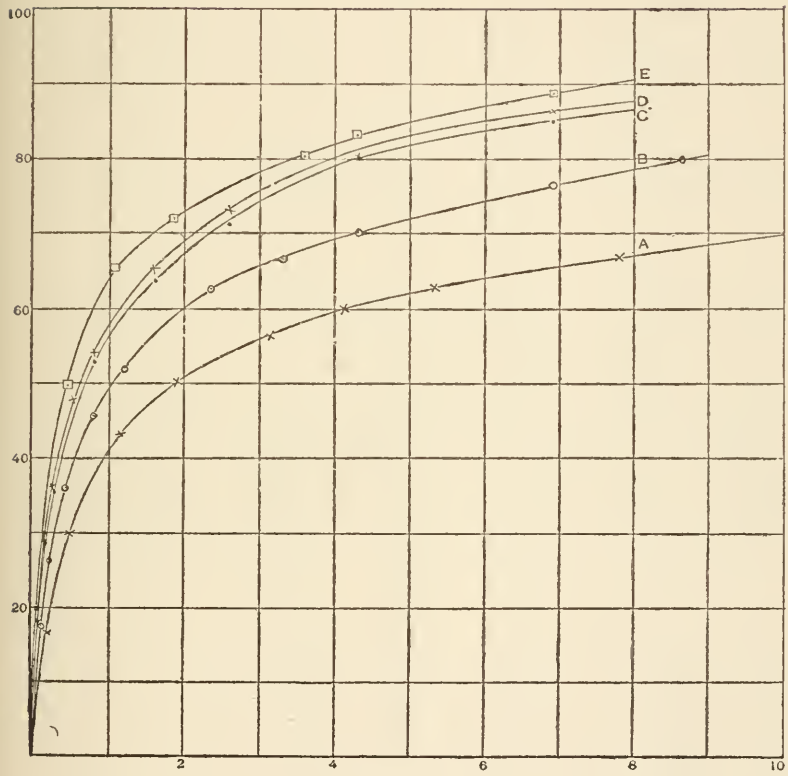
(2) Hydrochloric acid serves as the accelerator.[2]

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2 S_2 O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	7.2	18.0
20	10	11.5	28.8
30	10	14.4	36.0
55	10	19.1	47.8
80	10	21.6	54.0
160	10	26.1	65.3
260	10	29.15	72.9
430	10	32.15	80.4
690	10	34.55	86.4

[1] Curve E, Figure 6.

[2] Curve D, Figure 6.

VI.



(3) Nitric acid is the accelerator.[1]

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	7.2	18.0
20	10	11.4	28.5
30	10	14.1	35.3
55	10	18.6	46.5
110	10	21.15	52.9
185	10	25.45	63.6
360	10	28.45	71.1
430	10	32.1	80.3
690	10	34.0	85.0

(4) Sulphuric acid is the accelerator.[2]

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	6.1	15.3
25	10	10.55	26.4
45	10	14.4	36.0
80	10	18.25	45.6
120	10	20.8	52.0
260	10	25.2	63.0
330	10	26.5	66.3
360	10	26.65	66.6
430	10	28.3	70.8
690	10	30.5	76.3
840	10	32.0	80.0

[1] Curve C, Figure 6.

[2] Curve B, Figure 6.

(5) Boric acid was also investigated. A comparison of the following results with series (1), section D, shows that the speed of iodine liberation is very slightly retarded instead of accelerated by the presence of this acid.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2 S_2 O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	3.65	9.1
20	10	6.4	16.0
25	10	7.4	18.5
50	10	11·1	27.8
80	10	14.7	36.8
200	10	19.35	48.4
400	10	23.6	59.0
740	10	25.85	64.6

(6) Ten normal organic acids were also investigated. With the exception of formic acid, the results from these acids vary but slightly, so that to give any one series will be sufficient. A comparison with series (1), section D, shows a slight retardation in the speed of iodine liberation.

Duration of reaction in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	3.7	9.3
25	10	7.6	19.0
45	10	10.9	27.3
80	10	14.3	35.8
120	10	16.5	41.3
330	10	22.05	55.1
840	10	25.6	64.0

(7) Formic acid being a good reducing agent retards the speed of iodine liberation to a remarkable degree, as the following results show:

Duration of reac- in minutes.	Cubic centimeters of solution taken.	Cubic centimeters of $\frac{n}{20}$ $Na_2S_2O_3$ used in each titration.	Per cent. of Iodine liberated.
10	10	3.7	9.3
20	10	5.6	14.0
80	10	8.35	20.9
120	10	8.7	21.8

CONCLUSIONS.

The foregoing results lead to the following conclusions:

1. The speed of the reaction is influenced to a marked degree by the temperature, the speed increasing with the rise of temperature.

2. The presence in the mixture of an excess of one or more of the components increases the speed. The effect of an excess of potassium iodide is about the same as an equivalent excess of potassium chlorate. But a corresponding excess of acid causes a greater increase of speed.

3. Other things being equal the speed of the reaction is modified by degree of concentration of the mixtures, the speed increasing with the concentration.

4. To obtain the complete reduction of potassium chlorate by potassium iodide and hydrochloric acid in a comparatively short time, the solutions must be concentrated, there must be present quite an excess of both potassium iodide and hydrochloric acid. and the mixture must be strongly heated.

5. The presence of an excess of the ordinary inorganic acids accelerates the reaction. Assuming their respective influences as indicating their relative strengths,[1] the results on acceleration show the following order of strength: (1) hydrobromic, (2) hydrochloric, (3) nitric, and (4) sulphuric.

6. Organic acids and boric acid do not increase the speed.

This work was undertaken at the suggestion of Mr. Louis Kahlenberg, instructor in chemistry at the University of Wisconsin, and was carried out under his immediate direction. For the kindly interest he has always taken in my work I here desire to express my sincere thanks.

[1] These acids are arranged in the same order by Ostwald, who investigated the influence of their presence on the speed of the reduction of bromic acid by hydriodic acid. Zeitsch. physik. Chem., 2. p. 135. (1888.)

The BULLETIN OF THE UNIVERSITY OF WISCONSIN is issued at irregular intervals and contains original papers by persons connected with the university.

The following numbers have already appeared:—

ENGINEERING SERIES, Volume 1:

No. 1. Track, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 24, April, 1894. Price 25 cents.

No. 2. Some Practical Hints in Dynamo Design, by Gilbert Wilkes, M. Am. Inst. E. E., Special University Lecturer. Pp. 16, May, 1894. Price 25 cents.

No. 3. The Steel Construction of Buildings, by C. T. Purdy, C. E., Special University Lecturer. Pp. 27, October, 1894. Price 25 cents.

No. 4. The Evolution of a Switchboard, by A. V. Abbott, C. E., Special University Lecturer. Pp. 32, pls. 4, October, 1894. Price 35 cents.

ECONOMICS, POLITICAL SCIENCE, AND HISTORY SERIES, Volume 1:

No. 1. The Geographical Distribution of the Vote of the Thirteen States on the Federal Constitution, 1787-8, by Orin Grant Libby, A. M., Fellow in History, with an introduction by Frederick J. Turner. Pp. 116. pls. 2, July, 1894. Price 75 cents.

SCIENCE SERIES, Volume 1:

No. 1. On the Speed of Liberation of Iodine in Solutions of Hydrochloric Acid, Potassium Chlorate, and Potassium Iodide, by Herman Schlundt, Assistant in Chemistry. Pp. 33, December, 1894. Price 35 cents.

Copies of the BULLETIN will be forwarded post free from the office of the State Superintendent of Public Property to all colleges, high schools, normal schools, and public libraries of the state which have a collection of 300 or more volumes, on making proper application at the Superintendent's office. Persons who reside in the state of Wisconsin can receive copies of the BULLETIN free by applying to the University Librarian and paying the cost of transportation. The postage required for the numbers thus far issued, is as follows: Eng. Ser., No. 1, 2c; No. 2, 2c; No. 3, 2c; No. 4, 3c. Hist. Ser., No. 1, 6c. Sci. Ser., No. 1, 3c. All the above are sent in one package by express for 10 cents.

The BULLETIN may be obtained at Brentano's, 31 Union Sq., New York and 204-206 Wabash Ave., Chicago; and at A. C. McClurg & Co.'s, 117, 119 and 121 Wabash Ave., Chicago.

Communications having reference to an exchange of publications should be addressed to Professor Wm. H. Hobbs of the board of editors, or to Mr. Walter M. Smith, University Librarian.

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SCIENCE SERIES, VOL. 1, NO. 2, PP. 35–56, PLS. 1–3.

ON THE QUARTZ KERATOPHYRE AND ASSOCIATED ROCKS OF THE NORTH RANGE OF THE BARABOO BLUFFS.

BY

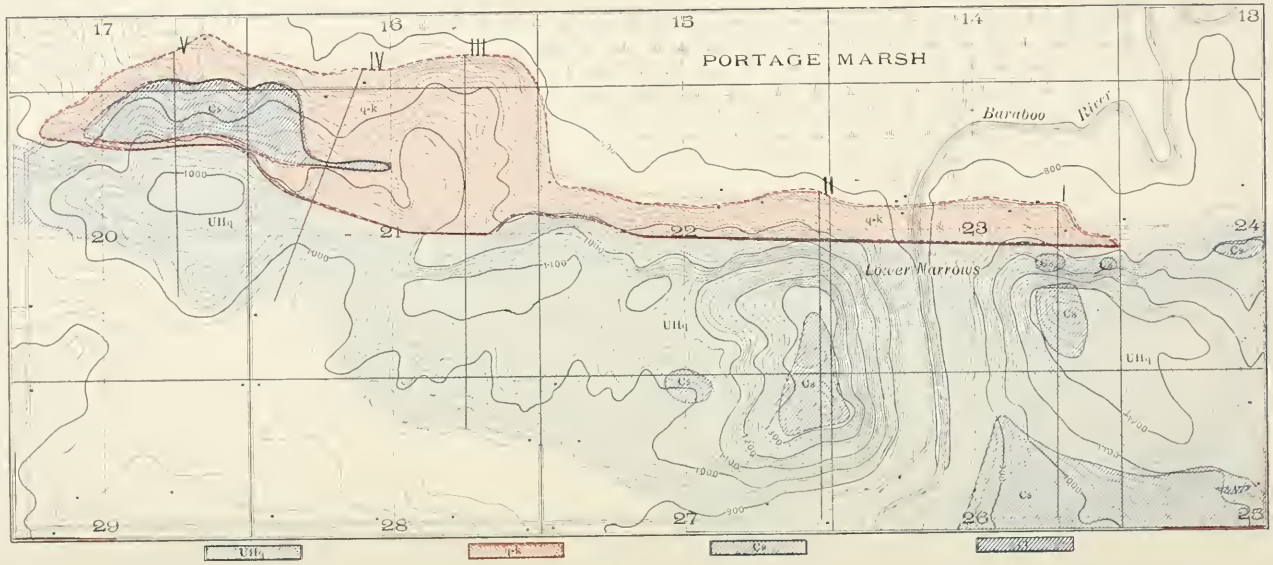
SAMUEL WEIDMAN

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
JANUARY, 1895

PRICE 25 CENTS

Democrat Printing Company, State Printer



U. Huronian Quartzite. Quartz keratophyre. Cambrian Sandstone. Cambrian Limestone.

GEOLOGICAL MAP OF A PORTION OF THE NORTH RANGE OF THE BARABOO BLUFFS.

By Samuel Weidman.

Scale: 1½ inches = 1 mile.

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 2, PP. 35-56, PLS. 1-3, JANUARY, 1895

ON THE QUARTZ KERATOPHYRE AND ASSOCIATED ROCKS OF THE NORTH RANGE OF THE BARABOO BLUFFS.[1]

BY SAMUEL WEIDMAN.[2]

CONTENTS.

In the south central part of Wisconsin, extending across the middle portions of the county of Sauk and for a short distance into that of Columbia, there arises above the surface of the surrounding area two long ranges of hills or ridges. These ranges trend across the country in an east and west

[1] A thesis submitted for the degree of Bachelor of Science in the Geology Group of the General Science Course, University of Wisconsin, June, 1894. Read before the Geological Society of America at the Baltimore meeting, December, 1894.

[2] This paper is the result of work undertaken and executed under the direction of Professors W. H. Hobbs and C. R. Van Hise. To the former I desire to express my thanks for superintending the work in the laboratory, for preparing the photo-micrographs, and for other valuable help, and to the latter for giving me aid and suggestions in the field study. I also desire to express my obligation to Mr. C. F. Austin who kindly furnished the chemical analysis for this paper.

direction for a distance of nearly thirty miles, and are known as the north and south ranges of the Baraboo Bluffs. In altitude they vary from a mere rise above the surrounding country to a height of five and even six hundred feet.

The north range, which is not so prominent as the south range, is joined to the latter at the eastern and western extremities, forming thus a canoe-shaped chain of bluffs, enclosing within a depressed area three or four miles broad at its widest part. Near the western end, where the Baraboo River enters the area, and also near the eastern end, where it emerges again, the north range is broken down by deep gorges known respectively as the Upper and the Lower Narrows.

The rock material of the Baraboo Bluffs is mainly of bedded quartzite, over whose upturned edges lie horizontal beds of sandstone and conglomerate, capping and flanking the ranges. Besides these sedimentary rocks there occurs in the vicinity of the Lower Narrows a considerable area of eruptive material.

The geology of the sedimentary rocks [1] has already been quite well worked out. The quartzite, which belongs to the Upper Huronian formation, is usually hard and massive, but in a few places there occur beds and zones of quartzite schists and slates. The dip of the quartzites is always to the north, and varies from 15° at Devil's Lake in the south range, to 60° at the Upper Narrows and even 90° at the Lower Narrows in the north range. This ever increasing dip from the south toward the north indicates, as shown by the Wisconsin geologists,[2] that the two ranges are the remnants of the north half of a great anticlinal fold. The sandstone and conglomerate, as well as a few small areas of limestone, all of which are of Upper Cambrian age, lie in horizontal beds capping the ranges.

---

[1] Correlation Papers — Archean and Algonkian, by C. R. Van Hise. Bulletin 86, U. S. Geological Survey; pp. 105–107, 111, 140, 148.

The Baraboo Quartzite Ranges, by R. D. Irving. Geol. of Wis., Vol. II; pp. 506, 507.

The eruptive rock, which was described as quartz porphyry by the state geologists, is a quartz keratophyre, and occurs in contact with the quartzite along the north side of the north range in the vicinity of the Lower Narrows. This rock was not discovered until 1874 or 1875 by Irving and his co-workers upon the Wisconsin Geological Survey, and all results of work done upon this formation are embodied in the state geological reports.

Irving[1] in 1877 described the porphyry as occurring on the west side of the Baraboo River at the Lower Narrows. He considered the porphyry to be very distinctly bedded, with an east and west strike and a dip of 58° to 60° to the north. He also found that near the quartzite it changes to a distinct schist, which he thought to be allied to the greasy quartz schists at Devil's Lake. Farther west at the northern limit of the porphyry, he found the much fractured area. A schistose structure, which is apparent in places, was taken as bedding and as evidence of the clastic origin of the rock. A specimen was analyzed and found to contain 71.24 per cent. of silica and a notably large quantity of soda as compared with potash.

Chamberlin,[2] in 1882, mentioned the massive quartz porphyries which overlie the Baraboo quartzites and referred to their origin as yet in doubt. According to him they might be either a metamorphosed silt-like sedimentary rock; or they might be of eruptive origin, in which case they must have constituted immense overflows of molten rock closely allied in chemical composition to rhyolite.

Irving,[3] in 1886, in referring to the Baraboo quartzites, stated that "the bedding structure of the quartzite of these ranges and of its associated schists and felsitic porphyries, which are taken to have been great eruptive flows, I studied with a great deal of care a number of years since * * *." It is evident from this that he was inclined to

[1] The Baraboo Quartzite Ranges, by R. D. Irving. Geol. of Wis., Vol. II; pp. 513–515.

[2] General Geology of Wisconsin, by T. C. Chamberlin. Geol. of Wis., Vol. I; p. 87.

[3] On the Classification of the early Cambrian and pre-Cambrian Formations, by R. D. Irving. 7th Ann. Rept. U. S. Geol. Surv., 1885-6; p. 407.

change his opinion as to the origin of the quartz porphyry. He, however, made no re-examination of the area, and it must be supposed that he was led to change his views on account of his knowledge of the extensive eruptive areas in the Lake Superior region.

II. Field Geology.

The accompanying map, Plate 1, shows the relations and extent of the different rock formations which occur in the vicinity of the Lower Narrows. Four distinct types of rock are seen to outcrop, representing the quartz keratophyre, Upper Huronian quartzite, Potsdam sandstone and conglomerate, and the Lower Magnesian limestone. The cross sections of Fig. 1 cross the range, and in a measure show the structural relations and vertical extent of these formations. For the purpose of convenience the reverse order will be taken in describing these formations.

LIMESTONE.

On the south side of the range, and near its summit, in the northwest ¼ of Sec. 25, is a ledge of dolomitic limestone overlying the sandstone. It is non-arenaceous, and contains many small cavities lined with calcite. In determining its stratigraphical position, one is met with difficulties owing to the peculiar fluctuations in level of the horizontal formations in the Baraboo region, but from the *Dikellocephalus* fauna which it carries, and from its lithological characters, it has been considered[1] as being at least not below the Lower Magnesian.

SANDSTONE AND CONGLOMERATE.

Overlying both the older formations of quartzite and quartz keratophyre there occur capping and flanking the

[1] Geol. of Wis., Vol. II; pp. 594, 595.

range horizontal beds of sandstone and conglomerate of the Upper Cambrian epoch. The conglomerate is composed of pebbles and boulders, varying in size from a fraction of an inch to more than a foot in diameter, imbedded in a matrix of quartz grains, stained more or less with ferruginous material. The conglomerate is found in great abundance in the ravines.

The sandstone which carries the *Dikellocephalus* fauna is interbedded with and overlies the conglomerate. It is composed of rounded quartz crystals in a matrix of silica, containing considerable oxide of iron. The sandstone caps the ridges in thin beds, but along the sides of the range, as in the area of cross-section V of Fig. 1 (see also Plate 1), it reaches a thickness of forty-five or fifty feet.

QUARTZITE.

The quartzite is a hard compact rock, and has a reddish purple hue, with a tendency to granular texture. The bedding is not everywhere distinct, but in places it is quite plain. At the contact of the quartz keratophyre along the ridge the bedding dip conforms to the dip of the overlying keratophyre schists, but farther south, at the top of the ridge, the dip is increased to 90°, and sometimes apparently dips to the south. On the south side of the range, however, it again dips 75° or 80° to the north. Everywhere the quartzite is jointed, and in many places the rock is seamed with reticulating veins of pure quartz, in which, at times, are to be seen small particles of specular iron ore.

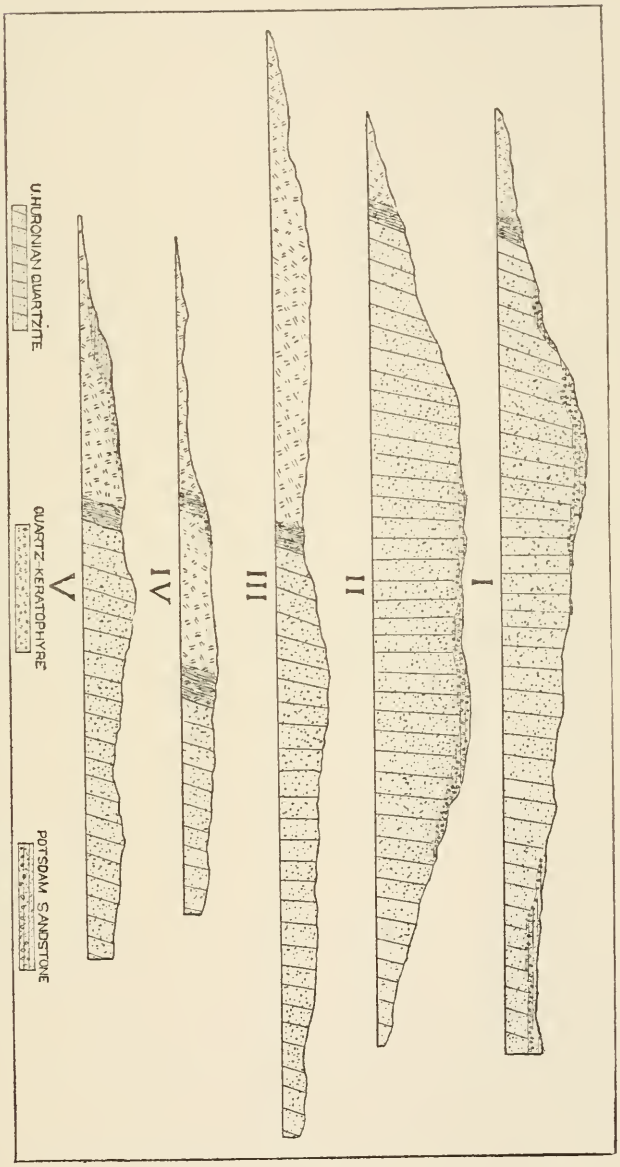
QUARTZ KERATOPHYRE.

Areal Extent.— From the map it is seen that quartz keratophyre extends along the north face of the range for a distance of over three and one-half miles. Its most eastern limit is in the northeast corner of the southeast ¼ of Sec. 23, and its most western is found in the northeast ¼ of the northwest ¼ of Sec. 20, thus extending along the range

in a slightly north of west direction. In Sections 16 and 21 the thickest portion of the eruptive mass is found, for its contact with the quartzite at this place is distinctly shown near the northern boundary of the southeast ¼ of Sec. 21, from whence it extends north forming a broad ridge cut by ravines, with its northern limit near the middle of the southeast ¼ of the southeast ¼ of Sec. 16.

It is apparent that Irving did not find the keratophyre extending as far east or as far west as a closer study of the area reveals, for it is described as only reaching from the Narrows to the south side of Sec. 16.

The Contact.—The contact between the eruptive rock and the quartzite is well defined, except where a bed of soil overlies it. At the eastern end of the area in Secs. 22 and 23, where the keratophyre occurs as a narrow strip, the quartzite is of a higher altitude than the keratophyre, and stands out as a vertical cliff from ten to thirty feet high. In the region from the center of Sec. 21 eastward, the contact is easily made out, and it is seen that its direction conforms very closely with the strike of the underlying quartzite, which is slightly south of east. From the center of Sec. 21 across the greater part of the northwest ¼ of this section, the contact was not seen, but it was clearly made out at the boundary of Secs. 20 and 21, near the southwest corner of the northwest ¼ of the northwest ¼ of Sec. 21. From this place eastward the actual contact was not seen, but many schistose blocks of keratophyre were found near the outcropping quartzite, and as the keratophyre was found *in situ* in the northwest ¼ of the northwest ¼ of Sec. 20, the contact is thought to be very near the line indicated upon the map. The eruptive rock at the contact occurs as schist, but the quartzite forms massive beds, and is fresh and unaltered. Dikes and veins from the eruptive rock were closely searched for the whole length of the ridge at the contact, with the thought that the eruptive mass might be intrusive and not extrusive, but no such phenomena were found to occur.



SECTIONS ACROSS THE NORTH RANGE OF THE BARABOO BLUFFS.

Horizontal and vertical scales are one inch to eleven hundred and fifty feet. Base line of sections is eight hundred feet above Lake Michigan.

The contact between the quartz keratophyre and the Cambrian sandstone and conglomerate is well shown in the northwest ¼ of Sec. 21. At this place a narrow strip of the conglomerate projecting from the large sandstone area to the west, lies in horizontal beds upon the dipping edges of the sericite schist (Fig. 1, Sec. IV). These schists dip to the north at an angle of 75° or 80°, essentially the same as those farther south at the contact with the quartzite. Farther west from this tongue of conglomerate, in a ravine which marks the eastern boundary of the massive sandstone area, the contact is again well shown, the horizontal sandstone lying upon the upturned edges of the sericite schist.

Absence of Bedding.— This rock does not, like the quartzite, exhibit stratification, but on the contrary all traces of bedding are entirely wanting. It does, however, at the contact form a zone of schists from 150 to 200 feet in width, and also in a considerable area in the northwest ¼ of Sec. 21, schists are found. The cleavage planes of these schists always dip to the north at an angle of 75° or 80°. Irving[1] in describing this area, speaks of the schists, and whenever he does so he invariably mentions the clearly defined bedding which the rocks show. Although he was one of the first geologists who later learned to recognize the importance of distinguishing schistosity from stratification, it is evident that he committed the common error of taking the one for the other in this region.

Types of Rock.— The eruptive rock as it appears in the field exhibits marked local variations, due both to conditions in the eruptions of the magma and to dynamic action since the general outflow. These differences allow a classification of the rock into three distinct types, which will be described separately. These types are normal quartz keratophyre, sericite schist, and volcanic breccia.

---

[1] Geol. of Wis., Vol. II; pp. 513-515.

Quartz keratophyre.—The quartz keratophyre, which forms the normal rock type of the whole eruptive area, as it occurs in the narrow strip at the eastern extension of the area is not much fissured, but is jointed and cut by reticulating veins of quartz. It forms rounded ledges and grades into the sericite schist zone, which lies to the south of it. The rock[1] is very fresh, and breaks with a conchoidal fracture. It is red in color, containing in about equal numbers many beautiful red and white feldspar phenocrysts, some of which are three-eighths inches in diameter. These are imbedded in a brownish red matrix. The rock on the eastern side of the Lower Narrows contains fewer phenocrysts than that on the western side. Both phenocrysts and groundmass become red on weathering.

Farther west, at the large northward projecting ridge which occurs in the northeast ¼ of Sec. 21 (Fig. 1, Sec. III), the keratophyre[2] is found to be unlike that farther east, in that it is much fractured, and the feldspar crystals are rarely apparent in the hand specimen. Reticulating quartz veins from a fraction of an inch to three or four inches in thickness are quite numerous. The fractures which cut the rock run in all directions, so that it breaks and weathers in small fragments, bounded on all sides by plane surfaces. On the weathered surface the rock is a reddish brown, but within it is of a darker hue.

Within the eruptive area are many detached blocks of quartz keratophyre. Some of these blocks are quite different from the quartz keratophyre found in place. A detached block[3] which was found upon the summit of the range in the northwest ¼ of Sec. 21, unlike the quartz keratophyre found *in situ*, is black in color, and on close examination it shows fluxion structure. Several blocks of similar black colored quartz keratophyre were found near

---

[1] Specimens 3089 and 3090. The specimen and thin section numbers referred to in this paper are those of the University of Wisconsin Collection.

[2] Specimens 3075 and 3092.

[3] Specimen 3080.

the exposure of volcanic breccia at Mr. Hewitt's place in the northeast ¼ of the northwest ¼ of Sec. 21.

Specimens from some of these blocks have a large number of small phenocrysts while others show but few. These phenocrysts are a light colored feldspar and usually plagioclase. It is possible that this black quartz keratophyre has its origin in the porphyry areas to the northeast, but it may be that a closer examination of the area would reveal it in place.

Sericite Schist.—Wherever the quartz keratophyre comes in contact with the quartzite, there occurs a zone of sericite schist from 150 to 200 feet wide. These schists are a dynamic alteration of the quartz keratophyre and they gradually pass into the latter, and hence are not, as Irving[1] supposed, closely related to the magnesian schists which occur at Devil's Lake. The schists vary in color from the reddish brown of the quartz keratophyre to a grayish white. In texture they are quite friable and are easily cleaved. They carry a considerable number of feldspar crystals, some of which have weathered out leaving cavities that are usually lined with iron oxide. In some specimens iron pyrite is seen. Some of the grayish white schists contain many greenish brown areas of cherty-like material, which the microscopic examination shows to be secondary quartz, the rock being a pseudo-breccia.

Besides the schists at the contact, there occurs within the area of quartz keratophyre in the north half of the northwest ¼ of Sec. 21, a large area of schist (Fig.1, Sec. IV), which is capped by sandstone and conglomerate, and which, like the schist at the contact, has a dip of 75° or 80° to the north. In all respects it is like the schist at the contact, except that feldspar crystals in the hand specimen are rare.

Volcanic Breccia.—There occur within the eruptive area several good examples of volcanic breccia. Within the

---

1 Geol. of Wis., Vol. II; page 513.

contact zone of schists in the southwest ¼ of the northeast ¼ of Sec. 22, there is an outcrop of volcanic breccia[1] fragments in which usually have the typical flow structure about them. A similar exposure[2] occurs at the contact near the center of Sec. 22. The included fragments in the rock of both the above localities are of a hard pink rock, and unlike the schist in which they are imbedded they are relatively unaltered. In the field these fragments were taken to be a pink quartzite, but the microscopic slides show them to be an acid porphyry.

The best exposures of breccia,[3] however, were found on the north side of the road opposite Mr. Hewitt's house, in the northeast ¼ of the northwest ¼ of Section 21. This outcrop exhibits a schistosity, the dip of the cleavage planes being 75° to the north and the strike a little north of east. The fragments forming this breccia are much larger than those found in the other schists and are usually angular and elongated in the plane of schistosity. They vary in size from an inch to a foot in diameter, and were at once taken to be of eruptive origin.

The fragments of this breccia represent several rock varieties. One is brownish pink in color and is composed almost wholly of secondary spherulites which are from two-eighths inch to three-eighths inch across. On the surface of the exposure these secondary spherulites have weathered out, leaving cavities lined with quartz, which makes them appear much like amygdaloidal cavities. An other variety is a brownish gray schistose rock which contains many feldspar phenocrysts, some of which have weathered out leaving cavities filled with black ferruginous material. Other fragments are composed of a dull lead colored rock, slightly schistose and having no phenocrysts.

A large number of loose blocks[4] was found in the road

---

[1] Specimens 3084 and 3085.

[2] Specimen 3081.

[3] Specimens 3093, 3094.

[4] Specimen 3096.

near the house of Mr. Montgomery, in the southeast ¼ of the southeast ¼ of Section 17. This rock on its weathered surface shows very clearly the flow structure about the included fragments. Unlike the fragment-bearing rock *in situ* this is not markedly schistose, is not much altered, and the included fragments are few. The weathered surfaces seem to give evidence of a few large and widely separated spherulites, but none of these were included in the sections which were prepared. An outcrop of fresh breccia[1] in the northwest ¼ of the northwest ¼ of Sec. 21, shows numerous phenocrysts of feldspar intermingled with small rock fragments.

Conclusions Drawn from Field Study.—The work in the field shows the areal extent of the eruptive rock to be somewhat greater than was formerly supposed. A marked difference is found in the rock as it outcrops in various places. The contact closely conforms in direction for the greater part of the distance, with the strike of the underlying quartzite beds and the dip of the cleavage planes of the contact schists agrees with the dip of the quartzite. Volcanic breccia occurs in considerable quantity in various localities. All the phenomena observed during the field study are evidence that the porphyry in its several phases represents a volcanic outflow which took place over beds of quartzite. During the elevation which followed, the overlying eruptive rock was in part metamorphosed into schist.

III. Microscopic Geology.

The structure of the rock, as it is presented by the microscopic sections in the laboratory confirms the evidence gathered in the field for the extrusive character of the quartz keratophyre. The porphyritic structure is developed in all the types of rock, being well shown in the volcanic

[1] Specimen 3079.

breccia and sericite schist as well as in the unaltered quartz keratophyre. The porphyritic minerals are chiefly the feldspars, quartz occurring very rarely in phenocrysts. The few that are found are intensely corroded, and the indications are that they were once much more numerous, the rock being at this earlier period mineralogically as it is now chemically a quartz keratophyre.

Two analyses of the rock have been made, one by Prof. W. W. Daniells for the State Geological Survey, the other by Mr. C. F. Austin during the preparation of this paper. Below are given the analyses of the Baraboo rock in comparison with quartz keratophyres from other localities.

	I.	II.	III.	IV.	V.
SiO_2	70.97	71.24	72.42	73.00	71.9
Al_2O_3	13.84	12.20	13.04	15.61	13.4
Fe_2O_3	3.21	1.71	.68	—	.6
FeO	.78	5.44	2.49	1.95	
CaO	1.26	.98	.66	.79	.2
MgO	.20	.13	.58	—	1.0
K_2O	1.57	1.86	4.97	.88	.2
Na_2O	6.27	4.29	3.44	4.95	12.6
H_2O	.74	.81	1.21	1.06	.5
CO_2	.79	—	—	—	—
P_2O_5	.08	—	—	—	—
TiO_2	.25	—	.40	—	—
MnO	—	.97	.09	—	—
BaO	—	—	.15	—	—
Li_2O	—	—	tr.	—	—
SO_3	—	—	—	.76	—
Total	99.96	99.63	100.33	99.00	100.00
Sp. Gr.	—	—	2.62	2.63	—

I. Quartz keratophyre from Mühlenthal zw. Elbingerode and Rübeland, Harz. (Jacobs.)[1]
II. Quartz keratophyre from Baraboo, Wis. (Daniells.)[2]
III. Quartz keratophyre from Pigeon Pt., Minn. (Bayley.)[3]
IV. Quartz keratophyre from Baraboo, Wis. (Austin.)
V. Quartz keratophyre from Mt. Elizabeth, Australia. (Howitt.)[4]

It is seen that the Baraboo rock compares very well in composition with the quartz keratophyre of other regions. The large amount of soda as compared with potash in this rock, as shown by the analyses, indicates the presence of a feldspar whose composition corresponds with a soda-orthoclase. The excess of soda over lime in the Baraboo rock also indicates that the plagioclase present contains a large per cent. of the *Ab.* molecule. The specific gravity of the orthoclase and plagioclase as determined by the Thoulet solution was found to be about 2.63, both varieties being apparently the same. This high specific gravity of the feldspars is explained by the large amount of soda in their composition, and in part, also, by the particles of oxide of iron which they contain.

A macroscopic description of the several types of rock as they appear in the different parts of the eruptive area has already been given. As the microscope shows the structure of these types to be essentially the same both as regards the minerals of the first generation and the groundmass, the phenocrysts and accessory minerals will first be described, and then the various structures of the groundmass.

Feldspar Phenocrysts.—Feldspar constitutes almost the only porphyritic mineral. Soda-orthoclase and plagioclase are about equally abundant. Sometimes both varieties are equally distributed in the same slide, and at other times a single variety only is present. Microcline

---

[1] Quoted by Zirkel, Lehrb. d. Petrog., 2te Aufl., Vol. II; p. 334.

[2] Irving, Geol. of Wis., Vol. II; p. 515.

[3] Bayley, Am. Jour. Sci., (3) Vol. XXXVII; p. 61.

[4] Howitt, Roy. Soc. Victoria, 1883, p. 25. Quoted by Rosenbusch, Min. u. petrog. Mitth. Vol. XI; p. 177.

is found to some extent as both large and small phenocrysts.

The phenocrysts vary in size from two-tenths millimeter to four millimeters across. The crystals are more or less altered to sericite, sometimes completely, but at other times only slightly. The alteration takes place very often at the boundary of the feldspar, and forms zones of sericite surrounding the crystal. At other times the fine sericite needles are promiscuously scattered throughout the phenocryst. Very often the feldspar is replaced by secondary quartz. At times[1] it is only partly replaced, but very often the angular shape which the secondary quartz assumes indicates that there has been a complete replacement of the feldspar.

Numerous beautiful examples were observed of bent and broken crystals due to the motion of the magma after the crystallization of the phenocrysts (Plate 2, Figs. 1 and 2). Broken phenocrysts are not uncommon phenomena of effusive rocks. As the viscous streams of lava, including the crystals of feldspar, flowed over the surface, the motion within the mass bent and broke the phenocrysts. Sometimes they are merely cracked or broken, but very often the broken parts are separated from each other (Plate 2, Fig. 2), allowing a thin stream of groundmass to flow between the dismembered parts. It very often happens that the crystals of feldspar, both the broken and unbroken ones, have their corners rounded by corrosion. The embayments in the feldspar shown by some of the slides[2] show plainly this resorption.

Quartz phenocrysts.— This usually abundant mineral as a primary constituent of the acid rocks, occurs very rarely as phenocrysts in the Baraboo quartz keratophyre. In a total of thirty-two slides examined from this region only four were found to contain porphyritic quartz, and these showed only a few crystals, all of which were of small

[1] Section 3084.1

[2] Sections 3079 and 3089.

size. All, however, show by their rounded appearance and embayments, the resorption effects of a corroding magma, and thus they indicate that they were once of larger size and probably more numerous. Some[1] of the quartz-phenocrysts, like those of feldspar, show the effect of a moving magma by being cracked and broken.

The small number of quartz phenocrysts present would apparently indicate that this rock is a keratophyre rather than a quartz keratophyre. Mineralogically it is a keratophyre; but the analyses show it to compare very closely to quartz keratophyre in the amount of silica contained, and the few corroded quartz crystals seem to indicate that the rock was originally a typical quartz keratophyre, though the silica per cent. has been somewhat increased by the secondary quartz present.

Accessory Minerals.— Ilmenite is an abundant accessory constituent occurring in small and large crystals. It is commonly either partially or completely altered to leucoxene. The alteration to leucoxene along the gliding planes of the ilmenite is well shown in one section.[2] Sometimes the ilmenite has gone over to well crystallized sphene, which is commonly mingled with more or less of the impure variety. In some cases (Plate 3, Fig. 1) the crystals of ilmenite are partly replaced by secondary quartz, the latter occupying the space of the former, as in the replacement of the feldspar crystals.

Biotite occurs in considerable abundance in a few of the sections. It is crystallized into small blades which are scattered promiscuously throughout the groundmass and in longer blades[3] arranged in sheaves, or in aggregates which seem to be about small cavities in the rock.

Zircon occurs to a small extent, sometimes being bounded by its usual crystal planes. It is frequently associated with the ilmenite.

---

[1] Section 3073.

[2] Section 3080.

[3] Sections 3079 and 3080.

Magnetite occurs in considerable quantity as shown by the action of the magnet on the powdered rock, and the microscopic sections show it disseminated in small particles throughout the groundmass. Besides the magnetite there is considerable amorphous iron oxide or ferrite present, which appears as a red substance about cavities [1] and in streaks through the groundmass.

The Groundmass.—The groundmass of the quartz keratophyre is holo-crystalline and composed of quartz and feldspar, stained more or less with oxide of iron. It is crystallized in at least three structures which are common to volcanic rocks, viz.; the fluxion structure, the poikilitic structure, and the spherulitic structure.

Fluxion structure.—In all the sections examined under the microscope the rock shows clearly sinuous lines of flow in the groundmass. These lines of flow curve and wind about phenocrysts, and give them the appearance of eyes. They also curve about the fragments and between the broken parts of fragments and phenocrysts. The fragments about which flowage is apparent in the hand specimen have also a flow structure of their own and in one case [2] a fragment within a fragment showed the typical flow lines under the microscope. One section [3] (Plate 3, Fig. 2), shows quite well the flow structure in a volcanic breccia, in which the lines of flow in the fragments are at right angles to those in the surrounding mass. In the sericite schists the fluxion structure is clearly defined, which as well as the field relations proves them to be the metamorphosed equivalents of the quartz keratophyre.

Poikilitic Structure.—This structure, which has recently been described by Haworth,[4] Williams,[5] and others, is quite

---

[1] Section 3076.

[2] Section 3084.1

[3] Section 3096.

[4] A Contribution to the Archean Geology of Missouri, by Erasmus Haworth. Am Geol., Vol. 1; p. 368.

[5] On the use of the terms Poikilitic and Micropoikilitic in Petrography, by G. H. Williams. Jour. of Geol., Vol. I; pp. 176-179.

common in acid volcanic rocks, and occurs to some extent in these rocks. This structure is not apparent in ordinary light, but in polarized light on revolving the stage, small areas in the groundmass appear alternately dark and light in patches, giving a mottled appearance. These areas are composed of irregular grains of quartz in close contact with feldspar. They do not have sharp extinction individually, but gradually pass into one another as the stage is revolved. Sections[1] taken from the fractured rock show this structure better than the others.

Spherulitic Structure.—The spherulitic structure is well developed in many of the sections examined. Some of the spherulites are a primary crystallization and are composed of radial fibres of feldspar associated with quartz, and occur in small circular and semicircular areas,[2] and in larger fan-shaped forms[3] (Plate 2, Fig. 2), like those described by Iddings[4] from the Yellowstone Park rhyolites. They are scarcely perceptible in ordinary light, but in polarized light the usual distinct dark cross is seen. Besides those showing the radiating structure there also occur some spherulites which have a granular texture, and are of secondary origin. Similar secondary spherulites have recen ly been described[5] from the acid volcanic rocks of South Mountain. In the Baraboo quartz keratophyre these secondary spherulites as they appear in the thin section are much larger than those of primary origin. In the hand specimen, too, the only spherulites found are the secondary ones. One of the specimens[6] shows many such spherulites one-fourth inch across, with lines of flowage passing around them. Under the microscope these spherulites[7] ap-

[1] Section 3075.

[2] Section 3074.

[3] Section 3080.

[4] Obsidian Cliff, Yellowstone National Park, by J. P Iddings. 5th Ann. Rep. U. S. Geological Survey; pp. 276-279.

[5] The Structures, Origin, and Nomenclature of the Acid Volcanic Rocks of South Mountain, by F. Bascom. Jour. of Geol., Vol. I; pp 817-819.

[6] Specimen 3094.

[7] Sections 3085, 3094a and 3094b.

pear to be composed of grains of quartz of smaller size than that which replaces the feldspar, and which is otherwise aggregated in the groundmass. Within the secondary spherulite, too, the quartz seems to be associated with sericite and iron oxide, whereas the secondary quartz otherwise aggregated is free from these minerals. One section[1] which contains secondary quartz partly surrounding one of the secondary spherulites shows very plainly both in ordinary and polarized light the difference between the two structures.

The aggregations and general appearance of the secondary quartz in the groundmass is of considerable interest in these rocks. The secondary quartz of the groundmass most generally forms interlocking areas of grains of various sizes, and it is possible that much of it may be chalcedony. Large reticulating veins of quartz up to two inches in width have been described as occurring in large numbers in the eruptive rock in the field. The thin sections likewise show many minute veins of secondary quartz ramifying throughout the rock. The quartz often occurs in angular forms, when it very probably is a replacement of ilmenite and feldspar. The spherical shape which the secondary quartz assumes is a very noticeable and interesting feature (Plate 3, Fig. 1). These spheres vary in size from one-tenth of a millimeter to one and five-tenths millimeters across, and usually have an elliptical outline, with the boundary sometimes slightly crenulated. The quartz in these spheres differs from that in the secondary spherulites in being of coarser grain, and in being also unassociated with sericite and iron oxide. Some of the sections,[2] show very large areas of secondary quartz. This secondary quartz is also apparent in the hand specimen, where it appears in areas about an inch in diameter resembling greenish brown chert, and the rock is considered a

[1] Section 3085.
[2] Section 3077.

pseudo-breccia. These secondary quartz areas, as seen under the microscope, appear to be composed of much finer grains of quartz than that which is aggregated in spheres and angular shapes. The groundmass outside of these areas shows the fluxion structure, is not mingled with the fine-grained secondary quartz, and there is no characteristic arrangement of the minerals at the boundary between the two.

CONCLUSION.

The eruptive rock of the Baraboo region is thus shown by chemical analysis to be a quartz keratophyre, whereas its mineralogical composition alone would class it rather as a keratophyre. Typical volcanic structures of the groundmass are clearly shown. The broken phenocrysts and the marked fluxion structure indicate the usual motion of a lava flow. In the field are found outcrops of volcanic breccia, some of the fragments of which are likewise volcanic breccia. The quartz keratophyre, like the bedded quartzite, lies unconformably below the horizontal formations of the Upper Cambrian. The dip of the cleavage planes of the schists conforms to the dip of the underlying quartzite beds, which is at a high angle to the north, and the general direction of the contact agrees with the strike of the quartzite beds and the strike of the schists of eruptive origin. The changes in the general direction of the contact in the western portion of the area indicates that the quartzite beds were eroded previous to the deposition of the porphyry. It may be that the quartz keratophyre eruption took place when the underlying quartzite beds were horizontal, in which case the eruptive material must have had the enormous thickness of 3,300 feet, as shown by its areal extent from north to south. Or it may be that one or more elevations had taken place in the quartzite previous to the eruptive flow, in which case its actual thickness cannot be estimated. Since no quartzite lies to the north of the

eruptive area, the quartz keratophyre is probably the topmost member of the Huronian rocks in this region, and was upturned by the orographic movement which tilted the quartzite beds into their present position.

EXPLANATION OF PLATES.

PLATE 1.

Geological Map of a Portion of the North Range of the Baraboo Bluffs. The scale is one and one-half inches to the mile.

PLATE 2.

Photographs of Thin Sections.

Fig. 1.

Volcanic Breccia. Section 3079. Polarized light, × 25. This figure shows a large number of fractured soda-orthoclase phenocrysts. Near the lower side is a fragment of foreign rock. The figure also shows crystals of ilmenite partly altered to leucoxene. The groundmass of this slide shows the fluxion structure, though less plainly than many of the others.

Fig. 2.

Black Quartz Keratophyre. Section 3080. Polarized light, × 25. This section was prepared from a block and shows a large broken phenocryst of soda-orthoclase. In the lower left-hand corner are several small crystals of soda-orthoclase, belonging to a younger generation than the large broken one. Quite near the large phenocryst in the upper part of the figure are a few radial fibres of biotite. The groundmass shows clearly the lines of flow passing between the parts of the phenocryst. The groundmass

also contains spherulites, a large fan-shaped one being quite well defined in the upper right-hand corner of the figure.

PLATE 3.

Photographs of Thin Sections.

Fig. 1.

Fragment of Volcanic Breccia. Section 3085. Polarized light, × 25. In the upper part of the figure is seen a crystal of ilmenite, partly replaced by quartz. Through the groundmass, which shows fluxion structure, are elliptical areas of secondary quartz.

Fig. 2.

Volcanic Breccia. Section 3096.1. Ordinary light, × 25. This section was prepared from a block and shows in the figure a fractured rock fragment, which has flow lines at right angles to the flow structure of the groundmass. The space between the broken parts of the fragment is filled with secondary quartz. The groundmass of the rock and that of its imbedded fragment are essentially the same.

Fig. 1.

Fig. 2.

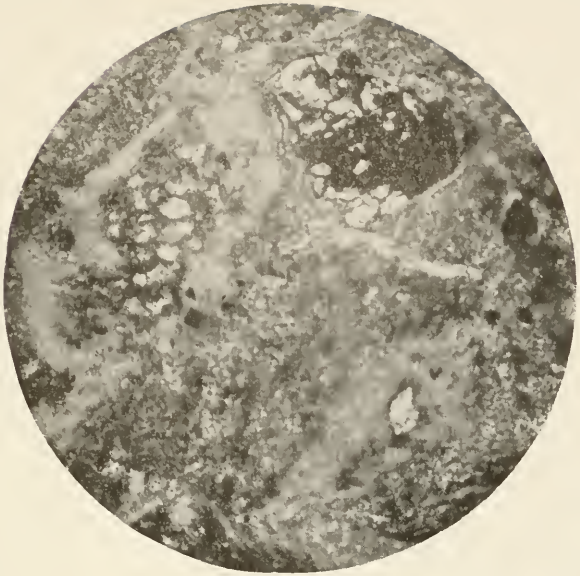


Fig. 1.

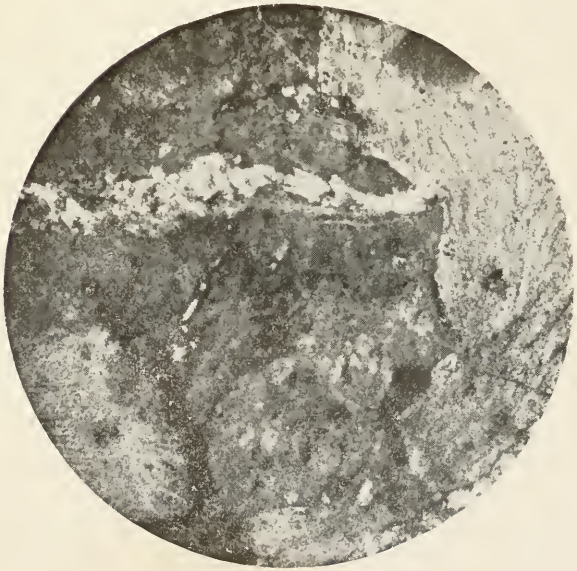


Fig. 2.

The BULLETIN OF THE UNIVERSITY OF WISCONSIN is printed by the state and is issued at irregular intervals. It contains original papers by persons connected with the university.

The following numbers have already appeared:—

ENGINEERING SERIES, Volume 1:

No. 1. Track, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 24, April, 1894. Price 25 cents.

No. 2. Some Practical Hints in Dynamo Design, by Gilbert Wilkes, M. Am. Inst. E. E., Special University Lecturer. Pp. 16, May, 1894. Price 25 cents.

No. 3. The Steel Construction of Buildings, by C. T. Purdy, C. E., Special University Lecturer. Pp. 27, October, 1894. Price 25 cents.

No. 4. The Evolution of a Switchboard, by A. V. Abbott, C. E., Special University Lecturer. Pp. 32, pls. 4, October, 1894. Price 35 cents.

ECONOMICS, POLITICAL SCIENCE, AND HISTORY SERIES, Volume 1:

No. 1. The Geographical Distribution of the Vote of the Thirteen States on the Federal Constitution, 1787-8, by Orin Grant Libby, A. M., Fellow in History, with an introduction by Frederick J. Turner. Pp. 116, pls. 2, July, 1894. Price 75 cents.

SCIENCE SERIES, Volume 1:

No. 1. On the Speed of Liberation of Iodine in Solutions of Hydrochloric Acid, Potassium Chlorate, and Potassium Iodide, by Herman Schlundt, Assistant in Chemistry. Pp. 33, December, 1894. Price 35 cents.

No. 2. On the Quartz Keratophyre and Associated Rocks of the North Range of the Baraboo Bluffs, by Samuel Weidman. Pp. 21, pls. 3, January, 1895. Price 25 cents.

Copies of the BULLETIN will be forwarded post free from the office of the State Superintendent of Public Property to all colleges, high schools, normal schools, and public libraries of the state which have a collection of 300 or more volumes, on making proper application at the Superintendent's office. Persons who reside in the state of Wisconsin can receive copies of the BULLETIN free by applying to the Secretary of the Board of Regents of the University and paying the cost of transportation. The postage required for the numbers thus far issued, is as follows: Eng. Ser., No. 1, 2c; No. 2, 2c; No. 3, 2c; No. 4, 3c. Hist. Ser., No. 1, 6c. Sci. Ser., No. 1, 3c; No. 2, 2c. All the above are sent in one package by express for 12 cents.

The BULLETIN may be obtained at Brentano's, 31 Union Sq., New York and 204-206 Wabash Ave., Chicago; and at A. C. McClurg & Co.'s, 117, 119, and 121 Wabash Ave., Chicago.

Communications having reference to an exchange of publications should be addressed to Professor Wm. H. Hobbs of the board of editors, or to Mr. Walter M. Smith, University Librarian.

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 3, PP. 57–107.

STUDIES IN SPHERICAL AND PRACTICAL ASTRONOMY

BY

GEORGE C. COMSTOCK
Director of the Washburn Observatory

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF
THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
JUNE, 1895

PRICE 40 CENTS

Democrat Printing Company, State Printer

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 3, PP. 57–107, JUNE, 1895

STUDIES IN SPHERICAL AND PRACTICAL ASTRONOMY.

BY GEORGE C. COMSTOCK,
Director of the Washburn Observatory.

The following pages contain an exposition of methods for the treatment of certain problems in spherical and practical astronomy, which, from his own experience, the author has found to be advantageous in practice. For the most part these methods are original and hitherto unpublished, but in part they are due to others, whose published exposition of them is not readily accessible to American students. In cases of the latter kind due acknowledgement is made in connection with the presentation of the subject matter, but I have not scrupled to modify or to completely alter the mode of presentation of those subjects which have been treated by others, adopting in each case that method which has seemed to me simplest and most easily followed.

MINOR SUGGESTINOS.

The Reduction of Level Readings.—To determine the inclination of a nearly horizontal line or plane by use of a spirit level, Chauvenet[1] gives rules which in all cases require the same operations to be performed with the level, but in which the mode of treatment of the level readings depends upon the manner in which the scale is graduated, one method when the zero is at the end of the scale and another when it is in the middle of the scale. The modes of reduction are sufficiently illustrated in the following examples given by Chauvenet.[2]

[1] Spherical and Practical Astronomy, Vol. II, §§ 52, 55.
[2] *Loc. cit.*

Zero at end.		Zero in middle.	
W.	E.	W.	E.
29.1	31.2	+ 64.0	+ 13.5
35.4	24.9	− 10.1	− 60.7
64.5	56.1	+ 77.5	
56.1		− 70.8	
$z = 8.4 \div 4 = 2.1$ *div.*		$z = +6.7 \div 4 = +1.675$ *div.*	

A method of reduction which is the same for both types of level, and which is in most cases more convenient than the above, is as follows: In the square array of numbers which constitute the observed readings of the level, take the diagonal differences. The mean of the two diagonal differences is the inclination of the line in half divisions of the level. That end of the line is the higher which is adjacent to the greatest single reading. If the level readings have been correctly made the two diagonal differences will be the same, and the reduction thus serves as a check upon the accuracy of the record.

Thus, from the readings given above, we see at a glance that in the first case $z = 4.2$ half divisions and the readings have been correctly made. In the second case $z = 3.35$ half divisions and there is a discrepancy of 0.1 *div.* in the readings.

Although I cannot doubt that this simple mode of reducing level readings has been employed by others, I do not find it in any of the treatises upon practical astronomy to which I have access.

To Focus a Telescope.—Let the telescope be directed to a circum-polar star near culmination and introduce between the objective and the star an opaque screen pierced with a circular aperture from 10 to 20 *mm* in diameter. As the aperture is moved about in front of the objective an image of the star will be formed by different parts of the objective, and if the telescope is not perfectly focused these images will fall at slightly different parts of the field; e. g., let the aperture be held opposite the upper part of the objective and the star's image be bisected with a horizontal

thread. Then shift the aperture to the lowest part of the objective and note whether the image of the star is sensibly displaced from the thread. If the image moves in the same direction with the aperture in the screen, the eye end should be drawn out; if in the opposite direction it should be pushed in until a position is found at which there is no displacement of the star image.

By this process the telescope may be so adjusted that the error of focusing shall not exceed 1:10000 part of the focal length, provided it is so firmly supported as to be free from the effect of accidental tremors and vibrations, e. g. the telescope of a transit instrument.

I.—A SIMPLE BUT ACCURATE EXPRESSION FOR THE ATMOSPHERIC REFRACTION.

Bessel's expression for the refraction [1]

$$R = \alpha \beta^{A} \gamma^{\lambda} \tan z$$

is commonly employed for all accurate computations of the refraction, and when so employed requires that the five quantities, $\alpha, \beta, \gamma, A, \lambda$, shall be interpolated from specially prepared refraction tables. It is the purpose of the present paper to so transform this expression that the refraction may be computed without recourse to these tables.

Since the refraction admits of development in terms of the odd powers of $\tan z$, we may write for the mean refraction:

$$R_m = \alpha \tan z = \alpha_1 \tan z - \alpha_3 \tan^3 z \ldots . \text{ etc.}$$

$$= \alpha_1 \left(1 - \frac{\alpha_3}{\alpha_1} \tan^2 z\right) \tan z \quad (\textit{approximately}$$

The Pulkowa Refraction Tables are presumably the most accurate ones available at the present time, and from these tables I find:

$$\alpha_1 = 57''.584 \qquad \alpha_3 = 0''.0640$$

If with these values we compute

$$\alpha = \alpha_1 \left(1 - \frac{\alpha_3}{\alpha_1} \tan^2 z\right)$$

and compare it with the tabular values of α we shall find the following satisfactory agreement:

z	0°	20°	40°	60°	75°
	″	″	″	″	″
Tabular α	57.586	57.577	57.538	57.386	56.694
Formula	57.584	57.576	57.537	57.391	56.693

The quantity λ is a complicated function of the zenith

[1] *Tab. Reg.*, LXII.

distance, z, but for values of z less than 75° it may be represented by the empirical formula:

$$\lambda = 1 + h \tan^2 z \qquad h = 0.001362$$

The following comparison shows the degree of accuracy with which this formula represents the tabular numbers:

z	50°	60°	70°	75°
Tabular λ	1.0022	1.0044	1.0103	1.0188
Formula	1.0019	1.0040	1.0103	1.0190

If we represent by ε the adopted coefficient of expansion of air per degree C., by τ_0 the normal temperature of the refraction tables, and by τ any other temperature, we shall have:[1]

$$\gamma^{\lambda} = \left[1 + \varepsilon(\tau - \tau_0)\right]^{-\lambda}$$

Developing this expression by means of the exponential series it becomes, when the terms of the order ε^2 are neglected,

$$\gamma^{\lambda} = \frac{\varepsilon^{-1} + \tau_0}{\varepsilon^{-1} + \tau}\left\{1 - \log_e\left[1 + \varepsilon(\tau - \tau_0)\right] h \tan^2 z\right\}$$

$$= \frac{\varepsilon^{-1} + \tau_0}{\varepsilon^{-1} + \tau}\left\{1 - \varepsilon h \tan^2 z (\tau - \tau_0)\right\}$$

For zenith distances less than 75° the exponent A does not sensibly differ from unity, and we have

$$\beta^{A} = \frac{B}{B_0}$$

where B_0 is the normal barometric pressure of the tables and B is the actual pressure at any time, *i. e.* the reading of the barometer "reduced to the freezing point."

Collecting the expressions for the several factors above developed, we obtain:

$$R = \alpha_1 \frac{B}{B_0} \frac{\varepsilon^{-1} + \tau_0}{\varepsilon^{-1} + \tau} \tan z \left\{1 - \left[\frac{\alpha_3}{\alpha_1} + \varepsilon h (\tau - \tau_0)\right] \tan^2 z\right\}$$

[1] Chauvenet, Vol. II, p. 165.

From the Pulkowa Tables we find:

$$B_0 = 751.5\ mm. \qquad \tau_0 = 9.31\ ^\circ C. \qquad \varepsilon^{-1} = 271.05\ ^\circ C.$$

Denoting the quantity enclosed in brackets by F and introducing numerical values, we obtain:

$$\begin{aligned} R &= \left[1.33207\right] \frac{B\,F}{271.05 + \tau}\, tan\, z \\ log\, F &= -\,(46.2 + 0.22\,\tau)\, tan^2 z \end{aligned} \qquad \text{(A)}$$

In the use of these formulæ B and τ must be expressed in millimeters and degrees C. The formula gives *log F* in units of the fifth decimal place. The number enclosed in brackets is a logarithm.

The corresponding formulæ, when the pressures are expressed in English inches and the temperatures in degrees F., are:

$$\begin{aligned} R &= \left[2.99215\right] \frac{B\,F}{455.9 + \tau}\, tan\, z \\ log\, F &= -\,(42.3 + 0.12\,\tau)\, tan^2 z \end{aligned} \qquad \text{(B)}$$

The computation by these formulæ is not more laborious than the direct computation from the tables, and the following comparison shows that the differences between the formulæ and the tables are far less than the uncertainty in the tabular numbers themselves. For zenith distances not much exceeding 75° the formulæ may be considered for most purposes a complete equivalent for the tables:

COMPARISON OF THE REFRACTIONS FURNISHED BY THE FORMULÆ AND BY THE PULKOWA TABLES.

Barometer	765.0 *mm*	28.500 *in*	765.0 *mm*	28.500 *in*
Att. Thermom.	0.0 C	70.0 F	0.0 C	70.0 F
Ext. Thermom.	− 25.0 C	75.0 F	− 25.0 C	75.0 F
z.....	75°	75°	60°	60°
	″	″	″	″
Tabular Ref...	246.02	192.83	115.36	90.65
Formula A....	246.03	192.84	115.36	90.66
Formula B....	246.02	192.84	115.35	90.66

The coefficients in equations A and B have been so determined as to reproduce with all possible fidelity the refractions of the Pulkowa Tables, but they may be made to represent the actual refractions with greater precision by the application to the constant coefficients of the formulæ of certain corrections depending upon the latitude of the place at which the refraction is required, the amount of moisture in the air and the wave length of the light whose refraction is to be computed. These corrections are developed in Vol. IX, Publications of the Washburn Observatory. The most important of them, and the only one which need be considered here, is that depending upon the latitude. Its effect will be sufficiently taken into account by adding to the bracketed coefficient in the equations A and B, the quantity

$$C = 225 \sin(\varphi - 60^\circ) \sin(\varphi + 60^\circ)$$

where φ denotes the latitude and C is given in units of the fifth decimal place.

II.—TO CORRECT THE SUN'S DECLINATION FOR THE EFFECT OF REFRACTION.

A useful application of the formulæ of the preceding section occurs in connection with the use of the solar compass. It is here required to set off upon a certain divided arc the apparent declination of the sun, *i. e.* the true declination corrected for the effect of refraction. This correction is usually interpolated from rather cumbrous tables of double entry.[1]

Denoting the refraction in declination by d and representing by q the parallactic angle of the sun, we have:

$$d = R \cos q = \left[2.99215\right] \frac{B\ F}{456 + \tau} \tan z \cos q \qquad (1)$$

By applying the fundamental formulæ of spherical trigonometry to the spherical triangle, Pole — Zenith — Sun, and differentiating the equations, we find:

$$\frac{dA}{dt} = \cos \delta \cos q \operatorname{cosec} z \qquad (2)$$

Eliminating $\cos q$ between these equations, we obtain

$$d = \left[2.99215\right] \frac{BF}{456 + \tau} \sec \delta \sin z \tan z \frac{dA}{dt} \qquad (3)$$

where z, A, δ and t represent respectively the zenith distance, azimuth, declination, and hour angle of the sun.

The numerical value of $\frac{dA}{dt}$ varies with the position of the sun in the heavens, but may be readily determined at any time as follows: Let the horizontal circle of the solar compass or transit be set to read some integral 10′ and the telescope be then pointed upon the sun by rotating the instrument about the lower motion. The sun having been brought into the field of view, the earth's diurnal motion

[1] See Johnson's Theory and Practice of Surveying, pp. 47, 48.

will carry the sun across the vertical thread of the instrument, and the time at which one edge of the sun is just tangent to the thread should be noted to the nearest second upon a watch. Let the instrument be now turned upon the upper motion, keeping the lower motion clamped, in the direction of the sun's movement, and the vernier set at the next integral 10′. The time at which the sun's edge again becomes tangent to the vertical thread should be noted as before. If we represent by n the interval, in seconds, between the two observed times, we shall have:

$$\frac{dA}{dt} = \frac{40}{n}$$

If desired, the transit may be set so that the second vernier reading is 20′, 30′, etc., greater than the first reading, and we shall then have:

$$\frac{dA}{dt} = \frac{80}{n_2} = \frac{120}{n_3} \ldots . \; etc. \qquad \text{and}$$

$$n = \tfrac{1}{2}\, n_2 = \tfrac{1}{3}\, n_3 \ldots . \; etc.$$

This value of the differential coefficient enables us to express equation (3) in a form adapted to field use, but since for this purpose an error of even several seconds in the value of d is of small consequence, we shall introduce some modifications in the formula which will render it more convenient without seriously impairing its accuracy. The declination of the sun can never exceed $23^\circ.5$, and we therefore write in the place of $sec\, \delta$ its mean value, 1.051. We also put in place of the temperature τ a mean value, 50° F., and assume for the barometric pressure 30 inches of mercury. With these modifications equation (3) becomes:

$$d = \frac{[3.3854]\, F \sin z \tan z}{n}$$

We may put the numerator of this fraction equal to $100\, N$ and tabulate the values of N with the argument the sun's altitude, $h = 90^\circ - z$, as follows:

h	N		h	N	
10°	131″		30°	36″	
		45			14
15	86		40	22	
		24			9
20	62		50	13	
		15			6
25	47		60	7	
		11			4
30	36		70	3	

We now have for the refraction in declination:

$$d = 100 \frac{N}{n}$$

The altitude of the sun, h, should be noted on the vertical circle of the instrument to the nearest half degree at the time of determining n.

The tabulated values of N correspond to a temperature of 50° F. and a barometric pressure of 30 inches. They may be adapted to any other temperature by diminishing d by one per cent for each 5° by which the temperature exceeds 50°, or by increasing one per cent for each 5° below 50°, but this correction and the correction for variation of the barometer can usually be neglected. At great elevations the barometric pressure becomes so much reduced that its variation must be taken account of, and this may be done by diminishing d by one per cent for each 300 feet of elevation above the sea.

The following examples will serve to illustrate the application of the formulæ above developed. On the afternoon of May 12, 1894, at a place in latitude 43° 5′ N., longitude approximately 90° west of Greenwich, I took the following observations with an engineer's transit:

Vernier.		Watch.			Vernier.		Watch.		
°	′	h.	m.	s.	°	′	h.	m.	s.
170	0	4	5	30	170	10	4	23	18
170	10	4	6	27	170	20	4	24	17
Vertical Circle = 32° 8′					Vertical Circle = 28° 46′				
$n = 57$					$n = 59$				
$N = 33$					$N = 39$				
$d = 58''$					$d = 66''$				

By a direct computation from the formula[1]

$$d = 57'' \cot (\delta + N)$$

where N denotes the Bessel auxiliary, I find for the refraction in declination at the time of these observations 59″ and 67″ respectively, thus showing an agreement far within the limits of error permissible in surveying practice.

If, as is often the case, an accuracy of 20″ is sufficient, and the altitude of the sun is not less than 10°, we may dispense with the tabular values of N and write

$$d = 2000 \div hn$$

where h is the altitude in degrees and the value of d is given in minutes of arc. The error of this formula in the preceding cases is 7″ and 4″, respectively.

[1] Chauvenet, Spherical and Practical Astronomy, Vol. I, p. 171.

III.—DETERMINATION OF THE ANGULAR EQUIVALENT OF ONE DIVISION OF A SPIRIT LEVEL.

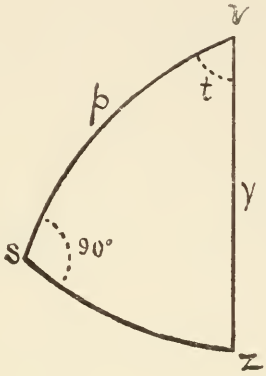
The methods most in use in this country for the determination of the value of one division of a level require that the level should be attached either to a level-trier or to a telescope provided with a good micrometer. In field astronomy it frequently happens that neither of these auxiliaries is available and the following method, which in respect of precision is not inferior to either of the others, may be employed with advantage since it requires no auxiliary apparatus other than a theodolite or engineer's transit. The original suggestion of this method is supposed to be due to Braun.[1]

Let the spirit level be firmly attached to a theodolite which is thrown out of level so that its vertical axis makes an angle of from 1° to 3° with the true vertical. It is practically convenient to so attach the level that the radius of curvature drawn through the middle point of its scale shall be approximately parallel to the vertical axis of the theodolite, *i. e.* the level shall be in adjustment. As the theodolite is turned about its vertical axis the level bubble will run from one end of its tube to the other and back again during a complete revolution of the instrument, and two positions, two readings of the azimuth circle, may be found in which the bubble will stand near the middle of its scale. A small turning of the instrument either way from one of these positions will produce a corresponding small motion of the bubble in its tube, and this turning of the theodolite and resulting motion of the bubble may be made to furnish not only the value of a division of the level, but also a test of the uniformity of its curvature.

To determine the relation between the readings of the

[1] Astronomische Nachrichten, No. 2490.

azimuth circle of the theodolite and the readings of the level bubble upon its scale, let the accompanying figure



represent a portion of the celestial sphere adjacent to the zenith, Z, and let V and S be the points in which the axis of the theodolite, and the line drawn from the center of curvature of the level tube through the middle of the bubble, respectively, intersect the sphere. The arc SV is the intersection with the celestial sphere of a plane passing through S, V, and the center of curvature of the level tube, and if the adjustment of the level above referred to is approximately made, VS may be considered as the intersection with the sphere of the plane in which the curvature of the level tube lies, so that as the bubble moves in its tube its successive positions, when projected upon the sphere will lie along VS, and any position may be indentified by its distance from V, represented in the figure by p. Since the bubble always stands at the highest part of the tube, its position, S, and the corresponding value of p are found by letting fall a perpendicular from the zenith upon the arc VS, and in the right angled spherical triangle thus formed we have the relation,

$$\tan p = \tan \gamma \cos t$$

where γ, as it appears from the figure, is the angle by

which the axis of the theodolite is deflected from the true vertical.

Since the level tube turns with the theodolite when the latter is revolved in azimuth, while the positions of the points V and Z remain unchanged, it appears that the angle t must vary directly with the readings of the azimuth circle, since it measures the inclination of the plane of the level tube to a fixed plane passing through the vertical axis of the instrument. If we represent by A_0 the reading of the circle when the arc VS is made to coincide with VZ, we shall have corresponding to any other reading A′:

$$\tan p = \tan \gamma \cos (A_0 - A') \qquad (1)$$

The value of A_0 in any given case may be determined by finding two positions of the instrument, circle readings A_1 and A_2, in which the bubble stands at the same part of the tube. Since the values of p corresponding to these two readings are equal, we must have:

$$A_0 - A_1 = A_2 - A_0 \quad \text{and} \quad A_0 = \tfrac{1}{2}(A_1 + A_2)$$

If A' and A'' denote slightly different readings of the azimuth circle, and b' and b'' the corresponding readings of the middle of the bubble on the level scale, we may write two equations similar to equation (1), and taking their difference obtain:

$$\frac{\sin (p' - p'')}{\cos p' \cos p''} = 2 \sin \frac{A' - A''}{2} \sin \left(A_0 - \frac{A' + A''}{2} \right) \tan \gamma \qquad (2)$$

Since $p'—p''$ is the distance moved over by the bubble, we may write $p'—p''= (b'—b'')\, d$, where d is the value of a division of the level, and transform (2) into

$$d = \frac{2 \tan \gamma \cos^2 p \sin \frac{1}{2}(A' - A'')}{\sin 1''} \cdot \frac{\sin \left[A_0 - \frac{1}{2}(A' + A'') \right]}{b' - b''} \qquad (3$$

In this equation $\cos^2 p$ may usually be put equal to 1, or its actual value may be found from the average value of p given by equation (1). Every other factor in the second member of this equation is known with exception of $\tan \gamma$, and the determination of γ will determine d.

For this purpose the instrument should be carefully levelled at the beginning of the work and the telescope directed at some object, approximately at right angles to the line joining two of the leveling screws of the instrument. Let the zenith distance, z', of this object be determined from readings of the vertical circle taken Circle Right and Circle Left. The vertical axis is now to be deflected toward the object by turning the leveling screws, and the zenith distance of the object, reckoned from the vertical axis of the instrument, z'', is to be determined from circle readings in the same manner as z'. We then have, obviously,

$$\gamma = z' - z''$$

To make sure that the deflection of the axis lies in the plane passing through the object sighted upon, it is well to note the position of the bubble of that level of the instrument which is at right angles to the telescope tube. The leveling screws must be so turned that the reading of the bubble of this level on its scale is approximately the same after deflection as before.

By comparison with micrometric apparatus, this determination of γ and the resulting value of d may seem crude, but with a vertical circle reading to minutes only, the values of z' and z'' can be determined within $30''$, and if γ be made 3°, d will be determined with a probable error of one part in four hundred, an accuracy quite sufficient for even the most delicate level. The value of γ should be between 1° and 3°, a coarse vertical circle and fine horizontal circle corresponding to the larger limit, and the reverse conditions to the smaller one.

To illustrate the method, I select the following partial investigation of the microscope level of a small universal instrument, Bamberg No. 2598. The level was investigated by means of the circles of the instrument to which it was attached, without removing or in any way disturbing it:

DETERMINATION OF γ.

Instrument.	Circle R	Circle L.	z.
Levelled	180° 26′ 49″	358° 4′ 13″	91° 11′ 18″.
Deflected	179 27 3	359 3 48	90 11 37.5

$$\gamma = 0° 59' 40.5''$$

After the level readings which follow were completed, these circle readings were repeated with the instrument deflected and subsequently leveled, giving a second determination of $\gamma = 0° 59' 42''$. I adopt:

$$\gamma = 0° 59' 41''$$

The following are the bubble observations in the deflected position of the instrument:

Bubble.		Circle.	Bubble.		Bubble.		Circle.	Bubble.	
25.3	− 0.8	111°34′	− 0.7	25.6	26.3	0.2	291° 6′	0.4	26.0
27.7	1.6	24	1.8	28.1	28.1	2 3	16	1.9	27.7
30.2	4.1	14	3.9	30.1	30.2	4.2	26	3.9	29.7
32.6	6.5	111 4	6.4	32.6	32.3	6.4	36	6.2	32.1
34.8	8.6	110 54	8.7	35.0	34.0	8.1	46	8.5	34.2
37.0	10.9	44	10.8	37.0	36.2	10.2	56	10.6	36.5

The observations began with the level bubble at one end of its scale, circle reading 111° 34′, and the instrument was turned through successive intervals of 10′ until the bubble reached the opposite end, when the settings were repeated in the inverse order to eliminate the effect of any slight change in the instrument or level. The instrument was then turned into the position corresponding to the second set of circle readings which were taken with the bubble running from one end of the tube to the other, in both directions.

The mean of the four readings of the ends of the bubble corresponding to any circle reading may be adopted as the

corresponding reading of the middle of the bubble, and these mean readings are given in the following table:

Circle.	Bubble.	Circle.	Bubble.	τ	$2b$	Diff.
111°34′	12.35	291° 6′	13.22	89°46′	25.57	
						4.23
24	14.80	16	15.00	89 56	29 80	
						4.28
14	17.08	26	17.00	90 6	34.08	
						4.72
111 4	19.55	36	19.25	90 16	38.80	
						4.18
110 54	21.78	46	21.20	90 26	42.98	
						4.32
44	23.92	56	23.38	90 36	47.30	

Since the bubble readings which stand on the same line in the second and fourth columns of the table are approximately equal, it is apparent that the corresponding circle readings lie on opposite sides of A_0 and equally distant from it. A_0 may, therefore, be determined by taking the mean of any pair of circle readings which stand in the same line, and the angles $A_0—A'$, $A''—A_0$, which we shall designate by τ, may be found by taking half the difference of corresponding circle readings. Values of τ are given in the fifth column of the table.

The quantities $2b$ are the sums of the numbers in the second and fourth columns, and their differences given in the last column show that any irregularities which may exist in the curvature of the level tube are very small, and we may determine a mean value of d to be used over the whole extent of the level tube. Since the values of τ differ so little from 90°, we may assume in equation (3)

$$\cos^2 p = 1 \qquad \sin\left[A_0 - \tfrac{1}{2}(A' + A'')\right] = 1$$

and taking the differences between the first and fourth, second and fifth, third and sixth lines of the table, we shall have $A'—A''$ constantly equal to 30′, and equation (3) becomes

$$d = \frac{4 \tan \gamma \sin 15'}{2 (b' - b'') \sin 1''} = \frac{[1.7959]}{2b' - 2b}$$

from which we obtain the following three values:

$$d = 4.72'' = 4.74'' = 4.73''$$

the mean of which may be adopted.

IV.—THE SIMULTANEOUS DETERMINATION OF FLEXURE, INEQUALITY OF PIVOTS, AND VALUE OF A LEVEL DIVISION FOR A "BROKEN" TRANSIT.

In a "broken" transit, *i. e.* one in which the rays of light are bent at right angles by a reflecting prism placed in the axis, it is well known that the bending of the axis under the weight which it has to carry produces an effect upon the observed times of transit of a star, which may be represented by the expression $f.\cos z \sec \delta$, where f is a constant peculiar to each instrument, and z and δ denote the zenith distance and declination of the star. Since this expression has the same algebraic form as the corrections for inclination of the axis, and for inequality of pivots, they may all be united into a single term:

$$(b' + i + f) \cos z \sec \delta$$

where $\pm(i+f)$ is a constant correction which must be applied to the value of b' directly determined with the spirit level. If $i+f$ is positive for Ocular West it will be negative for Ocular East, and the sign $\pm$ is, therefore, prefixed to it. Since it is not necessary in the use of a broken transit to separate the constant correction $i+f$ into its constituent parts, it will for the present be treated as a single unknown quantity whose value β is to be determined in connection with τ, the angular value of a half division of the level used for measuring b. In a straight transit f is zero, but i has usually an appreciable value and the correction β must, therefore, be determined, and may be conveniently determined by the method here developed for a broken transit.

If from the general equation of the transit instrument[1]

$$\sin c + \sin \delta \sin n - \cos \delta \cos n \sin (\tau - m) = 0 \qquad (1)$$

[1] Chauvenet, Spherical and Practical Astronomy, Vol. II, § 123.

the quantities m and n be eliminated by means of the relations (78),[1] we have the following:

$$\sin c + \cos z \sin b - \sin z \cos b \sin (a + A) = 0 \qquad (2)$$

where $90^0 - a$ and b represent the azimuth and altitude of the point in which the rotation axis of the instrument, produced toward the west, intersects the celestial sphere. A and z are the azimuth (reckoned from the north toward east) and zenith distance of a star at the instant of its transit over a thread whose collimation is c, *i. e.* the point $90^0 - a$, b is the pole of the small circle traced upon the celestial sphere by the thread in question when the instrument is rotated about its axis, and the distance of this circle from its pole equals $90^0 + c$.

Since in practice b and c are never so great as 10′, equation (2) may be written without sensible loss of accuracy:

$$c + \cos z . b = (a + A) \sin z \qquad (3)$$

Substituting in this equation for b its value as given by the spirit level, and writing a similar equation for the case in which the object observed is not the star, but its image reflected from mercury or some other level surface, we have:

$$\begin{aligned} &Dir. \quad c' + \cos z' (n' \tau + \beta) = (a + A) \sin z' \\ &Ref. \quad c'' - \cos z'' (n'' \tau + \beta) = (a + A') \sin z'' \end{aligned} \qquad (4)$$

where n' and n'' are the measured inclinations of the axis expressed in half divisions of the level scale. We now put

$$z' = z + x \qquad z'' = z - x$$

and introducing these values into (4) find by subtraction:

$$\begin{aligned} &c' - c'' + (n' + n'') \cos x \cos z . \tau + 2 \cos x \cos z \ \beta \\ &\quad = (A' - A'') \cos x \sin z + (2a + A' + A'') \sin x \cos z \end{aligned} \qquad (5)$$

In practice the object observed will usually be a circumpolar star, and owing to its slow motion the quantity $x = \frac{1}{2} (z' - z'')$ will be so small that we may assume

$$\cos x = 1 \qquad \sin x = \cos \delta \sin t \sin \tfrac{1}{2} (T' - T'')$$

where T' and T'' are the observed times and t is the hour angle of the star at the instant $\frac{1}{2} (T' + T'')$.

---

[1] *Loc. cit.*

For the coefficient of the last term in equation (5) we obtain from (4) with sufficient precision

$$2a + A' + A'' = (c' + c'') \operatorname{cosec} z$$

and introducing these values into (5) we have

$$(n' + n'')\,\tau + 2\beta = (A' - A'') \tan z - (c' - c'') \sec z$$
$$+ (c' + c'') \cos\delta \sin t \operatorname{cosec} z \sin \tfrac{1}{2}(T' - T'') \qquad (6)$$

If the star is near the meridian or is observed near the collimation axis of the instrument, the last term in this expression will be very small and may frequently be neglected. Putting

$$P = (A' - A'') \tan z$$
$$Q = (c' + c'') \cos\delta \sin t \operatorname{cosec} z \sin \tfrac{1}{2}(T' - T'')$$

we obtain from the equations

$$\sin z \sin A = -\cos\delta \sin t$$
$$\sin z \cos A = \cos\varphi \sin\delta - \sin\varphi \cos\delta \cos t \qquad (7)$$

reduced by means of the relations furnished by the astronomical triangle, the equation

$$P = \cos\delta \cos q \sec z \,.\, 2 \sin \tfrac{1}{2}(T' - T'')\, 206265$$

where q is the parallactic angle of the star. Introducing Bessel's auxiliary N into this equation, substituting in the last term of (6) in place of $\cos\delta \sin t \operatorname{cosec} z$ its equivalent, $\sin A$, and collecting in a form convenient for computation the equations necessary for the reduction of a series of observations, we have the following:

$$\tan N = \cot\varphi \cos t$$
$$P = \left[5.61546\right] \cos\delta \frac{\sin \frac{1}{2}(T' - T'')}{\sin z \tan (N + \delta)} \qquad (8)$$
$$Q = (c' + c'') \sin A \,.\, \sin \tfrac{1}{2}(T' - T'')$$
$$(n' + n'')\,\tau + 2\beta = P + Q - (c' - c'') \sec z$$

The zenith distance and azimuth of the star, z and A of the formulæ, may either be derived from the instrument at the time of observation, or may be computed from the latitude and the co-ordinates of the star, φ, δ, t, by means of equations (7).

Since β changes sign when the instrument is reversed, a

similar pair of observations in the reversed position will furnish the equation

$$(n' + n'')\,\tau - 2\beta = P + Q - (c' - c'')\,sec\,z$$

which, with the last of equations (δ), suffices for the determination of τ and β. A large change in the inclination of the axis, *e. g.* one which will give values of n' and n'' with altered sign, may be employed for the same purpose. If the inclination of the wyes of the instrument is not disturbed by the reversal, the level readings will furnish directly a determination of the inequality of pivots, and we shall have for the flexure

$$f = \beta - i$$

Formulæ (δ) become somewhat simplified when the star observed is very near the meridian, but this advantage will often be outweighed by the convenience of observing Polaris at any part of its diurnal path.

The application of the formulæ is illustrated by the following observations of transits of Polaris over the micrometer thread of a large "broken" transit. Each observed time and corresponding micrometer reading is the mean of from five to seven observations made in quick succession. Owing to disturbance of the mercury surface by wind, the reflection observations were difficult and rather discordant. Since the readings of the micrometer diminish in the direction of motion of a star at upper collimation for Ocular West, the collimation corresponding to any reading, R, of the screw is given by the expression

$$c = \pm\, 57.57''\,(R - 15) \qquad \begin{matrix} + \textit{Ocular W.} \\ - \textit{Ocular E.} \end{matrix}$$

The reading of the screw when the thread is in the collimation axis is assumed to be 15.000 *rev.*

WASHBURN OBSERVATORY, OCTOBER 16, 1894.

POLARIS FOR FLEXURE, INEQUALITY OF PIVOTS, ETC.

α = 1 h. 20 m. 55.1 s. φ = 43° 4′ 38″

δ = 88° 44′ 53″.5 *Chronometer* $\triangle T$ = + 3.9s.

log [5.61546] *cos* δ = 3.95484

Ocular.	West.	West.	East.	East.
	h. m. s	*h. m. s.*	*h. m. s.*	*h. m. s.*
T'	20 46 20.7	21 5 52.0	21 32 8.2	22 3 54.0
R'	11.172	8.090	15.274	15.720
n' n''	+ 39.4 + 38.3	− 42.9 − 42.7	− 48.9 − 49.4	+ 40.7 + 40.4
T''	20 35 57.4	21 14 16.7	21 40 39.3	21 53 50.7
R''	12.800	6.289	17.431	13.060
t	19 20 17.8	19 49 13.2	20 15 32.6	20 38 1.1
z	46 30 15	46 21 35	46 14 0	46 8 5
A	1 37	1 32	1 26	1 20
log cos t	9.53558	9.66155	9.74628	9.80355
N	20 9 25	26 7 56	30 48 25	34 13 43
log cosec z	0.13941	0.14045	0.14136	0.14208
log cot $(N + \delta)$	9.53463_n	9.66630_n	9.75362_n	9.81213_n
log sin $\frac{1}{2}(T' - T'')$	8.35530	8.26364_n	8.26911_n	8.34113
log sin A	8.452	8.429	8.400	8.369
log $(c' + c'')$	2.541_n	2.955_n	2.193_n	1.848
log P	1.98618_n	2.02523	2.11893	2.25018_n
log Q	9.348_n	9.648	8.862	8.558
log $(c' - c'')$	1.97185_n	2.01571	2.09405	2.18508_n
log sec z	0.16222	0.16107	0.16007	0.15929
	″	″	″	″
$(c' - c'')$ *sec z*	− 136.17	+ 150.24	+ 179.52	− 220.99
P	− 96.87	+ 105.98	+ 131.50	− 177.90
Q	− 0.22	+ 0.44	+ 0.07	+ 0.04

The preceding computation furnishes the absolute terms of the following equations:

$$
\begin{aligned}
+ 77.7\,\tau + 2\beta &= + 39.08'' \\
- 85.6\,\tau + 2\beta &= - 43.82 \\
- 98.3\,\tau - 2\beta &= - 47.95 \\
+ 81.1\,\tau - 2\beta &= + 43.13
\end{aligned}
$$

A least square solution of these equations furnishes the values:

$$\tau = + 0.506'' \qquad \beta = - 0.600''$$

From numerous determinations with the spirit level, the inequality of the pivots is known to be $i = - 0''.64$, which, combined with the value of β, gives for the flexure the value $f = + 0''.04$.

V.—DETERMINATION OF TIME AND AZIMUTH FROM TRANSITS OVER THE VERTICAL OF THE POLE STAR.

In a development of the formulæ for determining the time from transits over the vertical of a circum-polar star, published in 1828, Bessel says by way of introduction: "That this may not appear futile I remark, what Hansteen and Schumacher have properly noted, that the most appropriate use of a portable transit instrument for a time determination consists in mounting it, not in the meridian, but in an azimuth which admits of an observation of one of the polar stars, wherever this may be with respect to the meridian, closely followed or preceded by a transit of a fundamental star."

The obvious advantage which this mode of observing possesses lies in the shorter period of time during which the observer depends upon the stability of his instrumental constants. For meridian observations this period is rarely much less than half an hour, while by the method suggested it need never exceed five minutes. Nevertheless, the general opinion of two generations of field astronomers seems fairly represented by the words of Chauvenet, who, after devoting a score of pages to a discussion of the method, remarks in closing: "The methods which have here been given * * * are intended for the use of observers in the field who have but little time to adjust their instruments and wish to collect all the data possible, reserving their reduction for a future time. The greater labor of these reductions, compared with those of meridian observations, is often more than compensated by the saving of time in the field." This greater labor of reduction is now obviated through the simplifications introduced into the method by the Russian astronomer, Döllen, who maintains with equal zeal and cogency the greater precision and

at least equal convenience of his method for all purposes of field astronomy. Under Döllen's influence the method has, within the last quarter century, come into considerable use in eastern and central Europe, and from an extended practical application of it the writer of these pages is satisfied of the justice of the claims made in its behalf. This section of the present paper is an attempt to bring to the attention of American teachers of practical astronomy, in substance, the theory of Döllen's method, but it cannot be considered a substitute for the precepts and discussion contained in the elaborate introduction to the *Stern Ephemeriden zur Bestimmung von Zeit und Azimut*, published annually by Döllen since 1886.

As indicated by the above title, the observations for time are equally available for a determination of azimuth, and reduced to their simplest terms these observations are as follows: Let the transit (universal instrument, or theodolite, in case a determination of azimuth is also desired) be pointed at Polaris, and the chronometer time, S', at which the star appears bisected by the middle vertical thread, noted. Then revolve the telescope about the horizontal axis without disturbing the azimuth of the instrument and observe the time of transit, S, of a clock star over all of the threads, and measure the inclination of the axis, b, with a spirit level, if possible both before the observation of Polaris and after that of the southern star. Reverse the instrument, point again upon Polaris, and observe it and a clock star, as before. If the instrument possess a graduated horizontal circle, which is read in connection with the observations of the stars, these data will determine the zero point of the circle, *i. e.* its reading when the telescope points north, and the azimuth of any terrestrial point toward which the telescope may be directed.

We proceed to consider the theory of the method and adopt as a basis for the investigation the fundamental equation of the transit instrument,[1]

[1] Chauvenet, Vol. II, Eq. (79).

$$\sin(\tau - m) = \tan n \tan \delta + \sin c \sec n \sec \delta \tag{1}$$

together with the equations

$$\tan n = \sin b \sec n \operatorname{cosec} \varphi - \sin m \cot \varphi \tag{2}$$

$$\cos a \tan m = \tan b \cos \varphi + \sin \varphi \sin a \tag{3}$$

furnished by the spherical triangle, PZA, formed by the pole, the zenith and the point in which the rotation axis of the instrument, produced toward the west, intersects the celestial sphere. The sides and angles of this triangle have the following values:

$$PZ = 90^\circ - \varphi \qquad PA = 90^\circ - n \qquad ZA = 90^\circ - b$$
$$P = 90^\circ - m \qquad Z = 90^\circ + a$$

The symbol τ represents the east hour angle of the star at the instant of transit over the middle thread, and we have obviously the relation

$$\tau = \alpha - S - \Delta T \tag{4}$$

Since each star observed furnishes an equation of the types (*1*) and (*4*), it appears that if the instrumental constants b and c are known an observation of the transits of a circum-polar star and a southern star suffice for the determination of the unknown quantities ΔT, m, n, a, and our problem consists solely in so transforming the preceding equations as to facilitate the determination of ΔT and a.

Denoting by the subscripts 1 and 2, respectively, quantities pertaining to the polar and the southern star, we write equation (*1*) for each of these stars as follows:

$$\left.\begin{aligned} \sin(\tau_1 - m - \vartheta) &= \tan \delta_1 \tan n \left\{ 1 + \operatorname{cosec} \delta_1 \operatorname{cosec} n \sin(c + x_1) \right\} \\ \sin(\tau_2 - m - \vartheta) &= \tan \delta_2 \tan n \left\{ 1 + \operatorname{cosec} \delta_2 \operatorname{cosec} n \sin(c + x_2) \right\} \end{aligned}\right\} \tag{5}$$

where ϑ, x_1, and x_2 are small arbitrary quantities subject only to the condition that they must be so determined as to satisfy the equations. Since this is equivalent to only two relations among the three quantities we are at liberty to impose a third relation, for which we choose

$$\sin(c + x_1) \sin \delta_2 = \sin(c + x_2) \sin \delta_1$$

which makes the bracketed factors in the two equations equal. Presupposing that ϑ, x_1, and x_2 are small quantities we differentiate equations (5), and eliminating x_1, and x_2 find, when quantities of the order cn^2 are neglected,

$$\vartheta = \frac{(1 - \sin \delta_2)\, c}{\cos \delta_2 - \sin \delta_2 \cot \delta_1 \cos (\tau_1 - m)}$$

If for δ_2 we substitute the polar distance, $p_2 = 90^\circ - \delta_2$, this equation becomes, very approximately,

$$\vartheta = c \,.\, \tan \tfrac{1}{2} p_2 \left\{ 1 + \cot \delta_1 \tan \delta_2 \cos (\tau_1 - m) \right\} \qquad (6)$$

Dividing the first of equations (5) by the second, we obtain:

$$\tan \left[\tfrac{1}{2} (\tau_1 + \tau_2) - m - \vartheta \right] = \frac{\sin (\delta_1 + \delta_2)}{\sin (\delta_1 - \delta_2)} \tan \tfrac{1}{2} (\tau_1 - \tau_2) \qquad (7)$$

We now assume the auxiliary quantities,

$$\begin{aligned} 2\tau &= (\alpha_1 - S') - (\alpha_2 - S) \\ U &= \alpha_2 - S - \Delta T - m - \vartheta \end{aligned} \qquad (8)$$

and introducing them into (7) find

$$\tan (\tau + U) = \frac{\sin (\delta_1 + \delta_2)}{\sin (\delta_1 - \delta_2)} \tan \tau$$

whose solution is

$$\tan U = \frac{\cot \delta_1 \tan \delta_2 \sin 2\tau}{1 - \cot \delta_1 \tan \delta_2 \cos 2\tau} \qquad (9)$$

In equations (8) $\Delta T + m$ is now the only unknown quantity, and to determine m we apply (1) to the polar star and substitute in it the value of $\tan n$ given by (2) and the value of $\tau_1 - m$ given by (4) and (8), and find

$$\sin m = - \cot \delta_1 \tan \varphi \sin (2\tau + U + \vartheta) + \sin b \sec \varphi + \sin c \tan \varphi$$

in which terms of the order cn^2 are neglected. Subtracting from each member of the equation the auxiliary quantity

$$\sin m' = - \cot \delta_1 \tan \varphi \sin (2\tau + U) \qquad (10)$$

we obtain to the same degree of approximation

$$m = m' + b \sec \varphi + c \tan \varphi - \vartheta \cot \delta_1 \tan \varphi \cos (2\tau + U)$$

Substituting for ϑ its value in terms of c, and introducing into (8) the resulting value of m, we obtain

$$\Delta T + Cc = \alpha_2 - (S + U + m' + b \sec \varphi) \qquad (11)$$

where the coefficient C has the value

$$C = \tan\varphi + \tan\tfrac{1}{2}p_2 \left\{ 1 + (\tan\delta_2 - \tan\varphi)\cot\delta_1 \cos(2\tau + U) \right\} \quad (12)$$

If at the time of observation the southern star was near the zenith, or Polaris was near elongation, or the collimation constant, c, was very small, the bracketed factor may be put equal to 1, giving

$$C = \tan\varphi + \tan\tfrac{1}{2}p_2$$

For a determination of azimuth we write equation (3) in the form

$$\tan a = \tan m \operatorname{cosec}\varphi - \tan b \cot\varphi$$

and assuming the equation

$$\tan a' = \tan m' \operatorname{cosec}\varphi \quad (13)$$

find by subtraction

$$a = a' + b\tan\varphi + c\sec\varphi \left\{ 1 - \cot\delta_1 \tan\tfrac{1}{2}p_2 \cos(2\tau + U) \right\} \quad (14)$$

If K and M denote respectively the reading of the azimuth circle corresponding to the star observations, and to that position of the instrument in which the rotation axis lies in the plane of the prime vertical (collimation axis in the meridian), we have, obviously,

$$M = K + a' + b\tan\varphi + C'c \quad (15)$$

where C' is an abbreviation for the coefficient of c given in the preceding equation.

Since the collimation constant, c, changes sign when the instrument is reversed, an observation of Polaris and a southern star in each position of the instrument, W. and E., will suffice for the determination of ΔT and c from the observed times of transit, and also, if the instrument is provided with an azimuth circle, for the determination of M and c, from the circle readings. The agreement between the two values of c thus determined furnishes a valuable control upon the accuracy of the observations and their reduction.

In the preceding investigation the effect of flexure, ine-

quality of pivots and diurnal aberration has been neglected. These quantities may, however, be taken into account, as in the case of meridian observations, by applying to the observed level constant, b, a correction, $\pm \beta$, for the first two sources of error, and by applying to S a correction,

$$-\overset{s.}{0.021} \cos \varphi \,.\, C$$

for the aberration.

The formulæ requisite for the reduction of observations in the vertical of the pole star may now be collected, slightly simplified and arranged as follows:

Data known independently of the observations:

$$\varphi,\ \alpha_1,\ \alpha_2,\ \delta_1,\ \delta_2,\ \varkappa = \overset{s.}{0.021} \cos \varphi,\ \ p_2 = 90^\circ - \delta_2$$

Data given by the observations: S', S, b, K.

$$\begin{aligned}
t &= (\alpha_1 - \alpha_2) + (S - S') \\
h &= 1 + \tan \delta_2 \cot \delta_1 \cos t \\
l &= 1 - \tan \tfrac{1}{2} p_2 \cot \delta_1 \cos t \\
C &= h \tan \tfrac{1}{2} p_2 + l \tan \varphi \\
C' &= 15\, l \sec \varphi \\
\tan U &= \frac{\cot \delta_1 \tan \delta_2 \sin t}{1 - \cot \delta_1 \tan \delta_2 \cos t} \\
-\sin m' &= \tan \varphi \cot \delta_1 \sin (t + U) \\
\tan a' &= \tan m' \operatorname{cosec} \varphi \\
\Delta T + Cc &= \alpha_2 - (S + U + m' + b \sec \varphi - C\varkappa) \\
M - C'c &= K + a' + b \tan \varphi - C'\varkappa
\end{aligned} \tag{16}$$

The computation of these formulæ may be somewhat facilitated by an algebraic device upon which Döllen places great stress. From the ordinary development of $\sin x$ and $\tan x$ in series, we have, when x is small,

$$\log \sin x = \log x - \frac{Mx^2}{6} \qquad \log \tan x = \log x + 2\,\frac{Mx^2}{6}$$

where M denotes the modulus of the common system of logarithms. Putting

$$\sigma = \tfrac{1}{3}\, Mx^2$$

we may tabulate σ with x or $\log x$ as argument, and such a

table is given by Döllen with $log\, x$, when x is expressed in seconds of time, as argument. When x is expressed in arc values of σ may be taken from any logarithmic table by means of the relation

$$\sigma = \tfrac{1}{3}(log\, tan\, x - log\, sin\, x)$$

If $\sigma(U)$ denote the value of σ corresponding to $log\, U$ when U is expressed in seconds of time we may, by the introduction of the divisor, $15\, sin\, 1''$, obtain in seconds of time and arc, respectively,

$$\begin{aligned} U &= \left[4.13833 - 2\sigma(U)\right] \frac{cot\, \delta_1\, tan\, \delta_2\, sin\, t}{1 - cot\, \delta_1\, tan\, \delta_2\, cos\, t} \\ (-m') &= \left[4.13833 + \sigma(m')\right] cot\, \delta_1\, tan\, \varphi\, sin\, (t + U) \\ log\, a' &= log\, (15\, cosec\, \varphi) + log\, m' + 2\,\sigma(m') - 2\,\sigma(a') \end{aligned} \tag{17}$$

In equations (16) the quantities h, l, C, C' are analogous to the transit factors A, B, C used for the reduction of meridian observations, and C, C' may be tabulated for a given latitude and assumed constant for a period of several years. The quantities U and m' must be computed anew for each observation, and a' must also be computed in case the azimuth is required. To diminish the labor of this computation Döllen tabulates for a selected list of 180 stars certain General Constants, through which these computations are considerably shortened.

With assumed values of the coördinates of the stars and an assumed interval $S - S' = 4^m$ put

$$-U = x_0 \qquad + \frac{206265}{15} cot\, \delta_1\, sin\, (t + U) = N_0$$

We shall then have

$$-(U + m') = x_0 + p\, N_0 = t_0 \qquad a' = p'\, N_0$$

where p and p' are functions of the latitude which differ from $tan\, \varphi$ and $15\, sec\, \varphi$ by terms of the kind above represented by σ,

$$\begin{aligned} log\, p &= log\, tan\, \varphi + \sigma\, (N\, tan\, \varphi) \\ log\, p' &= log\, (15\, sec\, \varphi) + 3\,\sigma\, (N\, tan\, \varphi) - 2\,\sigma\, (N\, sec\, \varphi) \end{aligned}$$

The values of p and p' may be conveniently tabulated for a given latitude with $log\, N$ as the argument, and for this purpose $log\, p'$ is best expressed in the form

$$log\, p' = log\,(15\, sec\, \varphi) + \sigma\,(N \sqrt{tan^2\varphi - 2})$$

where the two σ terms given above have been united into a single term whose numerical value is to be obtained regardless of the sign of the quantity under the radical, and then to be added or subtracted as this quantity is positive or negative. The following is such a table for the latitude of the Washburn Observatory, $\varphi = 43° 4' 37''$, and it should also be noted that the values of $log\, N$ are limiting values at which the tabular p, p' changes from one value to the next:

p	$log\, N$	p'	$log\, N$
9.97083		1.31251	
	2.238		1.921
.97084		.31250	
	2.381		2.239
.97085		.31249	
	2.476		2.363
.97086		.31248	
	2.539		2.442
.97087		.31247	
	2.587		2.499
.97088		.31246	

The construction of such a table is the only point at which the σ terms are required in the application of Döllen's ephemerides.

In general the coördinates of the stars and the observed interval $S - S'$ will differ from that assumed in the computation of x_0 and N_0 and it will be convenient to pass from these latter quantities to the values x, N corresponding to the actual observation by means of differential formulæ.

It is evident from an inspection of equations (*16*) that these differential formulæ will contain some terms which involve only the coördinates of the stars and are, therefore, the same for all parts of the earth's surface, while other terms will involve functions of the latitude, and only that part of these terms which is independent of the latitude can conveniently be tabulated. Leaving the reader to dif-

ferentiate for himself equations (*16*), we reproduce here the form in which Döllen expresses the differential coefficients and the correction terms involving them:

$$x + pN = t_0 + Qk + RG + D\,\Delta\,\delta$$
$$a' = p'N = p'N_0 + Qk + RG$$

where k, G and $\Delta\,\delta$ represent variations in the elements with which x_0 and N_0 were computed, and Q, Q', R, R', D are differential coefficients having the following values:

$$Q = p\lambda + \beta \qquad R = p\mu + \gamma$$
$$Q' = p'\lambda \qquad R' = p'\mu$$

The values of $\beta, \gamma, \lambda, \mu$ and D involve only the coördinates of the stars and are given among the general constants for each star of Döllen's list.

The values of k, G and $\Delta\,\delta$ are as follows:

$$\Delta\,\alpha = \alpha_2 - (\alpha_2)_0 \qquad g = -\left\{\alpha_1 - (\alpha_1)_0\right\}$$
$$\Delta\,\delta = \delta_2 - (\delta_2)_0 \qquad k = -\left\{\delta_1 - (\delta_1)_0\right\} \qquad G = g + \Delta\,\alpha$$

where the subscript $_0$ denotes the tabular values of the coördinates corresponding to x_0, N_0. These assumed values are given as a part of the table of constants for each star, and an ephemeris of g and $log\,k$ precedes the table of constants.

The actual reduction of a set of observations by means of these general constants will not often be made, but recourse will be had to the General Ephemerides constructed from them for 93 of the 180 stars. These ephemerides give at intervals of ten days throughout the year the instantaneous values of N and T, $T = \alpha_2 + x$, and from them the observer should construct a local ephemeris of the values of θ and a' for a few of the tabular dates near the epoch of his observations, using the relations

$$\theta = T + pN \qquad a' = p'N$$

Values of θ and a' interpolated from the local ephemeris will be immediately available for the reduction of observations in which the observed interval $S - S'$ equals the

value 4^m assumed in the computation of x_0 and N_0 The observations should be so arranged as to secure at least a rough approximation to this interval between the observation of Polaris and the clock star, but a deviation of even several minutes from the prescribed amount may be very simply corrected.

Since the interval $S - S'$ affects U, m' and a' precisely as does $\alpha_1 - \alpha_2$ whose effect is represented in the term RG, we apply to S and K the corrections

$$R\left\{S - (S' + 4^m)\right\} \qquad R'\left\{S - (S' + 4^m)\right.$$

and the reduction of the observations takes the very simple form:

$$r = \frac{1}{100}\left\{S - (S' + 4^m)\right.$$

$$S_0 = S + R_0 r + Bb - C\varkappa \qquad \Delta T \pm Cc = \mathfrak{h} - S_0$$
$$K_0 = K + R'_0 r + B'b - C'\varkappa \qquad M \mp C'c = K_0 - a'$$

The level corrections Bb, $B'b$ are most conveniently taken from a table of multiples of

$$\frac{\tau}{30} \sec \varphi = B\tau \qquad \frac{\tau}{2} \tan \varphi = B'\tau$$

where τ represents the angular value of one division of the level scale. The factor R_0 equals $100\,R$ and its value together with that of the collimation factors C, C' are to be derived from the data given with each star in the ephemeris

$$R_0 = p\mu_0 + \gamma_0 \qquad C = pC_1 + C_0$$
$$R'_0 = p'\mu_0 \qquad C' = p'C_1$$

These values when once computed should be preserved for future use.

The reduction to the middle thread of transits of a clock star observed over the side threads must not be made, as in the meridian, by the use of the factor C, but by a special factor F whose logarithm is given in the ephemeris and among the general constants for each star.

$$F = \sec \delta_2 \sec n \sec \tau$$

Certain auxiliary quantities to be used in setting the instrument so as to find the stars to be observed are also given in the tables. Their use will be understood from the following precept: "At the sidereal time $\theta - 4^m$ point upon the pole star by means of its azimuth a' and zenith distance $z' = H - (\varphi + \nu \tan \varphi)$ and without changing the azimuth of the instrument await the clock star at the zenith distance $z = \rho - z'$."

The following two examples illustrate, respectively, the application of the trigonometric formulæ, equations (*16*) and (*17*), and of Döllen's ephemerides, to the reduction of observations made with a very small universal instrument, having an objective with a clear aperture of 35 *mm*, focal length 373 *mm*, magnifying power of ocular 36 diameters, azimuth circle read by estimation to single seconds. In view of the small dimensions and feeble power of the instrument the agreement between the values of the collimation constant c given by the observed times and the circle readings is sufficiently satisfactory.

The computation by the trigonometric formulæ is so arranged that the values of U, m', etc., may be obtained either with or without the use of the σ terms.

1891, September 4. Observer, G. C. C.

BAMBERG UNIVERSAL INSTRUMENT.

$\varphi = 43^\circ\ 4'\ 47''$	$\alpha_1 = 1^h\ 19^m\ 33^s$	$\delta_1 = 88^\circ\ 43'\ 24.7''$
$\log \tan \varphi = 9.97082$	$\log \operatorname{cosec} \varphi = 0.16559$	$\log \cot \delta_1 = 8.34702$

Star. Oc.	*ε Cygni W.*	*ζ Cygni E.*	$\alpha_1 - \alpha_2$	4 37 43	4 11 13
α_2	20 41 50.19	21 8 20.00	$S - S'$	4 28	4 35
δ_2	+ 33 33 57	+ 29 47 1	t	70 32 45	63 57 0
$C \quad C'$	1.47 20.7	1.51 20.7	$\cos t$	9.52251	9.64262
S'	20 38 56	21 5 39	$\tan \delta_2$	9.82187	9.75764
S	20 43 23.59	21 10 14.03	$\sin t$	9.97447	9.95348
	$''$ $s.$	$''$ $s.$			
$b\ .\ b \sec \varphi$	− 7.2 − 0.65	+ 5.1 + 0.46	$(\cot \delta_1 \tan \delta_2 \cos t)$	7.69140	7.74738
U	+ 3 12.22	+ 2 38.08	$1 - (\quad)$	9.99736	9.99757
m'	− 4 30.87	− 4 18.27	$\cot \delta_1 \tan \delta_2 \sin t$	8.14336	8.05814
	$s.$ $''$	$s.$ $''$			
$C\varkappa \quad C'\varkappa$	0.02 0.3	0.02 0.3	$\tan U$	8.14550	8.06057
K	344 38 31.5	154 33 44.0	2σ	3	2
a'	− 1 39 8.1	− 1 34 31.6	$\sin (t + U)$	9.97656	9.95588
$b \tan \varphi$	− 6.7	+ 4.8	$- \sin m'$	8.29440	8.27372
$\Delta T \pm Cc$	− 14.08	− 14.28	σ	3	3
$M \mp C'c$	332 59 16.4	152 59 16.9	$\tan a'$	8.46008	8.43939

$$\Delta T + 1.47\, c = -14^s.08 \qquad M - 20''.7\, c = 16''.4$$

$$\Delta T - 1.51\, c = -14^s.28 \qquad M + 20''.7\, c = 16''.9$$

$$\Delta T = -14^s.18 \qquad M = 16''.6$$

$$c = +0^s.07 \qquad c = +0^s.01$$

1891, September 4.

$\log p = 9.97085 \qquad \log p' = 1.31247$

Star Oc.	*ε Cygni W.*	*ζ Cygni E.*	*Equations:*
$R \quad R'$	$-0.196 \quad -14.85$	$-0.350 \quad -19.85$	s.
$C \quad C'$	$1.471 \quad 20.46$	$1.513 \quad 20.42$	$\Delta T + 1.47\,c = -14.08$
θ	$20 \quad 43 \quad 8.79$	$21 \quad 10 \quad 0.06$	$T - 1.51\,c = -14.29$
b	$-7.2''$	$+5.1''$	$\Delta T = -14.18$
$S' + 4^m$	$20 \quad 42 \quad 56$	$21 \quad 9 \quad 39$	$c = +0.07$
S	$20 \quad 43 \quad 23.59$	$21 \quad 10 \quad 14.03$	$M'' - 20.5\,c = 16.3$
$C\varkappa.\ R_0 r$	$-0.02 \quad -0.05$	$-0.02 \quad -0.12$	$M'' + 20.4\,c = 16.7$
$b \sec \varphi$	-0.65	$+0.46$	$M = 16'.5$
$\Delta T \pm Cc$	-14.08	-14.29	$c = +0.01$ s.
a'	$1^\circ \quad 39' \quad 4.1''$	$1^\circ \quad 34' \quad 24.8''$	$M = 332^\circ \quad 57' \quad 16.5''$
K	$334 \quad 38 \quad 31.5$	$154 \quad 33 \quad 44.0$	
$C'\varkappa \quad R'r$	$-0.3 \quad -4.1$	$-0.3 \quad -7.0$	
$b \tan \varphi$	-6.7	$+4.8$	
$M \mp C'c$	$332 \quad 59 \quad 16.3$	$152 \quad 59 \quad 16.7$	

VI.—DETERMINATION OF LATITUDE AND TIME FROM EQUAL ALTITUDES OF STARS.

The simultaneous determination of time and latitude from the observed instants at which three different stars reach the same (unknown) altitude is discussed in the principal text books of spherical astronomy, but the laborious character of the reduction of the observations there developed has prevented the method from coming into general use, although from theoretical considerations and from experience it has been abundantly shown to furnish a very accurate determination of both time and latitude. In the following pages an attempt is made to simplify the method by substituting for the observation of three stars separated by considerable intervals of time the observation of the time at which a single star transits over the almucantar of a close circum-polar star, usually Polaris, the elapsed time between the pointing of the instrument upon the polar star and the observed transits of the clock star being made as short as possible, *e. g.* five minutes, or less.

Such a comparison of one clock star with one polar furnishes a single relation between the latitude and the clock correction, and a similar comparison of another star furnishes a second relation which suffices for the determination of both quantities. It should be noted that these two sets of observations are entirely independent of each other and require no assumption with regard to the stability of the instrumental constants, save for the brief interval between pointing upon Polaris and observing the southern star.

The almucantar and the zenith telescope are the instruments best adapted to observations of this kind, but any instrument which possesses a telescope rotating about a horizontal and a vertical axis and provided with a level whose plane is perpendicular to the horizontal axis, may be

used, *e. g.* a universal instrument or an engineer's transit. If the makers would furnish a simple means of fastening the striding level which accompanies the better class of transits, with its tube at right angles to the horizontal axis, the efficiency of these instruments would be very greatly increased, but even without this attachment the observation of equal altitudes is the most advantageous mode of employing such an instrument for the determination of either latitude or time. We proceed to develop the equations for the general case in which both of the quantities are required.

Let T_1 and T_2 denote the observed times at which two stars cross a given almucantar whose (unknown) zenith distance is z, and let $\alpha_1, \pi, \alpha_2, p$, be the right ascensions and polar distances of the northern and southern star, respectively. The formulæ for the transformation of coördinates furnish for the two stars the equations:

$$\begin{aligned} \cos z &= \sin\varphi \cos\pi + \cos\varphi \sin\pi \cos(T+\tau) \\ &= \sin\varphi \cos p + \cos\varphi \sin p \cos(T-\tau) \end{aligned} \tag{1}$$

where

$$T+\tau = T_1 + \Delta T - \alpha_1 \qquad T-\tau = T_2 + \Delta T - \alpha_2$$

Subtracting the second equation from the first and dividing by

$$2 \sin\tfrac{1}{2}(p+\pi) \sin\tfrac{1}{2}(p-\pi) \cos\varphi$$

we obtain

$$\tan\varphi = \cot\tfrac{1}{2}(p+\pi) \cos T \cos\tau - \cot\tfrac{1}{2}(p-\pi) \sin T \sin\tau \tag{2}$$

We introduce into this equation the auxiliaries

$$l \cos\lambda = \cot\tfrac{1}{2}(p+\pi) \cos\tau \qquad l \sin\lambda = \cot\tfrac{1}{2}(p-\pi) \sin\tau \tag{3}$$

and obtain

$$l \cos(T-\lambda) = \tan\varphi \tag{4}$$

From equations (3) we obtain

$$\begin{aligned} l \sin(\lambda-\tau) &= \left\{ \cot\tfrac{1}{2}(p-\pi) - \cot\tfrac{1}{2}(p+\pi) \right\} \sin\tau \cos\tau \\ l \cos(\lambda-\tau) &= \cot\tfrac{1}{2}(p-\pi) \sin^2\tau + \cot\tfrac{1}{2}(p-\pi) \cos^2\tau \end{aligned} \tag{5}$$

which furnish, after a little reduction,

$$tan\,(\lambda - \tau) = \frac{sin\,\pi\,sin\,2\tau}{sin\,p - sin\,\pi\,cos\,2\tau} \tag{6}$$

We also obtain from (3)

$$\left\{\frac{cos\,\lambda}{cos\,\tau} + \frac{sin\,\lambda}{sin\,\tau}\right\} l = \frac{sin\,p}{sin\,\frac{1}{2}\,(p + \pi)\,sin\,\frac{1}{2}\,(p - \pi)} \tag{7}$$

from which

$$l^{-1} = \frac{cos\,\pi - cos\,p}{sin\,p} \cdot \frac{sin\,(\tau + \lambda)}{sin\,2\tau} \tag{8}$$

In this expression we put

$$\frac{cos\,\pi - cos\,p}{sin\,p} = tan\,\tfrac{1}{2}\,(p - x)$$

and find the rigorous equation

$$tan\,\tfrac{1}{2}\,x = tan^2\,\tfrac{1}{2}\,\pi\,cot\,\tfrac{1}{2}\,p \tag{9}$$

for which there may usually be substituted

$$x = \frac{2\,sin^2\,\frac{1}{2}\,\pi}{sin\,1''}\,cot\,\tfrac{1}{2}\,p$$

Introducing (8) into (4) it becomes

$$cos\,(T - \lambda) = tan\,\varphi\,tan\,\tfrac{1}{2}\,(p - x)\,\frac{sin\,(\tau + \lambda)}{sin\,2\tau} \tag{10}$$

We now put

$$\lambda - \tau = M \qquad T - \lambda = N$$

and obtain

$$T - \tau = T_2 + \Delta T - \alpha_2 = M + N \tag{11}$$

These equations suffice for the determination of ΔT when the latitude, φ, is known, and the effect upon ΔT of an error in the assumed value of φ is readily shown to be

$$\frac{d\,\Delta T}{d\,\varphi}\,\Delta\,\varphi = \frac{d\,N}{d\,\varphi}\,\Delta\,\varphi = -\,2\,cosec\,2\,\varphi\,cot\,N\,.\,\Delta\,\varphi \tag{12}$$

Putting $t = 2\tau$ and eliminating the formulæ requisite for the reduction of an observation may be collected and arranged as follows:

$$t = (\alpha_2 - T_2) - (\alpha_1 - T_1)$$

$$a = \frac{\sin \pi}{\sin p} \qquad x = \frac{2 \sin^2 \frac{1}{2} \pi}{\sin 1''} \cot \tfrac{1}{2} p$$

$$\tan M = \frac{a \sin t}{1 - a \cos t} \tag{13}$$

$$\cos N = \frac{\tan \varphi \tan \frac{1}{2} (p - x) \cos M}{1 - a \cos t}$$

$$C = 2 \operatorname{cosec} 2 \varphi \cot N$$

$$\Delta T + C \Delta \varphi = (\alpha_2 - T_2) + (M + N)$$

Since $\cos N = \cos(-N)$ the algebraic sign of N is not determined by the equations, but it is apparent from the physical conditions of the problem that N must be positive for a star west of the meridian and negative for a star east of the meridian. The coefficient of $\Delta \varphi$ appears in equations (13) with changed sign in order that $\Delta \varphi$ may represent a correction to the assumed latitude. In the use of these formulæ x may be computed with four place logarithms, a and M with five place, and N with six or seven place tables.

It will frequently happen that the observations of the polar star and the southern star composing a pair will be made at slightly different zenith distances, the slight change in the zenith distance of the line of sight of the telescope being indicated by an altered reading of the level bubble. This alteration is most conveniently taken into account by applying to the observed time, T_2, a correction

$$\textit{Level Corr.} = \frac{dt}{dz} \Delta z = \frac{\sec \varphi}{\sin A_2} \cdot \frac{(b_2 - b_1)\tau}{15} \tag{14}$$

where b_2 and b_1 are the level readings, τ the value of a level division in seconds of arc, and A_2 the azimuth of the star. The factor $b_2 - b_1$ is to be considered positive when the bubble runs from its initial position toward the objective end of the telescope.

The factor $\frac{\sec \varphi}{\sin A_2}$ in the preceding equation may be replaced by an expression which is most conveniently treated in connection with the thread intervals.

The southern star, and occasionally the polar star, will be observed on several threads, and from the several observed times the time of transit over the middle thread may be found by Bessel's method,[1] or as follows: The reduction of any thread to the middle thread is given by the equation

$$T_2 = T + i\frac{dT_2}{dz} + \frac{i^2}{2}\frac{d^2T_2}{dz^2} + \ldots.$$

$$= T + i \sec\varphi \operatorname{cosec} A_2 + \frac{i^2}{2}\frac{\sec\varphi \operatorname{cosec} A_2 \cot A_2}{\sin z \tan q} \qquad (15)$$

where q is the parallactic angle of the star when on the middle thread.

When the star is observed at its transit over the almucantar passing through the pole, we have rigorously

$$q = t \qquad z = 90^\circ - \varphi$$

and since the last term of (15) is very small we may in most cases substitute these approximate values in it. From the observations on the first and last threads we obtain, approximately,

$$f = \sec\varphi \operatorname{cosec} A_2 = (T'' - T') \div (i'' - i') \qquad (16)$$

Applying (15) to each observed thread and taking the mean of the resulting equations, we obtain

$$T_2 = \frac{1}{n}\left\{\Sigma T + f\,\Sigma i\right\} + f^2 \cos A \cot t \frac{1}{n}\,\Sigma\,\frac{2\sin^2\frac{1}{2}i}{\sin 1''} \qquad (17)$$

The last term rarely amounts to more than a few hundredths of a second, and if the star observed is near the prime vertical, or near elongation, it may be neglected. It should be noted that owing to the factor $\operatorname{cosec} A_2$, f is positive for stars west of the meridian and negative for stars east of the meridian.

Effect of Diurnal Aberration.—The effect of the diurnal aberration is to displace every star toward the east point of the horizon by the amount

$$D = 0^s.021 \cos\varphi \sin\Delta$$

[1] Chauvenet, Table VIII.

where Δ is the angular distance of the star from the east point. If in the quadrantal triangle formed by the star, the zenith and the east point we represent the angle at the star by ψ we shall have for the effect of the diurnal aberration upon the time of the star's transit over an almucantar

$$\varkappa = \overset{s.}{0.021} \cos \varphi \sin \Delta \,.\, \cos \psi \,.\, \sec \varphi \operatorname{cosec} A$$

which reduces to

$$\varkappa = \overset{s.}{0.021} \cos z$$

or for an observation made near the almucantar passing through the pole

$$\varkappa = \overset{s.}{0.021} \sin \varphi$$

Since the effect of the diurnal aberration is thus shown to be constant for all stars observed at the same zenith distance, it will be most readily taken into account by applying to the clock correction derived from the uncorrected observations the correction $+\varkappa$.

The application of the preceding formulæ may be illustrated by the reduction of the following observations of four pairs of stars, made with a very small universal instrument mounted upon a portable wooden tripod. The aperture of the telescope was 33 *mm*, the magnifying power 27 diameters, the value of a level division $7''.4$:

WASHBURN OBSERVATORY, MAY 19, 1894.

COMPARISON OF CLOCK STARS WITH λ URSÆ MINORIS.

Observer, G. C. C.

Star. Circle.	*ζ Leo.* *L.*	*49 Herc.* *L.*	*μ Herc.* *R.*	*ϑ Leo.* *R.*
b_1	6.0 24.7	5.2 24.1	5.0 23.9	4.7 23.6
T_1	13 31 5	13 45 18	13 56 4	14 4 22
b_2	5.1 24.0	5.7 24.7	5.0 24.1	4.7 23.8
T_2'	13 40 43.24	13 50 4.56	14 0 1.48	14 8 19.72
	° ′	° ′	° ′	° ′
Azimuth Circle	83 35	292 54	270 18	69 3
f	1.39	1.51	1.39	1.50

NOTES.— The instrument was so set that the readings of the azimuth circle are very nearly the true azimuths of the line of sight. When the vertical circle is "*Left*" the zero of the level scale is adjacent to the objective. The symbol T_2' denotes the mean of the observed times on five threads, and requires a correction to reduce it to T_2. T_1 was observed on the middle thread only. The thread intervals are assumed to be

$$I = -31.5^s \quad II = -20.5^s \quad III = 0.0 \quad IV = +20.3^s \quad V = +30.8^s$$

the signs corresponding to an observation Circle R. Star W. It should be noted that owing to the reversal of the instrument the effect of any small error in the adopted thread intervals will be eliminated.

The coördinates of λ *Ursæ Minoris* and the other constants requisite for the reduction, are:

$$\alpha_1 = 19\ 29\ 25.6 \qquad \log \sin \pi = 8.25491$$

$$\pi = 1\ 1\ 49.88 \qquad \log \frac{2 \sin^2 \frac{1}{2} \pi}{\sin 1''} = 1.5232$$

$$\varphi = 43\ 5\ (\textit{assumed}) \qquad \log 2 \operatorname{cosec} 2\varphi = 0.3020$$

$$\textit{Hourly rate of chronometer} = -0.04^s$$

Star.	*ζ Leo.*		*49 Herc.*		*μ Herc.*		*ϱ Leo.*	
	s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
Red'n to Middle Thread	+0.25	+0.00	−0.27	−0.02	+0.25	+0.00	−0.27	+0.02
Chron. Rate. Level	+0.01	+0.54	+0.01	+0.40	0.00	−0.07	−0.01	+0.07
T_2	13 40 44.04		13 50 4.68		14 0 1.65		14 8 19.53	
α_2	10 10 49.05		16 47 17.55		17 42 20.71		11 8 42.21	
$\alpha_2 - T_2$	−3 29 54.99		+2 57 12.87		+3 42 19.06		−2 59 37.32	
$\alpha_1 - T_1$	+5 58 20.6		+5 44 7.6		+5 33 21 6		+5 25 3.6	
t	217 56 6		318 16 20		332 14 22		233 49 47	
p	66 3 13.9		74 51 7.6		62 13 18.7		73 59 31.1	
log sin p	9.96091		9.98464		9.94682		9.98283	
log cos t	9.89692_n		9.87292		9.94689		9.77099_n	
log a	8.29400		8.27027		8.30809		8.27208	
log sin t	9.78871_n		9.82321_n		9.66818_n		9.90702_n	
co log $(1 - a\ cos t)$	9.9933111		0.0060815		0.0078831		9.9952305	
log cos M	9.9999692		9.9999657		9.9999798		9.9999516	
M	−0 40 57.1		−0 43 13.9		−0 33 8.7		−0 51 21.2	
x	51.3		43.6		55.3		44.3	
log tan $\frac{1}{2}(p - x)$	9.8128460		9.8837244		9.7805448		9.8769541	
log $\{cos\ M \div (1 - a\ cos\ t)\}$	9.9932803		0.0060472		0.0078629		9.9951821	
log cos N	9.7770484		9.8606937		9.7593298		9.8430583	
N	+53 14 20.4		−43 28 54.2		−54 55 54.1		+45 50 8.0	
$M + N$	+ 3 30 13.55		− 2 56 48.54		− 3 41 56.19		+ 2 59 55.12	
log cot N	9.8733		0.0230_n		9.8463_n		9.9873	
C	+1.497		−2.113		−1.407		+1.946	
	s.		*s.*		*s.*		*s.*	
$\Delta T + C\,\Delta\,\varphi$	+18.56		+24.33		+22.87		+17.80	
$C\,\Delta\,\varphi$	− 2.32		+ 3.27		+ 2.18		− 3.02	
ΔT	+20.88		+21.06		+20.69		+20.82	

From the equations

$$\begin{aligned} \Delta T + 1.50\,\Delta\varphi &= 18.56 & v &= +\,0.02 \\ \Delta T - 2.11\,\Delta\varphi &= 24.33 & &\;+\;.20 \\ \Delta T - 1.41\,\Delta\varphi &= 22.87 & &\;-\;.17 \\ \Delta T + 1.95\,\Delta\varphi &= 17.80 & &\;-\;.04 \end{aligned}$$

we obtain

$$\Delta T = +\,20.86^{s.} \qquad \Delta\varphi = -\,1.55^{s.} = -\,23.3''$$

with the residuals placed opposite the several equations.

In the above reduction the computations have been carried to tenths of a second of arc and hundredths of a second of time, but it is evident that quantities of this order are imperceptible in so small an instrument, a second of arc being approximately the limit of what can be seen in its telescope or measured by its level. The internal agreement of the observations as shown by the residuals is, therefore, satisfactory, and the absolute values of the latitude and clock correction furnished by the observations are also in excellent agreement with the data furnished by a geodetic connection with the Washburn Observatory and a comparison of the chronometer with the normal clock. Thus after correcting ΔT for diurnal aberration we have

From Observation	$\Delta T = +\,20.88^{s.}$	$\varphi = 43^\circ\ 4'\ 36.7''$
From Comparisons	$= +\,20.80$	$= 43^\circ\ 4'\ 36.5''$

This excellent agreement is due, at least in part, to the reversal of the instrument, one-half of the observations having been made Circle Right and one-half Circle Left, thus eliminating the effect of error in the assumed thread intervals.

In order to secure the convenient observation of stars it will be advantageous to prepare in advance an observing programme showing the time at which the several clock stars cross the almucantar of the polar star, and their corresponding azimuths. If only a few stars are to be included in the programme this can be most conveniently done by putting $T_2 = T_1$ in equations (13) and solving with

four place logarithms the following approximate equivalents of those equations:

$$t = \alpha_2 - \alpha_1 \qquad \tan M = \frac{a \sin t}{1 - a \cos t}$$

$$a = \sin \pi \operatorname{cosec} p \qquad \cos N = \frac{\tan \varphi \tan \frac{1}{2} p}{1 - a \cos t} \tag{18}$$

$$T_1 = T_2 = \alpha_2 - \Delta T + M + N$$

When the sidereal times T_1 and T_2 are known the zenith distances and azimuths of the stars may be directly computed from the fundamental formulæ for the transformation of coördinates, but the following method will usually be found more convenient:

In the spherical triangle formed by the polar star, the zenith and the pole, we represent the east hour angle of the star by τ and find

$$\begin{aligned} \cos z &= \sin \varphi \sin \delta_1 + \cos \varphi \cos \delta_1 \cos \tau \\ &= \cos (\delta_1 - \varphi) - \cos \varphi \cos \delta_1 \, 2 \sin^2 \tfrac{1}{2} \tau \end{aligned}$$

and applying to this the development into series of

$$\cos x = \cos y + h$$

find when terms of the order π^2 are neglected

$$z = H - \varphi \qquad H = 90^\circ - \pi \cos \tau \tag{19}$$

Similarly from the development of the azimuth into series we find when the azimuth is reckoned from the north, positive toward east,

$$A_1 = \pi \sin \tau \sec \varphi = M_0 \sec \varphi \tag{20}$$

Values of H and M_0 with the argument "τ" are tabulated below.

To determine the difference of azimuth of the stars, we represent by ρ the length of an arc of a great circle joining them, and from the isosceles spherical triangle formed by the two stars and the zenith, find

$$\cos \rho = \cos^2 z + \sin^2 z \cos (A_2 - A_1)$$

which is readily transposed into either

$$\sin \tfrac{1}{2} (A_2 - A_1) = \sin \tfrac{1}{2} \rho \operatorname{cosec} z$$

or

$$\tan \tfrac{1}{2} (A_2 - A_1) = \frac{\sin \frac{1}{2} \rho}{\sqrt{\sin \left(z - \frac{\rho}{2}\right) \sin \left(z + \frac{\rho}{2}\right)}} \tag{21}$$

The first of these equations will usually be the more convenient.

To determine ρ we have from the triangle formed by the two stars and the pole

$$\cos \rho = \cos \pi \sin \delta + \sin \pi \cos \delta \cos (\alpha_2 - \alpha_1)$$

where δ is the declination of the southern star. In place of this rigorous equation we may write with sufficient precision

$$\rho = 90 - \delta - \pi \cos (\alpha_2 - \alpha_1) = H(t) - \delta \qquad (22)$$

where the symbol $H(t)$ denotes the tabular value of H corresponding to the argument $t = \alpha_2 - \alpha_1$.

Equations (18), (20) and (22), in connection with the tabular values of H and M_0, suffice for the construction of an observing list, but if any considerable number of stars are to be observed in the same latitude it will be found an economy of labor to construct for the given latitude special tables, such as those given below for the Washburn Observatory, which are based on the following analysis:

Neglecting terms of the order π^2 we put

$$\cos N_0 = \tan \varphi \tan \tfrac{1}{2} p$$

and find from equations (18)

$$\cos N = \cos N_0 + a \cos t \cos N_0$$
$$N = N_0 - \pi \cos t \sec \delta \cot N_0$$
$$M = \pi \sin t \sec \delta$$

The factor $\pi \sin t = M_0$ has been tabulated, and $-\pi \cos t$ is evidently equal to the tabular value of M_0 which corresponds to the argument $t - 6^h$. Putting

$$\sec \delta = h \qquad \sec \delta \cot N_0 = k$$

we tabulate N_0, h and k with the argument δ and find for the instant at which the two stars have equal altitudes

$$T = a + N_0 + h M_0 + k M'_0$$

the accents $'$ $''$ denoting that the arguments for the corresponding values of M_0 are t and $t - 6^h$.

It should be noted that since N_0 is an approximation to the N of the rigorous formulæ we shall have N_0 and k posi-

tive for a star west of the meridian and negative for a star east of the meridian.

Similar tables may be constructed for the difference of azimuth of the stars, but the direct computation by (19) and (21) is so simple that little advantage would be derived from them.

To illustrate the use of the tables we make the following computations for a comparison of Polaris with ρ Leonis west of the meridian and δ Herculis east of the meridian:

$$\varphi = 43^\circ\ 4'.6 \qquad \alpha_1 = 1^h\ 18^m.9$$

Star.	*ρ Leonis.*	*δ Herculis.*
α_2	10 27.3	17 10.7
t	9 8 4	15 51.8
δ	9 51	24 58
$H(t)$	90 54	90 39
ρ	81 3	65 41
N_0	+ 2 32 5	− 3 33.7
$h\,M_0'$	+ 3.4	− 4.6
$k\,M_0''$	+ 4.6	− 2.1
T	13 7.8	13 30.3
$H(\tau)$	91 14	91 14
z	48 10	48 10
$cosec\ z$	0.1278	0.1278
$sin\ \frac{\rho}{2}$	9.8127	9.7343
$A_2 - A_1$	121 23	93 25

The azimuth of Polaris corresponding to the times above computed is, in minutes of arc, $15\ sec\ \varphi \cdot M_0'$.

For a determination of time only, the latitude being supposed known or not required, the observation of the polar

star may be omitted and the observation confined to noting the times at which two southern stars reach the same altitude. Convenient formulæ and tables for observations of this kind have been published by Wittram.[1]

AUXILIARY TABLES FOR TRANSITS OVER THE ALMUCANTAR OF POLARIS.

FOR ALL LATITUDES.

t or τ	M_0		H		t or τ
h.	m.		° ′		h.
0	+ 0.0 −		88 46		24
		1.3		3	
1	+ 1.3 −		88 49		23
		1.2		7	
2	+ 2.5 −		88 56		22
		1.0		12	
3	+ 3.5 −		89 8		21
		0.8		15	
4	+ 4.3 −		89 23		20
		0.5		18	
5	+ 4.8 −		89 41		19
		0.1		19	
6	+ 4.9 −		90 0		18
		0.1		19	
7	+ 4.8 −		90 19		17
		0.5		18	
8	+ 4.3 −		90 37		16
		0.8		15	
9	+ 3.5 −		90 52		15
		1.0		12	
10	+ 2.5 −		91 4		14
		1.2		7	
11	+ 1.3 −		91 11		13
		1.3		3	
12	+ 0 0 −		91 14		12

[1] Tables Auxiliaires pour la Détermination de l'Heure par des Hauteurs Correspondantes de Différentes Etoiles. St. Petersburg, 1892.

FOR THE LATITUDE 43° 4.′6

δ	N_0 + W.	N_0 − E.	h	k + W.	k − E.	δ
°	h. m.					°
− 2	0 57.9		1.00	3.88		− 2
		13.8			79	
− 1	1 11.7		1.00	3.09		− 1
		11.4			45	
0	1 23.1		1.00	2.64		0
		9.9			31	
+ 1	1 33.0		1.00	2.33		+ 1
		8.9			23	
2	1 41.9		1.00	2.10		2
		8.0			17	
3	1 49.9		1.00	1.93		3
		7.3			15	
4	1 57.2		1.00	1.78		4
		6.9			11	
5	2 4.1		1.00	1.67		5
		6.6			10	
6	2 10.7		1.01	1 57		6
		6.1			9	
7	2 16 8		1.01	1.48		7
		5.7			7	
8	2 22.5		1.01	1.41		8
		5.5			7	
9	2 28.0		1.01	1.34		9
		5.3			6	
* 10 *	2 33.3	* *	* 1.02 *	1.28	* *	* 10 *
		9.8			10	
12	2 43.1		1.02	1.18		12
		9.2			8	
14	2 52.3		1.03	1.10		14
		8.5			7	
16	3 0.8		1.04	1.03		16
		8.0			6	
18	3 8.8		1.05	0.97		18
		7.6			5	
20	3 16 4		1.06	0.92		20
		7.2			4	
22	3 23.6		1.08	0.88		22
		6.9			4	
24	3 30.5		1.09	0.84		24
		6.5			4	
26	3 37.0		1.11	0.80		26
		6.3			3	
28	3 43.3		1.13	0.77		28
		6.0			3	
30	3 49.3		1.15	0.74		30
		5.8			3	
32	3 55.1		1.18	0.71		32
		5.7			2	
34	4 0.8		1.21	0.69		34
		5.4			2	
36	4 6.2		1.24	0.67		36
		5.3			2	
38	4 11.5		1.27	0.65		38
		5.1			2	
40	4 16.6		1.31	0.63		40

BULLETIN OF THE UNIVERSITY OF WISCONSIN.

SCIENCE SERIES, Volume 1:

No. 1. On the Speed of Liberation of Iodine in Solutions of Hydrochloric Acid, Potassium Chlorate, and Potassium Iodide, by Herman Schlundt, Assistant in Chemistry. Pp. 33, December, 1894. Price 35 cents.

No. 2. On the Quartz Keratophyre and Associated Rocks of the North Range of the Baraboo Bluffs, by Samuel Weidman. Pp. 21, pls. 3, January, 1895. Price 25 cents.

No. 3. Studies in Spherical and Practical Astronomy, by George C. Comstock, Director of the Washburn Observatory. Pp. 50 June, 1895. Price 40 cents.

No. 4. A Contribution to the Mineralogy of Wisconsin, by William Herbert Hobbs, Assistant Professor of Mineralogy and Petrology. With 5 plates. (In press.)

ENGINEERING SERIES, Volume 1:

No. 1. Track, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 24, April, 1894. Price 25 cents.

No. 2. Some Practical Hints in Dynamo Design, by Gilbert Wilkes, M. Am. Inst. E. E., Special University Lecturer. Pp. 16, May, 1894, Price 25 cents.

No. 3. The Steel Construction of Buildings, by C. T. Purdy, C. E., Special University Lecturer. Pp. 27, October, 1894. Price 25 cents.

No. 4. The Evolution of a Switchboard, by A. V. Abbott, C. E., Special University Lecturer. Pp. 32, pls. 4, October, 1894. Price 35 cents.

No. 5. An Experimental Study of Field Methods which will Insure to Stadia Measurements Greatly Increased Accuracy, by Leonard Sewal Smith. B. C. E., Instructor in Engineering. Pp. 45, Pl. 1, May, 1895. Price 35 cents.

No. 6. Railway Signalling, by W. McC. Grafton. (In preparation.)

ECONOMICS, POLITICAL SCIENCE, AND HISTORY SERIES, Volume 1:

No. 1. The Geographical Distribution of the Vote of the Thirteen States on the Federal Constitution, 1787-8, by Orin Grant Libby, A. M., Fellow in History, with an introduction by Frederick J. Turner. Pp. 116, pls. 2, July, 1894. Price 75 cents.

No. 2. The Finances of the United States from 1775 to 1789, with Especial Reference to the Budget, by Charles J. Bullock, A. B., Fellow in Economics. Pp. 157, May, 1895. Price 75 cents.

The BULLETIN OF THE UNIVERSITY OF WISCONSIN is printed by the State and is issued at irregular intervals. It contains original papers by persons connected with the university.

Copies of the BULLETIN will be forwarded post free from the office of the State Superintendent of Public Property to all colleges, high schools, normal schools, and public libraries of the state which have a collection of 300 or more volumes, on making proper application at the Superintendent's office. Persons who reside in the state of Wisconsin can receive copies of the BULLETIN free by applying to the Secretary of the Board of Regents of the University and paying the cost of transportation. The postage required for the individual numbers thus far issued, is as follows: Eng. Ser., No. 1, 2c; No. 2, 2c; No. 3, 2c; No. 4, 3c; No. 5, 3c. Hist. Ser., No. 1, 6c; No. 2, 7c. Sci. Ser., No. 1, 2c; No. 2, 2c; No. 3, 3c. All the above are sent in one package by express for 22 cents.

The BULLETIN may be obtained at Brentano's, 31 Union Sq., New York, and 204–206 Wabash Ave., Chicago; and at A. C. McClurg & Co.'s, 117, 119, and 121 Wabash Ave., Chicago. In Europe it may be obtained from Mayer & Müller, Markgrafenstrasse 51, Berlin W., and from Brentano's, 27 Ave de l'Opéra, Paris.

Communications having reference to an exchange of publications should be addressed to Mr. Walter M. Smith, University Librarian, or to Professor Wm. H. Hobbs of the board of editors.

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 4, PP. 109–156, PLS. 4–8.

A CONTRIBUTION TO THE MINERALOGY OF WISCONSIN.

BY

WILLIAM HERBERT HOBBS
Assistant Professor of Mineralogy and Petrology

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF
THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
JUNE, 1895

PRICE 40 CENTS

Democrat Printing Company, State Printer

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 4, PP. 109–156, PLS. 4–8, JUNE, 1895

A CONTRIBUTION TO THE MINERALOGY OF WISCONSIN.[1]

ERRATA

Bulletin of the University of Wisconsin, Science Series, Vol. I, No. 4

PAGE 124, *6th line from bottom.* For *carbo-octahedrons* read *cubo-octahedrons.*

PAGE 125, *3d line from bottom; also* PAGE 126, *6th line from top: and* PAGE 155, *9th line from top.* For *twinning plane* read *composition plane.*

PAGE 126, *10th line from bottom.* For *twinning* read *lamellation.*

The Druse Minerals from the Hamilton Cement Rock at Milwaukee: calcite, pyrite, sphalerite, marcasite, celestite, millerite.
Diamonds from the Drift.

INTRODUCTION.

So far as I am able to determine, nothing has been published descriptive of the crystallography of Wisconsin minerals. The minerals of economic importance have re-

[1] Read before the Wisconsin Academy of Sciences, Arts, and Letters, June 8th, 1895.

Democrat Printing Company, State Printer

BULLETIN OF THE UNIVERSITY OF WISCONSIN
SCIENCE SERIES, VOL. 1, NO. 4, PP. 109–156, PLS. 4–8, JUNE, 1895

A CONTRIBUTION TO THE MINERALOGY OF WISCONSIN.[1]

BY WILLIAM HERBERT HOBBS,
Assistant Professor of Mineralogy and Petrology.

CONTENTS.

INTRODUCTION.

So far as I am able to determine, nothing has been published descriptive of the crystallography of Wisconsin minerals. The minerals of economic importance have re-

[1] Read before the Wisconsin Academy of Sciences, Arts, and Letters, June 8th, 1895.

ceived attention, and the minerals in association with them have been mentioned in the several reports of the Wisconsin Geological Survey as well as in other publications. The present investigation has been devoted chiefly to the crystallographical development of Wisconsin minerals, and it has shown that from a purely scientific standpoint they possess considerable interest. Most of the species described have been before reported from the localities, and some, such as the calcites and smithsonites from the Galena Limestone, are quite widely distributed in cabinets. A few of the occurrences are quite new. The list of species considered includes with but few exceptions, it is believed, all that have been reported as occurring in definite megascopic crystals within the boundaries of the state.

The material on which this study has been made is chiefly from the Mineral Collection of the University of Wisconsin, in which is included the W. T. Henry collection, with little doubt the most complete collection of minerals that has been made from the mining region of southern Wisconsin. The writer is under obligations to Professor Edward Kremers of the University, for specimens of crystallized minerals collected from the Hamilton Cement Rock at Milwaukee, and to Mr. L. S. Cheney, also of the faculty of the University, for specimens from the vicinity of Platteville.

Below is given a partial list of the papers which treat of Wisconsin minerals. I have not included in this list the voluminous literature by Irving, Van Hise, Pumpelly, Brooks, and others, on the crystalline rocks of northern Wisconsin, in which descriptions of microscopic rock constituents are given.

Moses Strong, Geology and Topography of the Lead Region. Geology of Wisconsin, Vol. II, pp. 689–752. (1878.)

R. D. Irving, The Mineral Resources of Wisconsin. Trans. Am. Inst. Min. Eng., New York Meeting, 1880, pp. 1–31. (1880.)

T. C. Chamberlin, The Ore Deposits of Southwestern Wisconsin. Geology of Wisconsin, Vol. IV, pp. 377–398. (1882.)

R. D. Irving, Minerals of Wisconsin. Ibidem, Vol. I, pp. 309–339. (1883.)

George F. Kunz, (Note on finding of Eagle Diamond). Mineral Resources of the United States for 1883 and 1884, p. 732. (1885.)

George F. Kunz, On the Occurrence of Diamonds in Wisconsin. Bull. Geol. Soc. Am., Vol. 2, pp. 638, 639. (1891.)

E. S. Dana, Catalogue of American Localities of Minerals. System of Mineralogy, 6th Ed., p. 1087. (1892.)

Wm. P. Blake, The Mineral Deposits of Southwest Wisconsin. Trans. Am. Inst. Min. Eng., Chicago Meeting, pp. 1–11. (1893.)

Wm. H. Hobbs, On a recent Diamond Find in Wisconsin and on the Probable Source of this and other Wisconsin Diamonds. American Geologist, Vol. XIV, pp. 31–35. (1894.)

THE CRYSTALLIZED MINERALS FROM THE PRE-SILURIAN FORMATIONS OF SOUTHERN WISCONSIN.

Quartz Crystals from Devil's Lake.—The fissures in the Upper Huronian Quartzite of Devil's Lake, near Baraboo, are frequently found to be lined with crystals of quartz, which though quite small are very clear and have faces well fitted for measurement. The occurrence of crystallized quartz in the vicinity of Devil's Lake has been mentioned by Irving in a paper entitled "Minerals of Wisconsin."[1] These crystals are fully as limpid as the well known quartzes from Herkimer county, New York. A crystallographic study has been made of them on material recently collected at Devil's Lake by Professor Van Hise. The crystals have an average length of 3–6 mm. and a thickness of 1–2 mm. They have generally a marked trigonal habit occasioned by the unequal development of alternate faces of the prism, and by the subordination of the form *z* to *r*.[2] Besides the

[1] Geology of Wisconsin, Vol. I, p. 318, 1883.

[2] Throughout this paper the lettering of known planes agrees with that used by Dana in the 6th edition of the *System of Mineralogy*. In one or two cases the lettering used by

usual forms m, r, and z, the crystals are modified by the trigonal pyramids s and s', the right and left forms being often observed together on the crystal. Examination with a lens reveals the fact that some crystals are further modified by the occurrence of a positive right trapezohedron between s and z. Measurement with the goniometer shows this plane to be the form τ'_4, $+\frac{8}{7}P\frac{8}{7}$ r, $(71\bar{8}7)$, which I think has not before been observed, though the complementary negative left form τ_4, $-\frac{8}{7}P\frac{8}{7}$ l, $(17\bar{8}7)$ is given in the lists of Dana and Goldschmidt. In the zone of mr on another crystal a faint but distinct reflection was also obtained from a plane which has the symbol $\frac{47}{30}$R, $(47.\ 0.\ \overline{47}.\ 30)$ and which has not before been described on quartz. The habit and development of the crystals is represented in figure 1.

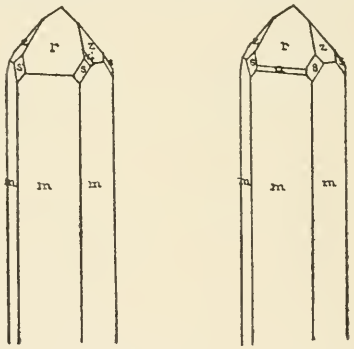


FIG. 1.—QUARTZ CRYSTALS FROM DEVIL'S LAKE.

The following list gives the forms observed in the order of their amounts of development:

m, ∞R, $(10\bar{1}0)$.

r, R, $(10\bar{1}1)$.

z, —R, $(01\bar{1}1)$.

s, $\frac{2P2}{4}$ r, $(11\bar{2}1)$.

s', $\frac{2P2}{4}$ l, $(2\bar{1}\bar{1}1)$.

τ'_4, $+\frac{8}{7}P\frac{8}{7}$ r, $(71\bar{8}7)$.*

$\mathfrak{a}$, $\frac{47}{30}$R, $(47.\ 0.\ \overline{47}.\ 30)$.*

Irby and Goldschmidt has been adopted. For new planes discovered German letters have been used wherever this is possible.

The angles were measured on two crystals with the following results:

	Measured.	Calculated.
$m : s,\ 10\bar{1}0 : 11\bar{2}1$	38° ½′	37° 58′
$s : r'_4,\ 11\bar{2}1 : 71\bar{8}7$	23 12	23 15
$r'_4 : z,\ 71\bar{8}7 : 01\bar{1}1$	5 31	5 39
$r'_4 : m,\ 71\bar{8}7 : 10\bar{1}0$	61 12½	61 13
$r : z,\ 10\bar{1}1 : 1\bar{1}01$	46 34	46 16
$r : s,\ 10\bar{1}1 : 11\bar{2}1$	28 55	28 54
$m : r,\ 10\bar{1}0 : 10\bar{1}1$	38 11	38 13
$m : a,\ 10\bar{1}0 : 47.\ 0.\ \bar{4}\bar{7}.\ 30$	28 56	28 57
$m : m,\ 10\bar{1}0 : 1\bar{1}00$	60 0	60 0

The considerable variation from the theory in the measurement fo the angle *rz* is due to the vicinal character of the face *z*. With this exception the faces gave excellent images of the signal.

Arsenopyrite in dike rock at Marquette, Green Lake County.—This mineral is found as an accessory constituent in a diabasic rock which occurs in a small dike in Marquette, Green Lake county. The locality is on the south side of the hill south of Mr. Ingalls's house and about one and one-fourth miles south-southwest of the village of Marquette.

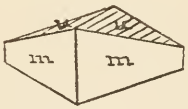


FIG. 2.—ARSENOPYRITE FROM MARQUETTE.

The mineral occurs in crystals three to four millimetres across and bounded by the forms *u*, $\frac{1}{4}\breve{P}\infty$ (014) and *m*, ∞P, (110) (See Fig. 2). The *u* faces are as usual striated parallel to their intersection. The faces are all bright and reflect well, but are too much rounded to admit of measurement Heated on charcoal in the oxidizing and reducing flames of the blowpipe, arsenic and sulphur fumes are

evolved and the iron is oxidized. The mineral is locally supposed to be silver and the locality is referred to as the "silver mine."

Crystallized Calcite from Madison.—In the extensive quarries in calcareous sandstone which are located just west of the city of Madison and which belong to the Lower Magnesian formation, are occasionally found druse crystals of calcite. A specimen collected from this locality exhibits crystals of three to four milimetres diameter lining a small cavity.

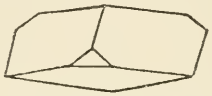


FIG. 3.—CALCITE FROM MADISON.

These crystals have a yellowish tint and are somewhat translucent. The faces are considerably rounded, so as to be unfit for measurement, but the forms can be easily determined to be $-\frac{1}{2}R$ $(01\bar{1}2)$ and R $(10\bar{1}0)$, the latter very small. Another specimen is made up of crystals varying from 1–2 cm. in diameter bounded by the form $-\frac{1}{2}R$. Still another is bounded by R, ∞R and a scalenohedron. Still another specimen, apparently dropped on the University Drive by the quarry teams, is bounded by 0P, R, $-\frac{1}{2}R$, and $-2R$.

THE CRYSTALLIZED MINERALS FROM THE CAVITIES IN THE GALENA LIMESTONE OF SOUTHERN WISCONSIN.

The lead and zinc ore region of the Upper Mississippi valley includes portions of Wisconsin, Illinois, Iowa, and Missouri. In Wisconsin the mines are now worked chiefly for zinc, which is obtained very largely from a porous variety of smithsonite colored brown by limonite, and known locally as *dry bone* or *dry bone ore.* This material is mainly utilized for the manufacture of zinc paint. At Shullsburg, where there is at present the greatest activity, black jack is the principal ore and is mined for *spelter.* The minerals

associated in the deposits in the Wisconsin area are calcite, smithsonite, galena, cerussite, sphalerite, gypsum, barite, marcasite, pyrite, chalcopyrite, azurite, malachite, and limonite. Hematite, siderite, pyrolusite, hydrozincite, and anglesite have also been reported. As will be shown below it is probable that what has been reported as anglesite is a well crystallized variety of gypsum, or selenite. Some additional minerals, notably amethystine quartz and calamine, are found in the areas of adjoining states, the so-called "calamine" of the Wisconsin mines is, however, not calamine but smithsonite.

Wisconsin calcites, smithsonite pseudomorphs, and azurites, are somewhat widely distributed in cabinets, as are also the galenas from Galena, Ill., but I am not aware that any crystallographical study has heretofore been made on any of these minerals.

CALCITE FROM MINERAL POINT, LINDEN MINE, MIFFLIN, AND GALENA.

Southern Wisconsin has long been known as a locality for crystallized calcite, and specimens from the region are, therefore, somewhat widely distributed in collections. The best crystals come from the Linden Mine, Mineral Point, Galena, and Mifflin. They are frequently found to be modified, and they show considerable variety in their habits. Without regarding the less important variations, seven distinct types of crystal are observed, four of which are frequently met with and stand in an interesting relationship to one another as regards their periods of formation. These types may be distinguished as follows:

Type 1. Habit, common scalenohedron R_3 $(21\bar{3}1)$ very much rounded; modified by R and by other undeterminable faces; color, milk white, brown, or pink, often variegated; opaque; crystals seldom over two inches in length, though larger cleavage pieces are found. Linden Mine and Galena. (See plate 4, fig. 1.)

Type 2a. Habit, scalenohedron R_3 $(21\bar{3}1)$ quite alone; color, light wine yellow; translucent to transparent; crystals almost always formed about a nucleal crystal of type 1; uniformly from three to six inches long; faces covered by *Aetzhügel* due to much corrosion by solvents. Mineral Point. (See plate 4, fig. 2a.)

Type 2b. Habit, flat rhombohedron $-\frac{1}{2}R$ $(01\bar{1}2)$ either quite alone or with small face of R $(10\bar{1}1)$; color like type 2a; translucent to transparent; faces quite free from etching phenomena; crystals from three to five inches broad; found generally in geodes which have a diameter of a foot or less. (These crystals were probably formed by the same solutions as those of type 2a, the difference in habit being explained by local conditions.) Mineral Point. (See plate 4, fig. 2b.)

Type 3. "Dog tooth spar." Habit, common scalenohedron R_3 $(21\bar{3}1)$ with moderate truncation by the fundamental rhombohedron R (1011) and much modified; color, grayish white; poorly translucent; faces marked by *Aetzfiguren* and *Aetzkanäle* but generally without *Aetzhügel*, hence less corroded than crystals of type 2a; usually has a core of type 2a within which is a core of type 1; two sizes of crystals, about two inches and four to seven inches long respectively. Linden Mine and Galena. (See plate 4, fig. 3.)

Type 4. "Nail head spar." Habit, fundamental rhombohedron R $(10\bar{1}1)$ moderately beveled by the common scalenohedron R_3 $(21\bar{3}1)$ and much modified, the forms being the same as on crystals of type 3; color, like type 3 but considerably more translucent, being in this respect intermediate between types 2a and 3; less marked by etchings than type 3; occurs either alone or as parallel growths on surface of crystals of type 3, forming knobby projections if attached to the lateral faces, and scepter calcite resembling "scepter quartz" if attached to the apex of the crystals; when large numbers of these crystals are attached to the faces of crystals of type 3 they may unite as sub-indi-

viduals to form apparent secondary enlargements to that type; usually one to two inches in diameter; Galena, Linden Mine, Mineral Point, and Mifflin. (See plate 4, fig. 4; also plate 5, fig. 1.)

Type 5. Habit, a combination of the common rhombohedron R $(10\bar{1}1)$, with the basal pinacoid, 0P (0001), and with small development of R_3 $(21\bar{3}1)$. The only representative specimens of this type are large twinned crystals which will be fully described below. Linden Mine. (See plate 4, fig. 5.)

Type 6. Habit, prismatic from development of steep rhombohedron 24R. $(24.0.\overline{24}.1)$; terminal planes *e*, *v*, and subordinate *k*; white and opaque; Diamond Grove. Only one crystal of this type has been observed. (See plate 4, fig. 6.)

Crystallographically the most interest attaches to the types 3 and 4, since the crystals of type 1 are too much rounded to permit of any determination of their forms, and both varieties of type 2 are very simple, 2a exhibiting only the form R_3 $(21\bar{3}1)$ and 2b the forms $-\frac{1}{2}R$ $(01\bar{1}2)$ and R $(10\bar{1}1)$. Although the crystals of types 3 and 4 are markedly different in their habits, between which no transitional forms have been observed, they are identical in their modification. The crystals of the latter type being less corroded, are best suited to measurement, but even on the best of these crystals the rounding of some of the faces renders very accurate measurements impossible. They are also too large for convenience of measuring with the reflecting goniometer. The following forms have been determined, those marked with an asterisk being so far as I know new to the species. They are not included in the lists of forms compiled by Irby,[1] Goldschmidt,[2] and Dana.[3]

---

[1] Irby, On the crystallography of calcite. Inaug. Diss. Göttingen, 1878.

[2] Goldschmidt, Index der Krystallformen, I. Berlin, 1886.

[3] Dana, E. S., System of Mineralogy, 6th Ed., New York, 1892.

r, R $(10\bar{1}1)$.
e, $-\frac{1}{2}$R $(01\bar{1}2)$.
v, R_3 $(21\bar{3}1)$.
a, $-\frac{11}{20}$R $(0.11.\overline{11}.20)$.*
b, $-\frac{18}{25}$R $(0.18.\overline{18}.25)$.*
f, -2R $(02\bar{2}1)$.
c, 24R $(24.0.\overline{24}.1)$.*
δ, 10R $(10.0.\overline{10}.1)$.
k, $\frac{5}{2}$R $(50\bar{5}2)$.
53,[1] $\frac{2}{3}$R2 $(11\bar{2}3)$.
t, $\frac{1}{4}$R3 $(21\bar{3}4)$.
57,[1] $\frac{1}{3}R\frac{7}{3}$ $(52\bar{7}9)$.
E, $\frac{1}{2}R\frac{5}{3}$ $(41\bar{5}6)$.

These forms have been determined by the following measurements which are for the most part averages of several readings made on corresponding angles[2]:

	Measured.	Calculated.
Zone of e and m.		
e : a, $01\bar{1}2$: $0.11.\overline{11}.20$	2° 2′	2° 14′
e : b, $01\bar{1}2$: $0.18.\overline{18}.25$	9 20	9 8
e : *f*, $01\bar{1}2$: $02\bar{2}1$	36 30	36 52
e : c, $01\bar{1}2$: $24.0.\overline{24}.1$	66 10	66 10
e : *δ*, $01\bar{1}2$: $10.0.\overline{10}.1$	69 30	69 32
Zone of e and r.		
e : *53*, $01\bar{1}2$: $11\bar{2}3$	14° 13′	14° 20′
e : *t*, $01\bar{1}2$: $21\bar{3}4$	20 30	20 58
e : *57*, $01\bar{1}2$: $52\bar{7}9$	22 50	23 4
e : *E*, $01\bar{1}2$: $41\bar{5}6$	27 15	27 4
v : *v* (Edge X), $21\bar{3}1$: $\bar{2}3\bar{1}1$	75 22	75 22
v : *v* (Edge Z), $21\bar{3}1$: $12\bar{3}\bar{1}$	46 55	47 1

[1] Numbers used by Irby.

[2] The vicinal character of r prevented measurement, but the plane is easily identified by the cleavage. The face *k* is determined by its zones.

The different forms show considerable difference in the character of their markings. The planes of R_3 are striated parallel to their combination edge with R. Both R_3 and R are often marked by *Aetzkanäle* which incline to follow the direction of cleavage. On R the etched figures have the symmetry and approximately the shape of the artificial figures produced by the action of hydrochloric acid. This face is very frequently vicinal, the facets representing two scalenohedrons of large indices. Between R and R_3 a small and undeterminable face occurs which is probably the result of corrosion—*Prärosionsfläche* of Hamberg. The new form a.—$\frac{18}{25}$R (0.18. $\overline{18}$. 25) may possibly also be of this character.

The parallel growths of four of the different types of crystals with one another demonstrate the fact that they represent successive separations from the solutions from which they were formed, their order of age being that represented by the numerals assigned to the types, viz.: 1, 2a, 3, 4, type 1 being the oldest. The crystals of type 2b were probably formed at the same time as those of type 2a, but in a different situation. Crystals of type 1, though common as a core of the later types, are most rarely found alone. The crystals of type 2a were most easily corroded by solutions, for specimens of parallel growths with the two later types are found in which the core of type 2 has been entirely removed, whereas the enclosing zone of type 3 has only been rendered porous and that of type 4 has been comparatively little affected. In one instance the cavity left by the removal of type 2 has been filled with sphalerite, thus forming a mechanical infiltration pseudomorph. Numerous specimens in the University Collection are parallel growths of the four types in isomorphous layers, and when broken across these types are seen to be sharply separated from one another by the differences in color and transparency. A few parallel growths include less than the full series of types, but no one of the types has been

observed out of the order stated. The character of one of these interesting parallel growths is represented in plate 5. fig. 1.

The only representative specimens of type 5 are two large twinned crystals from the Linden Mine. They are interesting both because they are the only specimens in the collection on which I have observed the basal pinacoid, and because they furnish the only observed illustration of twinning in the calcites of the region. The specimens are very large (the largest about 7 x 6 x 5 inches), and have a gray color and a much corroded surface. The individuals of both specimens exhibit the combination of the fundamental rhombohedron, R $(10\bar{1}1)$, with the basal pinacoid, 0P (0001) and the common scalenohedron, R_3 $(21\bar{3}1)$. On one of the individuals of the larger specimen the basal plane has a very large development influencing the habit of the crystal, while on the other individual it is quite small. The two individuals have parallel axes, and the twinning plane may be considered either a face of the fundamental prism, ∞P $(10\bar{1}0)$, or the basal pinacoid, 0P (0001). The large triangular area of the basal pinacoid on one individual is divided very accurately into two smaller and perfectly equilateral triangles by the projection above it of the rhombohedral faces of the other individual. On the largest of these triangular areas has formed a deep green yellow calcite enlargement. This addition of calcite material has extended the rhombohedral planes which outline two sides of the triangle, and on the third side opposite the rhombohedral face of the other individual it has developed a new rhombohedral face, so that the apparent lack of symmetry between the two individuals caused by the greater development of *c* on one of them, is in part removed. The other triangular section of the pinacoid has received no addition of calcite material. To one side of the specimen are attached small crystals of barite which will be described below.

The smaller specimen of this type is very similar to the one just described, but the basal plane has a smaller development, and on one individual it hardly appears at all. It is interesting, however, to note that there has been an addition of the yellow green calcite to this plane, so as to extend the surrounding rhombohedral faces and replace the pinacoid in the manner described for the first specimen.

The stereographic projection (plate 5, fig. 2) represents all the forms observed on the calcites of this region and exhibits their zonal relationships.

SMITHSONITE FROM MINERAL POINT.

The mineral smithsonite occurs at Mineral Point in two forms, one a massive, semi-vitreous, white to gray variety, locally called "calamine," which incrusts much of the calcite and blende of the locality, and the other a porous gray to brown variety known as "dry bone," apparently in all cases a replacement pseudomorph after either calcite or blende. The "dry bone" variety is much the more abundant. The more perfect pseudomorphs after calcite are very beautiful and represent the types 3 and 4 described under calcite. As these pseudomorphs are well known and are somewhat widely distributed in cabinets, a full description of them here is unnecessary. They have evidently been produced through the action of solutions by a metasomatic process of alteration, the lime of the calcite being replaced molecule by molecule by zinc. An examination of the wide range of specimens in the University Collection shows, however, that there have generally been several stages in the process. In most cases the first change was an incrusting of the calcite crystals by the compact "calamine" variety of smithsonite. As a result of this nearly all the pseudomorphs have an outer shell of compact material. The second stage of the process consisted in a partial, and in some cases even a complete, solution of the included calcite crystal. This solution if partial, as was

generally the case, took place along the cleavage cracks parallel to the rhombohedron, thus separating the crystal into partially detached rhombic blocks. Along the channels thus opened the solutions which effected the change found their way and replaced molecule by molecule the residual blocks, the channels remaining unfilled in the completed pseudomorph.

Numerous specimens in the University Collection indicate that the process above described was in some cases varied by the complete solution of the calcite and the failure to refill the cavity. Very beautiful incrustation pseudomorphs have resulted in this way. The majority of the specimens, however, contain residual portions of unaltered calcite, and clearly indicate that in most cases all stages of the process went on simultaneously in different parts of the crystal, the action beginning at the surface immediately under the incrustation of the "calamine" variety.

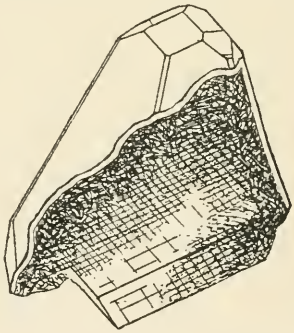


FIG. 4.—SMITHSONITE PSEUDOMORPH AFTER CALCITE, FROM MINERAL POINT.

Such specimens have immediately beneath the incrustation, a layer of the porous "dry bone" retaining the cleavage channels of the calcite. This layer is sharply delimited from the incrustation, but passes insensibly into the layer of porous corroded calcite immediately beneath, which likewise passes by all intermediate phases into the unaffected calcite nearer the center of the crystal. (See figure 4).

The dry bone material of these pseudomorphs is invari-

ably colored ochre yellow by limonite in the pulverulent form, and this material is sometimes found quite pure. Its fine state of subdivision as well as its uniform distribution in the pseudomorphs, makes it probable that its source is the iron of the "black jack" which supplied the zinc to the solutions, as has already been pointed out by Chamberlin.[1] The pseudomorphs of smithsonite after sphalerite which are in the collection are of much less interest, since they have the form simply of plates and spheroidal masses and not of definite crystals of blende.[2]

GALENA FROM YELLOWSTONE, MINERAL POINT, HIGHLAND, GALENA, ETC.

The crystals of Galena from this region are invariably either cubes or a combination of the octahedron and cube. On some specimens from Galena the rhombic dodecahedron occurs as a small truncation of either the cubic or the octahedral edge. The largest crystals come from the Yellowstone Diggings. The Yellowstone crystals are always elongated, either in the direction of a principal axis, which produces an apparently tetragonal combination (see plate 6, fig. 2), or in the direction of a digonal axis, which results in an apparently hexagonal combination (plate 6, fig. 1). The length of these apparently prismatic crystals may be several times their breadth. A crystal of tetragonal habit in the University Collection has a length of over a foot and a breadth and thickness of about four inches. Another crystal with hexagonal habit is about nine inches in length with transverse dimensions of about four inches. The faces of these crystals are considerably rounded from corrosion. The specimens which come from Highland are quite symmetrical cubes with the cubic edge

[1] T. C. Chamberlin. The ore deposits of southwestern Wisconsin. Geology of Wisconsin, Vol. IV, p. 396. (1882.)

[2] Dana states in his system (6th ed.) that pseudomorphs after crystals three inches or so in diameter are found at Mineral Point. None are, however, contained in the University Collection.

often as much as three inches in length. A specimen from Benton presents interesting skeleton growths, which outline the half of an octahedron truncated by a cube. This probably represents one phase of the Galena referred to as *reticulated galena* in the report of the state geologist.[1] The more beautiful feather-like skeleton growths have been figured in that report.

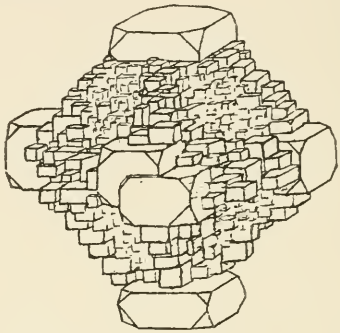


FIG. 5.—AGGREGATE OF GALENA FROM MINERAL POINT.

At Mineral Point have been found large quite symmetrical cubes resembling those found at Highland. On some specimens the faces of the galenas are studded with octahedrons of pyrite which are superficially altered to limonnite. On the crystals of other specimens are found gray cerussite crystals from 5–7 mm. in diameter. Still another series of specimens from Mineral Point presents very beautiful aggregations of sub-individuals on which the octahedron has a large development, forming hopper-faced aggregate individuals of the same habit (see figure 5). The average size of the component individuals is only a few millimeters and they are nearly perfect carbo-octahedrons, but at the ends of each of the principal axes of the aggregate crystal are large crystals with cubic habit, whose cubic face determines the size of the cube face on the aggregate crystal. The aggregate crystals have quite uniformly a diameter of about three to six centimeters and

[1] Chamberlin, Geol. of Wis., Vol. IV. p. 385. (1882.)

the component individuals at the ends of the principal axes a diameter of about one to two centimeters.

On specimens from Highland are found interesting arborescent forms not unlike the forms assumed by native copper (see figure 6). The individual cubes are much elongated in the direction of a principal axis and otherwise distorted, and the arborescent groups of crystals are often attached by the end of a single crystal, so that their resemblance to trees is very striking.

FIG. 6.—ARBORESCENT FORM OF GALENA FROM HIGHLAND.

Polysynthetic twin lamellæ like those described by Cross [1] have been observed on crystals from several of these localities. On crystals from Highland the twinning plane of the lamellæ is the octahedron, which corresponds to the second law mentioned by Cross. The crystals on which the lamellæ are observed, are cubes with small truncation by the octahedron. The faces of the cube are divided along lines parallel to their own edges into four sectors, in each of which pronounced striations run parallel to the adjacent octahedral face. All the cubic faces are affected in the same manner, but the octahedral faces are quite plane. This structure is indicated in plate 6, fig. 7.

Lamellar twinning according to the other law determined by Cross, where the twinning plane is a plane of the dodecahedron, is well shown by crystals from Mineral Point. The appearance of these crystals is shown in plate

[1] Whitman Cross, Note on Slipping Planes and Lamellar Twinning in Galena. Proc Col. Sci. Soc., 2, p. 171-174. (1887).

6, fig. 6, which has been drawn from one of the crystals examined. The top cubic face of this individual is striated in the same manner as the crystals from Highland, but the structure is different on the adjacent faces. Here the course of the lamellæ is parallel to the cleavage lines, showing clearly that the twinning plane is the dodecahedron. On one of these faces a division of the face into sectors is noticed, but in this case the lines of division run parallel to the diagonals of the face. A few of the striations take their course across the direction of the prevailing ones at such an angle as to suggest that they represent a third law of twinning for the mineral such as has been described by Sadebeck,[2] in which the twinning plane is a trisoctahedron. In all cases the sectors into which the striations divide the faces constitute vicinal planes, all of which slope away from the center of the face.*

An exceptionally beautiful instance of the dodecahedral twinning above described is afforded by a large crystal from Yellowstone. This specimen is the broken end of what was apparently one of the elongated crystals with tetragonal habit which are common from this locality. The crystal had a breadth of about five and a thickness of some four centimeters. Figures 3, 4, and 5 of plate 6, represent three parallel sections of this crystal along the cleavage planes, those of figures 4 and 5 being separated by about three centimeters and those of figures 3 and 4 by about a centimeter and a half. The central portion of the

---

[2] Zeitsch. d. D. geol. Gesellsch., Vol. XXVI, p. 631 (1874).

*Note.—That these twin lamellæ have been noticed before on Galena from the upper Mississippi valley, is evident from the following extract from a paper by James T. Hodge entitled, "On the Wisconsin and Missouri Lead Region," which was published in Silliman's Journal in 1842 (Vol. 43, p. 38):

"The smelters think they can distinguish the ores that are found in different fissures—that from an east and west fissure being perfectly crystallized, of a smooth surface, striæ indistinct; that from a north and south fissure, of crystalline structure, with two sets of striæ very distinct, crossing each other at right angles; and the ore from a quartering fissure crystalline, with many sets of striæ crossing each other obliquely; and to some extent I had opportunity of proving their observations correct."

Supposing this idea of the smelters to be correct, it is difficult to account for this difference unless the crystals of galena have a uniform orientation with reference to the walls of the fissure.

crystal is an unstriated nucleus whose former crystal boundaries are indicated by a line of tarnished mineral. The nucleus contains irregular-shaped cavities in which cerussite has crystallized. The striations in the outer portion of the crystal are high ridges near the periphery, but these diminish in prominence as they take their course toward the nucleus, dying out completely before they reach it, and as they do so often taking a sharp curve to a direction which suggests a sudden change to the law of Sadebeck. It is evident that this structure has not been produced by any stress to which the crystal has been subjected since its formation, but it is in some way to be connected with the strains induced in the outer portion of the crystal, as it accommodated itself to the nucleal crystal in growing about this and being oriented by it. Lamellæ have also been observed on crystals from Platteville, Wis.

Some very interesting forms of galena come from Galena, Ill. Many specimens indicate that there have been for the limestone cavities at least two periods in which galena crystallized out, separated by a period when crystallized marcasite was deposited. Cubes of galena, having an edge of three to five centimeters, are found coated with marcasite and studded with numerous nearly perfect octahedrons of galena, having a diameter of about two millimeters. The octahedron is usually absent from the crystals of the first separation of galena though it sometimes appears as a very minute truncation of the solid angles; while the cube, though always very small, is usually present on the octahedral crystals of the later generation.

One crystal in the collection has some interest from its twisted form. It is a simple cube elongated in the direction of a principal axis so that its length is about six inches and its breadth and thickness only about two inches. One end of the crystal is nearly or quite parallel to the other but occupies the position it would have if it had been rotated thirty degrees from its normal position about the long

axis of the crystal. The long faces of the crystal present a nearly perfect warped surface with only a single important interruption near one end.

On closer examination very slight interruptions are noticed at intervals of three or four centimeters, which indicate that the apparent individual is an aggregate of several individuals nearly, though not quite, parallel. Each individual is rotated through a small angle from its nearest neighbors about the axis of the aggregate, the rotation being always in the same direction. But this is not the only attempt which the crystal has made to assume a spiral form, for the faces of the sub-individuals are warped, and though the greater part of the aggregate is coated with marcasite, a cleavage surface is exposed at one point and exhibits the polysynthetic twin lamellæ. It is thus probable that the crystal has been subjected to some force from without which has inclined it to the direction it has taken.

CERUSSITE FROM HIGHLAND, MINERAL POINT, AND GALENA.

This mineral always appears on the surface of Galena crystals where it has doubtless been formed through the action of carbonated waters. The best specimens in the University Collection were found at Highland and Mineral Point. Larger but less perfect crystals are common on specimens from Mineral Point and from Galena, Ill., the latter place being located but a few miles from the state boundary. The Galena to which the Highland cerussite is attached occurs on the hopper-faced octahedrons composed of a great number of sub-individuals, which have been described under Galena (Fig. 5). Two strikingly different types of Cerussite crystals are found upon the same specimens, the one being long columnar in the direction of the brachydiagonal axis, and the other pseudo-hexagonal in habit, from the nearly equal development of pyramid and brachydome. Both types are to be found in

twins according to the common law, the twinning plane a face of the fundamental prism. Stellate forms of the second type are frequently only to be distinguished from the individual crystals by a search for the twinning lines, or by measurement of the angles on the goniometer.

Type 1. Crystals columnar in the direction of the brachydiagonal axis: Crystals of this type usually have a length several times their breadth, and have their habit conditioned by the brachydomes *i* (021) and *x* (012), and the pyramid *p* (111) (see plate 7, fig. 1). They vary from four to eight millimetres in length. The forms observed upon them are the following, *γ* being new to the species:

i, $2\bar{P}\infty$ (021).

x, $\frac{1}{2}\bar{P}\infty$ (012).

γ, $\frac{25}{4}\bar{P}\infty$ (0.25.4).*

p, P (111).

b, $\infty\bar{P}\infty$ (010).

m, ∞P (110).

r, $\infty\bar{P}3$ (130).

The above enumerated forms were determined by means of the following measurements:

	Measured.	Calculated.
$m : m'$, $110 : 1\bar{1}0$	62° 46′	62° 46′
$r : r'$, $130 : 1\bar{3}0$	57 35	57 19
$m : b$, $1\bar{1}0 : 0\bar{1}0$	58 37	58 42
$m : p$, $110 : 111$	35 46	35 46
$i : i'$, $021 : 0\bar{2}1$	69 13	69 20
$x : x'$, $012 : 0\bar{1}2$	39 51	39 45
$b : i'$, $0\bar{1}0 : 0\bar{2}1$	34 31	34 40
$b : \gamma$, $0\bar{1}0 : 0.\overline{25}.4$	12 30½	12 29

The face γ is certainly (0.25.4) and not the known form (061), as the face is a large one and quite perfect. Both γ and b reflect finely, giving single sharp images of the signal. The calculated angle $b : t$ (010 : 061), is 12° 59′, which differs from the value obtained by over 18′, whereas it is impossible that an error of more than a very few minutes should be made in the reading. With the exception of r, which is small and gives only a faint reflection of the signal, all the faces afford excellent readings.

Type 2. Crystals with pseudo-hexagonal habit due to the nearly equal development of the pyramid and brachydome: The individuals of this type (plate 7, fig. 2) are generally larger than the crystals of the first type and have the habit of the crystals from Berezov figured by Dana,[1] but they are more modified. Their habit is conditioned chiefly by the forms p, i, and b. They may be easily confused with stellate twins, which occur with them and from which they can often only be distinguished by a measurement of the angles in the prismatic zone, the angle $m : \underline{m}$ being either 54° 28′ or 62° 46′, while that of $m : b$ is 58° 37′. Most of the crystals are twinned at least once, the twinning line taking usually a somewhat irregular course over the faces and frequently bringing p and i nearly into coincidence. On single individuals the faces are all remarkably perfect and give each a single sharp bright image of the signal. The forms are as follows:

p, P (111).

m, ∞P (110).

a, $\infty\bar{P}\infty$ (100).

b, $\infty\breve{P}\infty$ (010).

i, $2\breve{P}\infty$ (021).

k, $\breve{P}\infty$ (011).

x, $\frac{1}{2}\breve{P}\infty$ (012).

[1] System, 6th ed., p. 287, fig. 8.

The following measurements were made to identify the above forms:

	Measured.	Calculated.
$m : m'$, $110 : 1\bar{1}0$	62° 47′	62° 46′
$m : b$, $110 : 010$	58 36	58 37
$m : a$, $110 : 100$	31 24½	31 23
$m' : a$, $1\bar{1}0 : 100$	31 22½	31 23
$m : p$, $110 : 111$	35 48	35 46
$i : k$, $021 : 011$	19 29	19 28
$i : x$, $021 : 012$	35 28	35 28

On twinned individuals:

$m : \underline{m}$, $110 : \underline{110}$	54 23	54 28

Many of the crystals have their faces studded with numerous small lenticular yellow crystals with much rounded faces, which are probably siderite.

The best cerussites which I have examined from Mineral Point are found, like the Highland crystals, on skeleton octahedrons of galena. Some of the smaller crystals have very sharp faces, and so far as examined they appear to have the same forms and habits as the Highland crystals.

Type 3. Crystals with domal habit. The large gray cerussites which come from Galena and Mineral Point, are less perfect and less highly modified than the types just described. The faces reflect poorly, but the following goniometer readings were made on crystals bounded by the forms *i*, *x*, *m*, and subordinate *p*, this being apparently the usual habit. (See plate 7, figure 3.)

	Measured.	Calculated.
$i : i'$, $021 : 0\bar{2}1$	111° 2′	110° 40′
$x : x'$, $012 : 0\bar{1}2$	40 6	39 51
$m : m'$, $110 : 1\bar{1}0$	62 35	62 46
$p : p$, (with front lens)	50	50 30

These crystals are as frequently simply twinned as the Highland crystals. Their form is represented in plate 7,

fig. 3. An analysis of such crystals on selected material from Galena yielded Mr. R. B. Green the following results:

		Calculated.
PbO	83.42	83.52
CO_2	16.45	16.48
	99.87	100.00

The material was specially examined for zinc with negative results.

SPHALERITE FROM SHULLSBURG, MINERAL POINT, AND GALENA.

Although sphalerite is one of the most common minerals in the crevices of the Galena Limestone, it is usually found in the massive form or in small and imperfect crystals. It usually contains a small amount of iron sulphide, as is indicated by its dark color. I recently collected at the Wisconsin Zinc and Lead Company's mine at Shullsburg, some specimens of this mineral on which the crystal forms can be made out. These sphalerite crystals occur in an elongated roughly cylindrical cavity, which has been formed by the solution and removal of a fossil, probably an orthoceras. The largest crystal is over a centimeter in diameter and is a much distorted simple individual on which are found the following forms:

o, $+\frac{O}{2}$ (111).

o_1, $-\frac{O}{2}$ (1$\bar{1}$1).

d, ∞O (110).

m, $+\frac{3O3}{2}$ (311).

$+\frac{mOn}{2}$ (hkl).

All the faces with the exception of *m* are dull and consequently give no image of the signal. The face *m* is very bright but is rounded through bevelment by a considerable number of hexoctahedrons having large indices. The angle *m* : *m* (over *a*), was measured by reflection and found to be 50° 53′, the theoretical value being 50° 28′. The angle *d* : *d*, (101 : 011) was roughly measured with a hand goniometer as 61°, the calculated angle being 60°. A hexoctahedron which has a development about equal to *m*, and whose faces occur on either side of the *m* face, could not be determined owing to the lustreless character of its faces.

A smaller crystal from the same specimen is bounded by the forms *o* (111) and *d* (110) and is twinned according to the common law for this mineral, the twinning plane a face of *o*. Other specimens from Shullsburg are light wine yellow in color to nearly colorless and transparent.

An analysis by Mr. E. B. Skinner of the darker crystals first described gave the following:

Zn	66.67
S	32.48
Fe	.37
	99.52

Sphalerite also occurs in crystals at Platteville and at Mineral Point, the individuals obtained from the former locality being a centimeter or more in diameter, while those from the latter locality are small though often with tolerably bright faces. The forms *d*, *o*, and *m* were observed upon both. Frequently, however, those found at Mineral Point are coated with a layer of white mineral which is probably smithsonite. Dana[1] states that crystals of this mineral three inches or more in diameter are found altered to smithsonite at Mineral Point. No such specimens are included in the University collection, though spheroidal aggregates of crystals as large as that are not uncommon, and these are sometimes altered to smithsonite. No crystals

[1] System, 6th Ed., p. 62.

of sphalerite much over a centimeter in diameter have been observed by the writer on Wisconsin specimens.

Sphalerite is found in exactly the same association at Galena. These crystals have much the same form, but some have been found on which the faces are much more perfect. They nearly always exhibit one form in addition to those observed on crystals from the other localities.

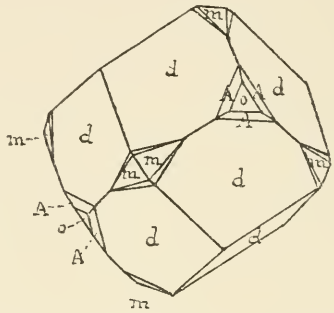


Fig. 7.—Sphalerite from Galena, Ill.

This is the tetragonal tristetrahedron or hemi-trisoctahedron A, $\frac{7}{5}$O (775) which has not, I believe, been before observed on this mineral. On one crystal in particular the faces d, o, and A are very perfect and give excellent reflections of the signal (Fig. 7). On this crystal the following measurements were made:

	Measured.	Calculated.
o : d, 111 : 110	35° 18′	35° 16′
d : A, 110 : 775	26 49	26 48

On the same crystal the faces of the icositetrahedron (probably m) and the hexoctahedron are too much rounded to admit of measurement. On less perfect crystals the face A was measured with results varying 11′ to 12′ from those obtained on the most perfect crystal.

GYPSUM FROM MINERAL POINT.

The specimen about to be described was presented to the University Mineral Collection by a friend, who obtained it from a local collector at Mineral Point. It was supposed to be anglesite by the person who collected it, possibly because it occurs on crystals of galena. The crystals referred to are long columnar in habit, colorless, and perfectly transparent. Their greatest length is 10^{mm}. and their greatest breadth about 2^{mm}. They are attached to small cubes of galena which are covered by a layer of red cryptocrystalline smithsonite. As this is an unusual appearance for the local smithsonite, it was determined to be that mineral by its reacting for zinc on charcoal and being completely soluble with effervescence in hydrochloric acid. The red color of the mineral is superficial, the under portions having the usual gray color.

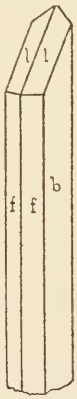


FIG. 8.—SELENITE FROM MINERAL POINT.

The transparent colorless crystals which are attached to the smithsonite and galena, are not anglesite as supposed, but gypsum or selenite. They have the usual habit of gypsum crystals, being bounded by the prism and clinopinacoid and the rounded terminal planes, *l*, (111) and occasionally *e*, ($\bar{1}03$) (see fig. 8). The following measurements

are the average of a number which were made with the reflecting goniometer on several crystals, the rounded character of the faces sometimes introducing errors of as much as 30′:

		Measured.	Calculated.
$m : m$ (front)	$110 : 1\bar{1}0$	68° 49′	68° 30′
$m : m$ (back)	$\bar{1}10 : \bar{1}\bar{1}0$	68 41	68 30
$m : b$ (front)	$\left\{\begin{matrix} 110 : 010 \\ 1\bar{1}0 : 0\bar{1}0 \end{matrix}\right\}$	55 40	55 45
$m : b$ (back)	$\left\{\begin{matrix} \bar{1}10 : 010 \\ \bar{1}\bar{1}0 : 0\bar{1}0 \end{matrix}\right\}$	55 50	55 45

The terminal faces were too much rounded to permit of measurement. The clino-pinacoidal cleavage is almost micaceous in perfection and the pyramidal cleavage (n) is well developed. There was no case of twinning observed. The hardness is 2. Ignited on charcoal in RF the powder of the mineral glows and yields an alkaline residue. Moistened with hydrochloric acid and introduced into the flame of the Bunsen burner it shows the calcium flame. The optical orientation of the mineral was found to agree in every respect with that of gypsum. Since the examination of this mineral was made, Prof. Kremers of this university has shown me a very similar specimen from Mineral Point which was brought to him labelled "anglesite." It is therefore almost certain that the mineral which has been referred to as "anglesite" from Mineral Point in the state reports is really gypsum. These references are always very indefinite, and usually state that the mineral is "reported" or is "said to occur" at the locality. No determination of the supposed anglesite seems to have been made.

BARITE FROM THE LINDEN MINE.

Barite or barytes, as it is called at the mines, has been found massive in considerable abundance at a number of localities in the eastern portion of the mining region. Specimens from Mineral Point, Crow Branch Mine, the Welsh Settlement in Iowa county, and the Linden Mine, are included in the University Collection. The mineral is almost invariably crystalline, as is shown by its cleavage and by the projection of indeterminable crystal edges from its knobby surfaces. Crystals have been reported from Scale's Mound just over the interstate boundary in Illinois. I have not been able to examine any specimens from this locality. A few crystals of the mineral were, however, found attached to one of the faces of the larger twinned crystal of calcite from the Linden Mine, which has already been referred to in this paper. These crystals of barite are represented in plate 7, figure 4. They have a maximum length of about a centimeter and a half, are of a light gray or brown color, and possess a rather unusual habit. They are lath-shaped, approaching acicular, with the direction of principal development the macro-diagonal axis. This fact is easily determined, since the acute angle of the perfect prismatic cleavage is found at the extremities of the crystals. The narrow tabular plane which forms the top of the laths is the basal pinacoid, since it is parallel to the best cleavage. The other planes present are m, ∞P (110) and d, $\frac{1}{2}\bar{P}\infty$ (102). The former can be seen to be parallel to the second cleavage, and the latter has been determined with sufficient accuracy by the following measurement made upon the reflecting goniometer, the face *c* affording a fair and *d* a much blurred image of the signal:

	Measured.	Calculated.
c : *d*, 001 : 101	37° 45′	38° 51′.

Most of the faces are dull and reflect poorly, but poor as the measurements are they are the best that were pos-

sible under the circumstances. Some very imperfect crystals of barite, in part colored brown by oxide of iron, have been collected by Mr. L. S. Cheney from Belmont, Wisconsin.

MARCASITE FROM LINDEN MINE, CROW BRANCH MINE, MINERAL POINT, DIAMOND GROVE, HAZEL GREEN, AND GALENA.

The mineral marcasite is found at many localities in the Galena limestone, and seems to be of much more common occurrence there than pyrite. It appears under a variety of forms. It is sometimes found as a cryptocrystalline to crystalline coating on the surface of galena or blende, and it also occurs in well formed crystals, the University Collection including a good suite of specimens from the several localities These crystals of marcasite show as great variety in habit and combination as the massive and cryptocrystalline varieties show in their shapes. At least seven different types of crystals have been observed on the specimens in the University Collection. These will be described in detail below. Their distribution is indicated in the following list:

Type 1. Linden Mine, Crow Branch Mine, and Mineral Point.
Type 2. Linden Mine.
Type 3. Diamond Grove.
Type 4. Hazel Green.
Type 5. Hazel Green.
Type 6. Galena.
Type 7. Galena.

Type 1. Crystals of this type have a thin tabular habit and are bounded by the forms *c*, 0P (001); m, ∞P (110); *l*, $\breve{P}\infty$ (011), and *v*, $\frac{1}{3}\breve{P}\infty$ (013). (See plate 8, fig. 1.) The base is as usual the plane of tabular development, and the edge *l* : *l* at the extremity of the *b* axis is about as long as the

face m, so that crystals have a hexagonal appearance when observed in the direction of the c axis. The specimen which shows the most perfect crystals of this type is without a label, but it was obtained from the W. T. Henry Collection with material from the Linden Mine, and was probably found at that locality. These crystals have a diameter of 5-8^{mm}. The following measurements were made upon them:

	Measured.	Calculated.
$m : m$, $110 : \bar{1}10$,	75° 22′	74° 55′
$l : l$, $011 : 0\bar{1}1$,	100 5	101 58

The prism m is sometimes beveled for a short distance by a prism which gives a reading of 78° 1′. the reflection of the signal being as sharp and bright as that from m. In one instance also a brachyprism gave a reading of 99° 52′. These two forms would correspond to the symbols of the brachyprisms $\frac{21}{20}\bar{P}\infty$ and $\frac{31}{20}P\infty$, but in view of the wide variations of the angles exhibited by crystals of marcasite, the correctness of these symbols can not be relied upon. The face l furnishes but poor images of the signal and c and v are altogether unsuited to measurement. The greater number of specimens of this type are parallel growths, each individual varying slightly from perfect parallelism with the individuals adjacent. This produces the usual "cockscomb" forms. Twins, with the twinning plane the prism m are quite common, but so far as observed they are composed of but two individuals (plate 8, fig. 1a). On one such twin the angle between adjacent prism faces lying on either side of the twinning plane was measured with the following result:

	Measured.	Calculated.
$m : \underline{m}$, $110 : \underline{110}$,	30° 1′	30° 10′

Pseudomorphs of limonite after marcasite have been found at Mineral Point as well as at other localities. Ex-

cellent specimens from Mineral Point are included in the University Collection.

Type 2. On some specimens from the Linden Mine the marcasite crystals have a lath-shaped habit due to their unusual development in the direction of the $\bar{b}$ axis, the macropinacoid forming the edge of the lath, *c* the fairly broad top, while the brachydomes at the top and bottom and *m* from the vertical faces, produce a slight sharpening of the laths at the ends (plate 8, fig. 2). All the faces are very much curved and can not be measured. It is noticeable that the prism is connected to the macropinacoid by a uniformly curved surface.

Type 3. This type of crystals is common on specimens from Diamond Grove. The crystals are invariably stellate twins, the individuals composing which have a thick tabular habit with *c* small and *l* large, and are but little striated or rounded (plate 8, fig. 3). No simple twins were observed, the groups being apparently cyclic fivelings though the fifth individual is not made out owing to the broad attachment of the twin by one of its edges. The reëntrant angles formed by *m* appear between individuals, but they are very small. The face *c* is striated by oscillatory combination with either *l* or *v*. Unlike the crystals of type 1, which have a brassy lustre, or those of type 2, which have a greenish color, the surface of these individuals has a reddish brown color and an iridescence which is ascribed to incipient alteration to the hydrated oxide. The stellate groups have a diameter of 3–4 ^{mm}. and are attached to greenish marcasite which forms a surface layer over blende, its tabular crystals being oriented normal to the surface of the blende and crowded so closely that only the edges of *l* can be seen.

Type 4. This type represents the simplest combination, the only forms developed being *c* and *m* (plate 8, fig, 4.). The individuals are quite thick so that they have rather the appearance of short prisms with diamond cross sec-

tion, than of tabular plates. Simple twins with twinning plane the prism are common on these specimens. The prism was determined as *m* by the following measurements:

	Measured.	Calculated.
m : *m*, 110 : 110,	105° 2′	105° 5′
On twinned crystals,		
m : $\underline{m}$, 110 : $\underline{110}$,	30° 34′	30° 10′

The face *c* is striated parallel to the brachydiagonal axis, which causes a slight rounding of the face near the edge 110 : $\bar{1}10$. The color of this type of crystals is brown. Parallel growths of a simple character produce the "cockscomb" aggregates.

Type 5. The second type of crystals from Hazel Green (plate 8, fig. 5) is quite different from the first, but almost identical with a marcasite from Schemnitz which is figured by Dana.[1] These crystals have a diameter of 4–5 mm. and are quite symmetrically developed. They are bounded by the following forms:

m, ∞P	(110).
l, $\breve{P}\infty$	(011).
e, $\bar{P}\infty$	(101).
s, P	(111).
x, m$\breve{P}\infty$	(01h).

The faces are bright with a brassy lustre and in most cases reflect but a single image of the signal, so that the probable error of reading is very small. Notwithstanding this fact the measurements of corresponding angles not only vary much from the values determined by Sadebeck for this mineral but they vary much from one another. This variation must therefore be explained by actual variations in the angles themselves, though the faces do not

[1] System, 6th Ed., p. 95, fig. 2.

show vicinal planes, and with the exception of *l* and *x* are not striated. The variation in the angles of marcasite is well known and the values obtained by Sadebeck are not supposed to be very accurate. The measurements made on the crystals from Hazel Green are as follows, the general correctness of the average determination being confirmed by the zone relations:

		Measured.		Calculated.
s : *s* (over *l*)	111 : $\bar{1}11$	88° 57′		90° 48′
s : *s* (over *e*)	111 : $1\bar{1}1$	65 35		66 7
s : *s* (over *m*)	111 : $11\bar{1}$	56 7		52 28
l : *l*,	011 : $0\bar{1}1$	99 56 99 13 102 9	100° 26′	101 58
e : *e*,	101 : $\bar{1}01$	113 48 112 30 112 3	112 47	116 20
l : *x*,	011 : $0\bar{1}h$	54 16 54 25		
x : *l*′,	$0\bar{1}h$: $0\bar{1}1$	44 38 44 48		

Beside the form *x*, which occurs with only half its planes on these crystals, the edge *ll*′ is occupied by a large number of indeterminate brachydomes, so that the edges *lx* and *xl*′ are well rounded. If the readings *lx* and *l*′*x* could be relied upon the form *x* would have the symbol $\frac{1}{14}\breve{P}\infty$, and it is in any case a very flat dome. That it is not the basal pinacoid, which occurs on the Schemnitz crystals, is apparent even by examination with the naked eye. A number of simple twins and several polysynthetic trillings were observed on these specimens (plate 8, fig. 5a). The twinning plane is shown to be *m*, the unit prism, by the twinning line following the edge *le* and then traversing the face *m* parallel to the edge *mm*. Trillings are easily determined from the zigzag forms assumed by the *x* plane.

Type 6. The crystals of marcasite from Galena which are in the University Collection bear most resemblance to the crystals of type 5 from Hazel Green. One variety has a distinctly prismatic habit conditioned by the large development of the prism *m*, the nearly equal development of the domes *l* and *e*, and the absence of the base *c*, the dome *x*, and the pyramid *s*. Crystals of this type are built up of a large number of sub-individuals and are nearly always twinned with a face of *m* the twinning plane (plate 8, fig. 6.). Such twins are either simple twins or polysynthetic trillings, in which latter case the middle individual is quite thin. A trilling is easily distinguished from a simple twin by the striations on the *l* faces. In a simple twin the larger striated *l* faces are adjacent, and opposite to a pair of adjacent and glistening *e* faces (plate 8, fig. 6b.). In a trilling two *e* faces appear opposite one another as in a simple individual (plate 8, fig. 6a), and the only evidence that the crystal is twinned may be the reentrant angle along the edge *le* and on the face *m*. Although a majority of the crystals are composed of small sub-individuals which appear as projections on the faces of the aggregate crystal, many of the composite individuals are terminated by one large simply twinned crystal. On such a twinned individual the following measurements were made:

	Measured.	Calculated.
$l : e$, 011 : 101	68° 18′	70° 49′
$e : \underline{e}$, 101 : $\underline{101}$	54 57	56 34
$l : \underline{l}$, 011 : $\underline{011}$	84 36	85 4

A specimen of marcasite collected at Galena by Mr. L. S. Cheney has a somewhat different development. The fundamental prism is large, giving the crystals their columnar form, while v, $\frac{1}{3}\breve{P}\infty$ and subordinate l, $\breve{P}\infty$ serve as terminal planes. These crystals are in part attached to larger octahedrons of pyrite.*

* NOTE.—Some quite interesting arborescent aggregates of marcasite crystals were collected by Mr. Cheney at Cuba City, Wis. These were received too late for study in connection with the other specimens of this mineral which are here described.

Type 7. Another variety of the Galena marcasite crystals resembles type 5 more closely, though *s* and *m* are both very small. They are frequently attached by one of the dome faces so that an opportunity is given for the development of dome faces at both ends of the crystals. The result is a mimicry of the octahedron, so that these crystals might be taken for octahedral pyrite having small truncations by the cube (plate 8, fig. 7). On some specimens radial groupings of such crystals produce aggregates having a diameter of about two centimeters, on which particularly large crystals or groups of crystals project at points corresponding to the ends of the crystallographic axes, and make the groups somewhat resemble hollow-faced octahedrons.

Dana[1] has figured a crystal from Galena which has a tabular habit, is bounded by the forms *l*, *v*, *c*, *b*, *m*, *e*, and *s*, and is twinned according to *m*.

PYRITE FROM SHULLSBURG AND MINERAL POINT.

Pyrite, like marcasite, is a common mineral in the crevices of the Galena Limestone. Well crystallized specimens would not, however, seem to be very common. During a recent visit to the Wisconsin Zinc and Lead Company's mine at Shullsburg, I picked up a specimen of limestone having a small cavity lined with pyrite crystals. Some of the individuals have a diameter of two to three millimeters, but the better crystals are seldom much over a millimeter in diameter. They are usually combinations of the common pentagonal dodecahedron (210) with the cube and octahedron, and are but little distorted. Their habit is generally conditioned by the pyritohedron, which is generously truncated by the cube and octahedron (plate 8, fig. 8). In a few cases the pyritohedron is but little developed, the form of the crystals being given by the cube. The faces

[1] System, 6th Ed., p. 95, fig. 4.

are bright but have a purplish iridescence due to incipient alteration. The pyritohedron was determined with sufficient accuracy as the common form e, $\frac{\infty O 2}{2}$ (210) by measuring the edge A on the reflecting goniometer, the result obtained being 52° 32′, and the calculated value 53° 8′.

Pyrite occurs at Mineral Point in cubes apparently unmodified and as much as three-quarters of a centimeter on an edge. Associated with these symmetrically developed cubes are interesting groups composed of long columnar individuals arranged radially about a centre located a little below the point of attachment (plate 8, fig. 9.). These crystals have a length of a centimeter or a little less, and a thickness of a little more than a millimeter. They are cubes developed in the direction of one of the principal axes. The individuals composing the group do not come in contact, except perhaps at the point of attachment. Other specimens from this locality are similar in character but of much larger dimensions, the pyrite needles having a length of several inches and a diameter of only a few millimeters. The space between the pyrite needles is occupied by crystallized sphalerite, which is in part coated with smithsonite. The large radial sheaves of iron sulphide which occur at Galena are for the most part pyrite.

A perfect unmodified octahedron of pyrite a half centimeter along the axes was collected by Mr. Cheney at Democrat, near Etna, Wis.

AZURITE FROM MINERAL POINT.

Both the carbonates of copper are found at Mineral Point attached to massive chalcopyrite, where they have doubtless been formed through the action of carbonated waters. The azurite is quite well crystallized, but the individuals are rarely over $2^{mm.}$ long. In a few specimens they attain dimensions of $3\text{-}4^{mm}$ The crystals have either a domal habit with the ortho-diagonal the axis of great-

est development, or a thick tabular habit with the basal pinacoid the tabular face. Crystals of the first mentioned variety possess about the proportions given by Farrington for the crystals of lath-like habit from Arizona.[1] Different crystals show considerable variation in the occurrence of forms as well as in the relative development of those which occur.

Three crystals have been completely measured, the first two being lath-shaped, but representing different combinations, and the third tabular. In all, ten forms have been determined, four of which are new to the species.

On crystal I the prominent faces in the zone of the axis $\bar{b}$ are the basal pinacoid, the negative unit orthodome (σ), and the new form $\frac{2}{5}\bar{P}\infty$ (205); and the crystal is terminated by a single plane of e, $\frac{4}{5}\grave{P}2$ ($\bar{2}$ 4 5). (See plate 7, fig. 6.) The habit of crystal II is conditioned chiefly by the same forms as crystal I, with the addition of the new form $\frac{2}{3}\bar{P}\infty$ ($\bar{2}03$) in the zone of $\bar{b}$; and though both e and the new form $\mathfrak{d}$, $-\frac{3}{2}\grave{P}\frac{4}{3}$ (9.12.8), are represented as terminal planes, the former is much the larger, and one of its faces is large and the other comparatively small (plate 7, fig. 7.).

On crystal III the terminal forms occur with their full complement of faces, which have nearly equal development (plate 7, fig. 8.). In addition there occurs on this crystal a small positive hemi-brachypyramid, which has larger parameters on both $\dot{c}$ and $\dot{a}$ than has the form e. This pyramid is not far removed from the zone of $\bar{2}45$ and $24\bar{5}$, but it could not be accurately determined. An indeterminate negative pyramid with much rounded faces and quite small development, is also found on the crystal. This crystal has as the largest faces in the principal zone, the tabular basal pinacoid, the form θ, $\bar{P}\infty$ ($\bar{1}01$) and the new form $\mathfrak{c}$, $-\frac{3}{7}\bar{P}\infty$ (307). The only forms which are found

[1] O. C. Farrington, On Crystallized Azurite from Arizona. Amer. Jour. Sci. (3) XLI, p. 300. (1891).

on all of the three crystals are *c*, *σ*, *e*, and *a*. The new forms lying in the principal zone were easily determined from their angles with the basal pinacoid. The forms *e* and *ɓ* were determined, the former from its angle with *c* and with 010 (one-half the angle *e* : *e* over the end of the $\bar{b}$ axis), the latter from its angle with *c* and with both *e* and *ɓ*.

The forms observed on the three crystals are given below, those that are new to the species being marked by an asterisk:

Forms.			*Crystals.*		
c,	0P	(001)	I	II	III
a,	$\infty\bar{P}\infty$	(100)	I	II	III
σ,	$-\bar{P}\infty$	(101)	I	II	III
ɕ,	$-\frac{3}{7}\bar{P}\infty$	(307)*			III
θ,	$\bar{P}\infty$	($\bar{1}$01)	I		III
ɓ,	$\frac{2}{3}\bar{P}\infty$	($\bar{2}$03)*		II	
n,	$\frac{1}{2}\bar{P}\infty$	($\bar{1}$02)		II	
ɑ,	$\frac{2}{5}\bar{P}\infty$	($\bar{2}$05)*	I	II	
e,	$\frac{4}{5}P\grave{2}$	(245)	I	II	III
ɓ,	$-\frac{3}{2}P\grave{\frac{4}{3}}$	(9.12.8)*		II	III

The average of several measurements of the interfacial angles of the planes of the above forms are given below. The reflections from the pyramid faces are fairly good, but in the principal zone the measurement is made difficult by striation, particularly on the faces *θ*, *ɑ*, and *n*, and by a curvature, or better warping, apparently caused by the intergrowth of nearly parallel individuals. This explains the considerable variation between the readings of angles and their calculated values, as indicated in the parallel columns of the following table.

		Measured.	Calculated.
c : θ,	001 : $\bar{1}01$	46° 12′	47° 12′
c : a,	001 : 100	88 5	87 37
c : σ,	001 : 101	44 23	44 44
c : $\mathfrak{c}$,	001 : 307	22 44	22 49
c : $\mathfrak{a}$,	001 : $\bar{2}05$	22 21	22 53
c : $\mathfrak{b}$,	001 : $\bar{2}03$	35 45	35 21
c : n,	001 : $\bar{1}02$	26 42	27 52
a : σ,	100 : 101	43 15	42 50
$\mathfrak{d}$: $\mathfrak{d}$,	9.12.8 : $\bar{9}.12.\bar{8}$	98 3	99 48
$\mathfrak{d}$: e,	9.12.8 : $\bar{2}45$	53 21	53 6
$\mathfrak{d}$: c,	9.12.8 : 001	58 4	59 12
$\mathfrak{d}$: σ,	9.12.8 : 101	40 35	
e : e,	$\bar{2}45$: 245	113 30	113 6

The crystals are translucent with the beautiful azure blue color characteristic of this mineral. They are sometimes coated with a thin film of green malachite.

MALACHITE FROM MINERAL POINT.

This mineral is found as a superficial alteration product of chalcopyrite. Some very beautiful radial and sheaf-like forms are to be seen in specimens in the University Collection. Some very minute crystals having a maximum length of only about three-tenths of a millimeter, when examined under low powers of the microscope appear as columnar crystals much flattened in the plane of the ortho-pinacoid (plate 7, fig. 5). This face is so much broader than the others that the crystals invariably rest upon it and consequently always exhibit parallel extinction. They are in all cases bounded very sharply by the forms a, $\infty\bar{P}\infty$ (100); m, ∞P (110); c, $0P$ (001); and b, $\infty\bar{P}\infty$ (010); the latter plane being very small and recognized only when the crystal is

adjusted on the goniometer. Owing to the minute size of the crystals, the face *a* is the only one which furnishes even a fair image of the signal. The angle *a* : *m* was roughly measured twice, using the front lens of the telescope, and found to be about 39°, the usual value given being 37° 50′.

THE DRUSE MINERALS OF THE HAMILTON CEMENT ROCK AT MILWAUKEE.

Calcite.—The Hamilton cement rock which occurs at Milwaukee carries cavities in which good crystals of calcite[1] may be found. A number of specimens have been collected by Professor Edward Kremers, the head of the School of Pharmacy of the University, and generously presented to the University Mineral Collection. I am therefore largely indebted to him for the material which is here described. The crystals are translucent and either colorless or yellowish.

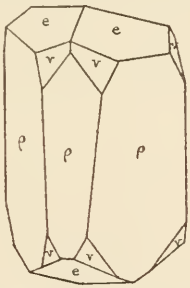


Fig. 9.—Calcite from Milwaukee.

They vary in length from 8–12$^{mm.}$, and in diameter from 3–5$^{mm.}$ Their habit is short columnar, conditioned by the combination of a steep positive rhombohedron and $-\frac{1}{2}$ R $(01\bar{1}2)$ (see figure 9). The former is much rounded but can be approximately determined to be 18 R by measurement of the convergence of the long sides of its faces. One crystal in the collection was attached by this face and is doubly

[1] The occurrence of calcite, pyrite, and rarely also sphalerite in the cavities of the cement rock has been mentioned by Chamberlin (Geology of Wisconsin, Vol. II, p. 395, 1878).

terminated. The common scalenohedron R_3, $(21\bar{3}1)$ sometimes appears as a replacement of the solid angle formed by two faces of $-\frac{1}{2}$ R and one of 18 R. The forms observed are therefore

ρ, 18R $(18.0.\overline{18}.1)$

e, $-\frac{1}{2}$R $(01\bar{1}2)$

v, R_3 $(21\bar{3}1)$

the two latter having been determined by the following measurements:

		Measured.	Calculated.
$e : e$,	$01\bar{1}2 : 1\bar{1}02$	44° 35′	45° 3′
$v : v$, (Y),	$3\bar{1}21 : 21\bar{3}1$	36 29	35 36

The faces are all somewhat rounded, particularly the faces ρ and v. One specimen in the collection shows a larger wine yellow calcite which is a parallel growth of several simple rhombohedrons, about which and on which the colorless crystals with habit ρe have formed. This larger crystal is thus shown to belong to an older generation.

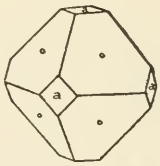


FIG. 10.—PYRITE FROM MILWAUKEE.

Pyrite.—The cavities in the Milwaukee Cement Rock which contain the calcite crystals just described, are often coated with pyrite, so that the calcite is formed on the pyrite. The pyrite appears in good crystals having a diameter of 1–2$^{mm.}$ and is bounded by the octahedron and cube. The habit is octahedral, the cube usually having a small though a quite constant development (Fig. 10.).

Sphalerite.—This mineral would seem to be much less abundant in the cavities of the cement rock than either calcite or pyrite. Only one specimen out of quite a num-

ber supplied the writer by Dr. Kremers included any crystals of sphalerite, and these were few and small. These crystals were twinned according to the common law, as a result of which they were flattened parallel to a face of the tetrahedon. The faces are not bright enough for measurement, but the forms $\frac{O}{2}$ (111), ∞O (101), an icositetrahedron, and a hexoctahedron, can be made out upon them.

As is frequently observed on this mineral, the faces of the tetrahedron show triangular markings. The faces of the icositetrahedron truncate the edges of the hexoctahedron, so that it is very probable that the icositetrahedron is 2O2 and the hexoctahedron $3O\frac{3}{2}$. In order to determine with certainty, however, it would be necessary to secure much better material.

Marcasite.—While this paper was in the printer's hands, I had an opportunity to visit the Milwaukee cement quarries and collect there specimens of marcasite and celestite. I also had an opportunity to make a hasty examination of the valuable mineral collection owned by Howard Green, Esq., in which are contained very beautiful millerite crystals from the cement works. So far as I know, none of these minerals have been reported from the locality.

The marcasite is found in very well formed, brightly iridescent crystals of lath-like habit, with the axis of development the brachy-diagonal. The largest crystals found had a length of only a few millimetres. The forms developed are apparently *c*, *v*, and *m*, with other smaller faces. They have not yet been carefully studied.

Celestite.—This mineral occurs in masses as large as a man's head composed of inter-grown crystals, the individuals of which are sometimes several inches in length. These masses are found in the layer of rock immediately underlying the one quarried for cement. The crystals seem quite pure and have a white color with irregular areas of pale celestial blue. A qualitative determination

was made to identify the mineral. The powder of the mineral moistened with hydrochloric acid yields in the Bunsen flame the intense red color of strontium. Heated on charcoal in the reducing flame of the blowpipe the mineral glows, and if fused with soda and placed upon moistened silver, gives a deep stain of silver sulphide.

Millerite.—Very beautiful specimens of millerite from the cement quarries are contained in the collection of Mr. Howard Green of Milwaukee. I have not yet found an opportunity to carefully examine them.

DIAMONDS FROM THE DRIFT.

Three large diamonds and a number of smaller ones have been found in the glacial drift of Wisconsin. There is also a report of three other diamonds, one of them as large as a robin's egg, which were found and subsequently lost, their real character not being known. It is not improbable that the report is correct, but there is not sufficient evidence to prove it. The large diamonds have all been found in the "kettle moraine" outlining the Green Bay lobe of the ice sheet, though the localities at which the finds were made are somewhat widely separated. Several small diamonds have been found in the bed of Plum Creek, Rock Elm township, in Pierce county. The report on the Pierce county diamonds has been made by Mr. George F. Kunz.[1] The writer has elsewhere[2] described the latest find at Oregon in Dane county, and recorded facts furnished by Col. S. B. Boynton of Chicago, concerning the finding of the Eagle and Kohlsville diamonds. In the paper referred to, the writer has also shown that the probable source of the diamonds found in the Green Bay lobe of the "kettle

[1] On the Occurrence of Diamonds in Wisconsin. Bull. Geol. Soc. Am., Vol. 2, p. 638. (1891.)

Cf. also Min. Res. of U. S., 1889-90, p. 446. (1892.)

[2] On a recent Diamond Find in Wisconsin and on the Probable Source of this and other Wisconsin Diamonds. Am. Geol., Vol. XIV, p. 31-35. (1894.)

moraine, is the region about the Menominee river in the northeast portion of the state. At the time that paper was written the Kohlsville stone had not been given an examination, but the writer has since had an opportunity to examine it and has found it to very closely resemble the other large diamonds found at Eagle and Oregon, so that the theory that the diamonds found in the kettle moraine have a common source, is thereby supported.

Below are given in tabular form the most important facts concerning the recorded diamonds from Wisconsin.

Where and how found and by whom owned.	Date of Finding.	Date of Determination.	Weight in Carats.	Crystal Form.	Color.
Eagle Diamond.					
Found by a laborer employed by Mrs. Clarissa Wood, on farm owned (1876) by Dr. Tucker and located in the town of Eagle, Waukesha county. Owned by Tiffany & Co.	1876	1883	16	Dodecahedron.	Wine Yellow.
Oregon Diamond.					
Found by a small son of Charles Devine on farm of Judson Devine in the town of Oregon, Dane county. Owned by Tiffany & Co.	1893	1893	$32\frac{7}{32}$	"	Nearly White.
Kohlsville Diamond.					
Found by a farmer, Louis Endlich, while rolling a field on his farm at Kohlsville, Washington county. Owned by his widow, who now resides at Kewaskum, Washington county.	1886	1894	21¼	"	Wine Yellow.
Pierce County Diamonds.					
Found by G. H. Nichols and party while prospecting for gold in the bed of Plum creek, Rock Elm township, Pierce county. Several of the stones owned by Tiffany & Co.	1887, 1888 and 1889	1891	Several stones, the largest $\frac{25}{32}$, $\frac{7}{16}$, $\frac{3}{32}$	Hexoctahedron.	White or Yellow.

It seems at first a little surprising that the Eagle and Kohlsville diamonds should not have been earlier identified, but it must be borne in mind that simple as is the determination of this gem, it is rare to find anyone not a professional mineralogist who would think to apply the

test of hardness. Experience seems to show that the average jeweler is as ignorant of the properties of the common gems as is the farmer. Most people can with little trouble have the use of either an emery wheel or a little coarse emery, and since diamond is the only natural mineral which can not be scratched by emery, no one need be without the means of determining at once whether a rough stone is diamond.

EXPLANATION OF PLATES.

PLATE 4.

Crystals of calcite from southern Wisconsin,

Fig. 1. Crystal of type 1 bounded by R_3 and R and having much rounded angles. *Fig. 2a.* Crystal of type 2a bounded by R_3 alone. *Fig. 2b.* Crystal of type 2b bounded by $-\frac{1}{2}R$ and R. *Fig. 3.* Crystal of the somewhat modified type 3. Excluding the small scalenohedrons which bevel the edge *re* this crystal exhibits the following forms: r, R; e, $-\frac{1}{2}R$; v, R_3; **a**, $-\frac{11}{20}R$; **b**, $-\frac{18}{25}R$; f, $-2R$; **c**, 24R; δ, 10R, k, $\frac{5}{2}R$. *Fig. 4.* Crystal of type 4 which has the same modification as type 3 but has rhombohedral instead of scalenohedral habit. *Fig. 5.* Twinned crystal from the Linden mine with twinning plane the basal pinacoid. The forms developed are R, R_3, $-\frac{1}{2}R$, and 0P. One of the individuals has received a secondary growth of darker and yellow green calcite, which tends to give symmetry of development to the twin. *Fig. 6.* Crystal of type 6 bounded by the forms 24R, R_3, $-\frac{1}{2}$ R, and $\frac{5}{2}R$.

PLATE 5.

Calcite from southern Wisconsin.

Fig. 1. Parallel growth of calcites of types 1, 2a, 3, and 4.

Fig. 2. Stereographic projection of forms observed on calcites from southern Wisconsin.

PLATE 6.

Galena from southern Wisconsin.

Fig 1. Large crystal from Yellowstone having an apparently hexagonal symmetry from development in the direction of a digonal axis.

Fig. 5. Crystal from Yellowstone having apparently tetragonal symmetry from development in the direction of a principal axis. *Figs. 3, 4, 5.* Sections across a crystal of Galena from Yellowstone in the direction of the cleavage. These sections show an interior core which is outlined by a line of tarnish and includes irregularly shaped cavities. This core is surrounded by a later growth which is polysynthetically twinned with the twinning plane the rhombic dodecahedron. *Fig. 6.* Crystal of Galena from Mineral Point showing polysynthetic twin lamellæ with the twinning plane the rhombic dodecahedron. *Fig. 7.* Crystal of Galena from Highland showing polysynthetic twin lamellæ with the twinning plane the octahedron.

PLATE 7.

Crystals of cerussite, barite, malachite, and azurite from southern Wisconsin.

Fig. 1. Crystal of cerussite of type 1 from Highland. The forms present are: *i*, $2\breve{P}\infty$; *x*, $\frac{1}{2}\breve{P}\infty$; *y* $\frac{25}{4}\breve{P}\infty$*; *p*, P; *b*, $\infty\bar{P}\infty$; *m*, ∞P; and *r*, $\infty\breve{P}3$. *Fig. 2.* Crystal of cerussite of type 2 from Highland. The forms present are: *p*, P; *m*, ∞P; *a*, $\infty\bar{P}\infty$; *b*, $\infty\breve{P}\infty$; *i*, $2\bar{P}\infty$; *k*, $\breve{P}\infty$; and *x*, $\frac{1}{2}\breve{P}\infty$. *Fig. 3.* Twinned crystal of cerussite of type 3 with the twinning plane the fundamental prism. The types present are: *i*, $2\bar{P}\infty$; *x*, $\frac{1}{2}\breve{P}\infty$; *m*, ∞P; and *p*, P. *Fig. 4.* Crystal of barite from the Linden mine, bounded by the forms *c*, 0P; *m*, ∞P; and *d*, $\frac{1}{2}\bar{P}\infty$. *Fig. 5.* Crystal of Malachite from Mineral Point. *Figs. 6 and 7.* Crystals of Azurite of domal habit. *Fig 8.* Crystal of azurite of thick tabular habit. The forms present on these azurite crystals are: *c*, 0P; *a*, $\infty\bar{P}\infty$; *σ*, $-\bar{P}\infty$; ɕ, $-\frac{3}{7}\bar{P}\infty$*; *o*, $\bar{P}\infty$; ɓ, $\frac{3}{8}\bar{P}\infty$*; *n*, $\frac{1}{2}\bar{P}\infty$; ɑ, $\frac{2}{5}\bar{P}\infty$*, *e*, $\frac{4}{5}P\grave{2}$; and ɔ, $-\frac{3}{2}P\grave{\frac{1}{3}}$*.

PLATE 8.

Crystals of marcasite and pyrite from southern Wisconsin and Galena, Illinois.

Fig. 1. Crystals of marcasite of type 1 which has thin tabular habit and is bounded by the planes; 0P, ∞P, and $\breve{P}\infty$. *Fig. 1a.* Orthographic projection on basal pinacoid of twinned crystal of type 1. *Fig. 2.* Lath-shaped crystal of marcasite of type 2 bounded by the forms 0P, $\infty\bar{P}\infty$, $\breve{P}\infty$, and ∞P. *Fig. 3.* Stellate twin (cyclic fiveling) of marcasite, constituting type 3. *Fig. 4.* Crystal of marcasite of type 4, bounded only by ∞P and 0P. *Fig. 5.* Crystal of marcasite of type 5 possessing pseudo-

isometric habit, bounded by the forms $\breve{P}\infty$, $\bar{P}\infty$, ∞P, P, and $m\breve{P}\infty$. *Fig. 5a.* Orthographic projection of a polysynthetic trilling of marcasite of type 5 on the basal pinacoid. *Fig. 6.* Twinned parallel growth of marcasite of type 6 bounded by the forms ∞P, $\breve{P}\infty$, and $\bar{P}\infty$. *Fig. 6a.* Orthographic projection of marcasite trilling of type 6 on the basal pinacoid. *Fig. 6b.* Similar projection of simple twin of same type of marcasite. *Fig. 7.* Crystal of marcasite of pseudo-octahedral habit (type 7) bounded by the forms $\breve{P}\infty$, $\bar{P}\infty$, 0P, ∞P, and P. *Fig. 8.* Crystal of pyrite from Shullsburg. *Fig. 9.* Pyrite aggregate from Mineral Point.

Mineralogical Petrographical Laboratory,
University of Wisconsin.

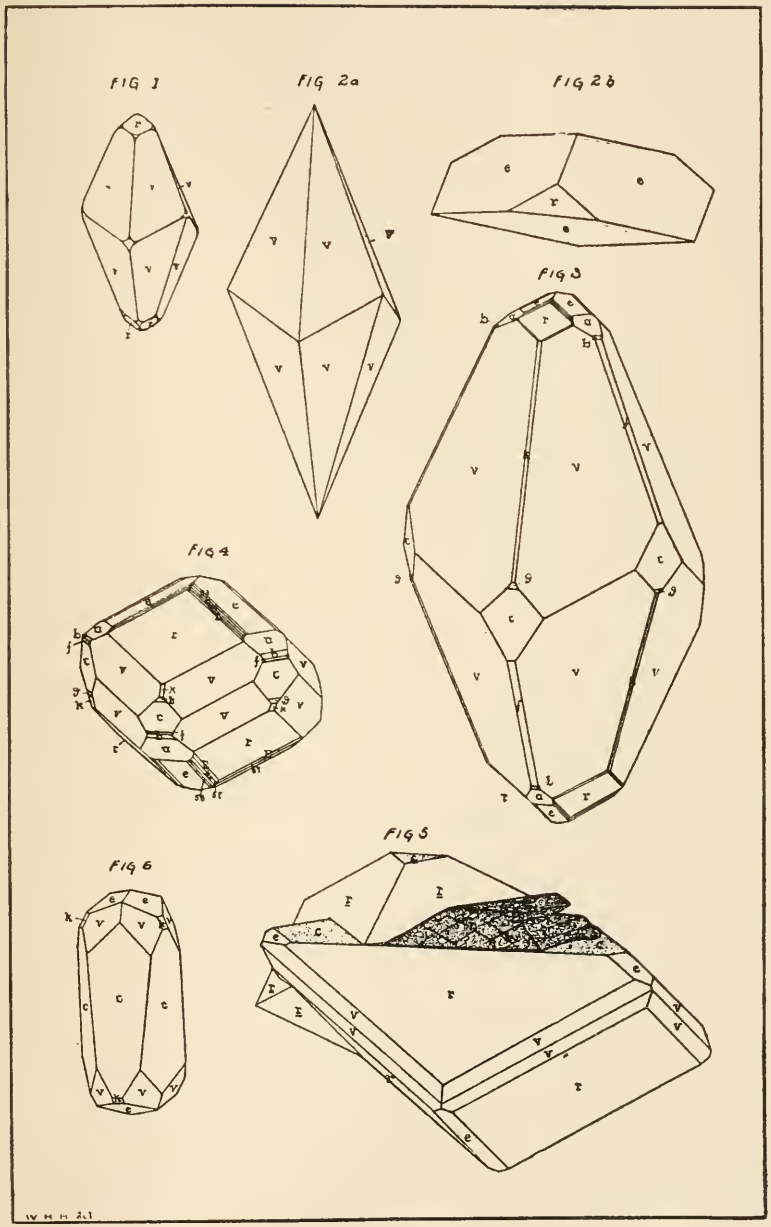


FIG 1
FIG 2a
FIG 2b
FIG 3
FIG 4
FIG 5
FIG 6

FIG 1

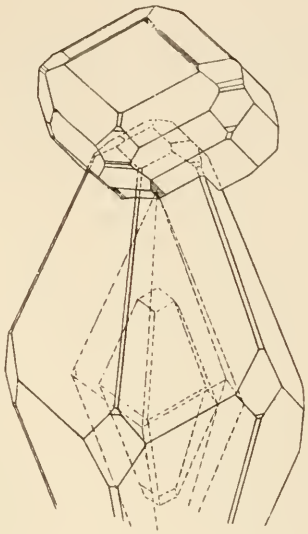
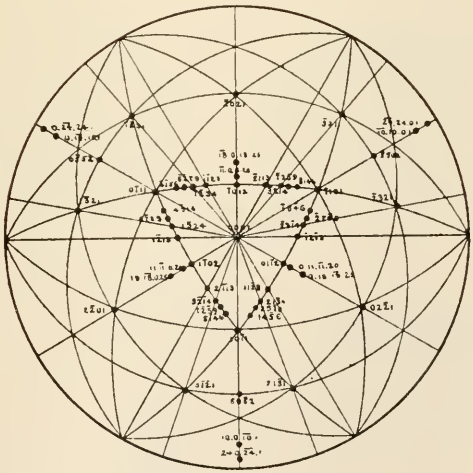


FIG 2



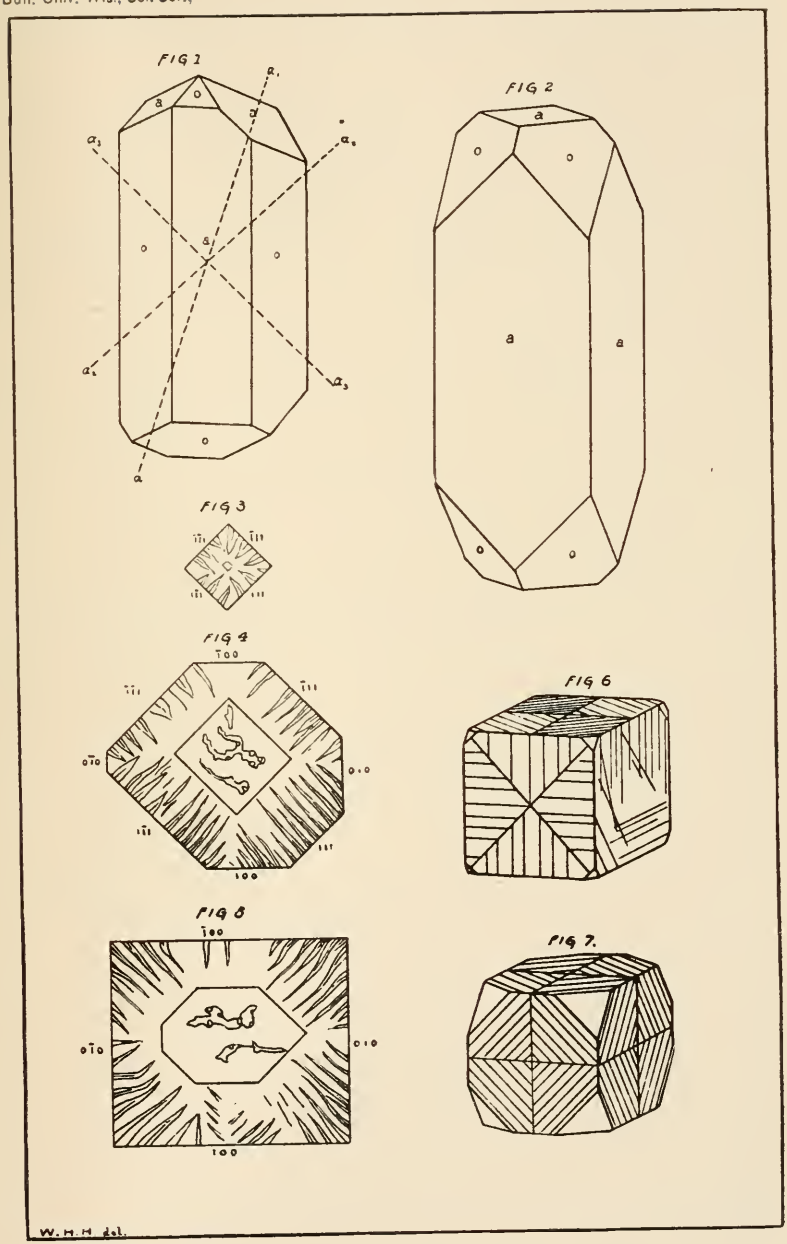


FIG 1
FIG 2
FIG 3
FIG 4
FIG 5
FIG 6
FIG 7.
W. H. H del.

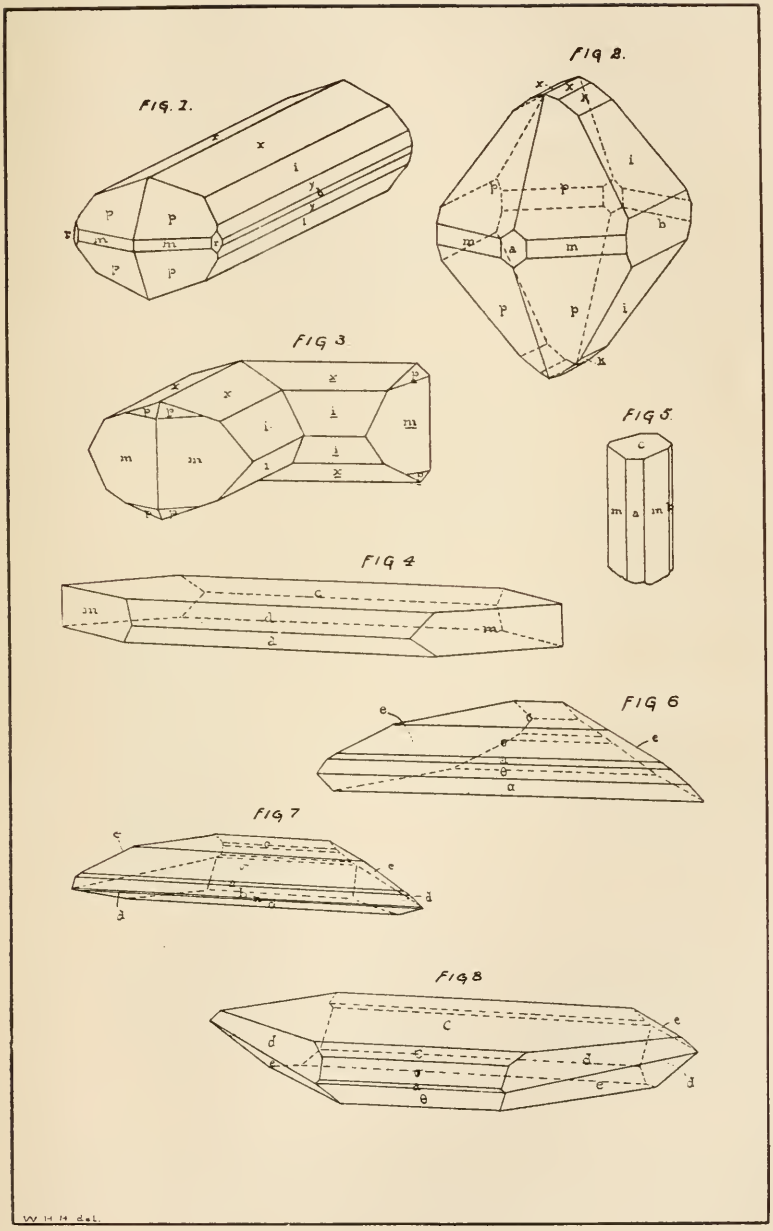


FIG. 2.
FIG 3
FIG 4
FIG 5
FIG 6
FIG 7
FIG 8
W H H del.

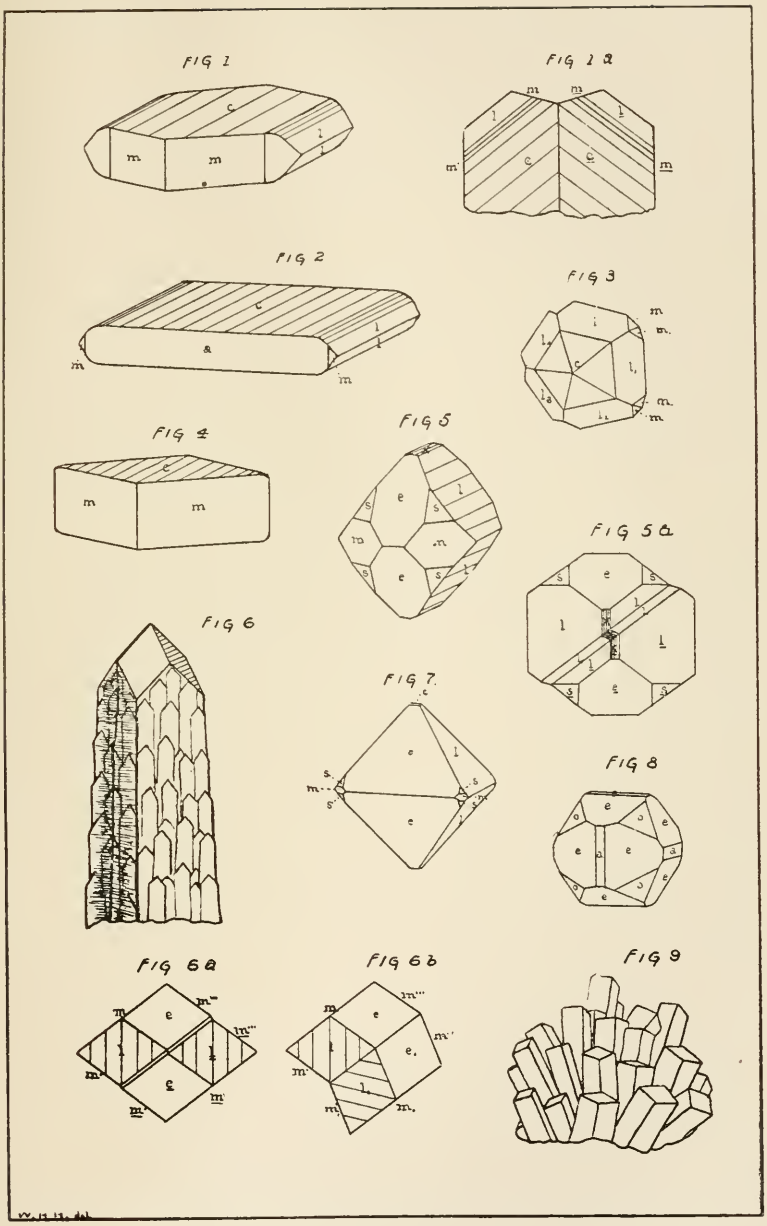


FIG 1
FIG 1 a
FIG 2
FIG 3
FIG 4
FIG 5
FIG 5 a
FIG 6
FIG 7
FIG 8
FIG 6 a
FIG 6 b
FIG 9

BULLETIN OF THE UNIVERSITY OF WISCONSIN.

SCIENCE SERIES, Volume 1:

No. 1. On the Speed of Liberation of Iodine in Solutions of Hydrochloric Acid, Potassium Chlorate, and Potassium Iodide, by Herman Schlundt, Assistant in Chemistry. Pp. 33, December, 1894. Price 35 cents.

No. 2. On the Quartz Keratophyre and Associated Rocks of the North Range of the Baraboo Bluffs, by Samuel Weidman. Pp. 21, pls. 3, January, 1895. Price 25 cents.

No. 3. Studies in Spherical and Practical Astronomy, by George C. Comstock, Director of the Washburn Observatory. Pp. 50, June, 1895. Price 40 cents.

No. 4. A Contribution to the Mineralogy of Wisconsin, by William Herbert Hobbs, Assistant Professor of Mineralogy and Petrology. Pp. 48, pls. 5, June, 1895. Price, 40 cents.

ECONOMICS, POLITICAL SCIENCE, AND HISTORY SERIES, Volume 1:

No. 1. The Geographical Distribution of the Vote of the Thirteen States on the Federal Constitution, 1787-8, by Orin Grant Libby, A. M., Fellow in History, with an introduction by Frederick J. Turner. Pp. 116, pls. 2, July, 1894. Price 75 cents.

No. 2. The Finances of the United States from 1775 to 1789, with Especial Reference to the Budget, by Charles J. Bullock, A. B., Fellow in Economics. Pp. 157, June, 1895. Price 75 cents.

ENGINEERING SERIES, Volume 1:

No. 1. Track, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 24, April, 1894. Price 25 cents.

No. 2. Some Practical Hints in Dynamo Design, by Gilbert Wilkes, M. Am. Inst. E. E., Special University Lecturer. Pp. 16, May, 1894, Price 25 cents.

No. 3. The Steel Construction of Buildings, by C. T. Purdy, C. E., Special University Lecturer. Pp. 27, October, 1894. Price 25 cents.

No. 4. The Evolution of a Switchboard, by A. V. Abbott, C. E., Special University Lecturer. Pp. 32, pls. 4, October, 1894. Price 35 cents.

No. 5. An Experimental Study of Field Methods which will Insure to Stadia Measurements Greatly Increased Accuracy, by Leonard Sewal Smith, B. C. E., Instructor in Engineering. Pp. 45, pl. 1, May, 1895. Price 35 cents.

No. 6. Railway Signalling, by W. McC. Grafton. (In preparation.)

The BULLETIN OF THE UNIVERSITY OF WISCONSIN is printed by the State and is issued at irregular intervals. It contains original papers by persons connected with the university.

Copies of the BULLETIN will be forwarded post free from the office of the State Superintendent of Public Property to all colleges, high schools, normal schools, and public libraries of the state which have a collection of 300 or more volumes, on making proper application at the Superintendent's office. Persons who reside in the state of Wisconsin can receive copies of the BULLETIN free by applying to the Secretary of the Board of Regents of the University and paying the cost of transportation. The postage required for the individual numbers thus far issued, is as follows: Eng. Ser., No. 1, 2c; No. 2, 2c; No. 3, 2c; No. 4, 3c; No. 5, 4c. Hist. Ser., No. 1, 6c; No. 2, 7c. Sci. Ser., No. 1, 2c; No. 2, 2c; No. 3, 3c; No. 4, 3c. All the above are sent in one package by express for 25 cents.

The BULLETIN may be obtained at Brentano's, 31 Union Sq., New York, and 204–206 Wabash Ave., Chicago; and at A. C. McClurg & Co.'s, 117, 119, and 121 Wabash Ave., Chicago. In Europe it may be obtained from Mayer & Müller, Markgrafenstrasse 51, Berlin W., and from Brentano's, 27 Ave de l'Opéra, Paris.

Communications having reference to an exchange of publications should be addressed to Mr. Walter M. Smith, University Librarian.

For list of Bulletins issued see inside of cover.

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SCIENCE SERIES, VOL. 1, NO. 6, PP. 157-368. (CONCLUSION.)

ANALYTIC KEYS TO THE GENERA AND SPECIES OF NORTH AMERICAN MOSSES

BY

CHARLES REID BARNES

Professor of Botany.

REVISED AND EXTENDED BY

FRED DEFOREST HEALD,

Fellow in Botany.

WITH THE COOPERATION OF THE AUTHOR.

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
JANUARY, 1897.

PRICE $1.00

Democrat Printing Company, State Printer.

BULLETIN OF THE UNIVERSITY OF WISCONSIN

SCIENCE SERIES, VOL. 1, NO. 5, PP. 157-368 (CONCLUSION.)

ANALYTIC KEYS TO THE GENERA AND SPECIES OF NORTH AMERICAN MOSSES

BY

CHARLES REID BARNES

REVISED AND EXTENDED BY

FRED DEFOREST HEALD,

WITH THE COOPERATION OF THE AUTHOR.

PUBLISHED BY AUTHORITY OF LAW AND WITH THE APPROVAL OF THE REGENTS OF THE UNIVERSITY

MADISON, WIS.
PUBLISHED BY THE UNIVERSITY
DECEMBER, 1896.

INTRODUCTION.

PREVIOUS PUBLICATIONS.

In the summer of 1886 I published for free distribution a key to the genera of mosses recognized in the Manual of Lesquereux and James. A large edition of that key was soon exhausted, and I have been frequently assured that it proved of real service to students of mosses. Although much misgiving was felt as to its accuracy very few changes have been found necessary, and it is now presented for the third time substantially as it was at the first, except for the changes involved in its extension to include the sub-genera of *Hypnum*, most of which, as given in the Manual referred to, are certainly of generic rank.

Encouraged by the approval of the key to genera, in May, 1890, I published keys to the species of North American mosses recognized by Lesquereux and James. These keys were printed in the eighth volume of the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, and a considerable edition of separates was also struck off. In those keys I included the comparatively small number of new species which had been described since the the issue of the Manual. The work made no pretensions to a critical study of North American mosses, but was designed only as a convenience for students. The new edition here presented is meant to serve the same purpose more fully.

THE NEW EDITION.

Three reasons have induced me to prepare a new edition. (1) The separate edition printed in 1890 was exhausted sev-

eral years ago, and requests for copies of it were being received continually. (2) It will be several years before the new Manual of North American mosses can be completed, and much information is needed to make critical study for that work possible. (3) A very large number of new species have been described since 1890, about which it is especially desirable to have more accurate information.

I was fortunate in being able to associate with me in this work Mr. Fred D. Heald, sometime fellow in botany in the University of Wisconsin, who has prepared the first draft of the revision. Of some particular parts of the work for which credit is due him I shall speak later.

COLLECTED DESCRIPTIONS.

Comparatively few who would be glad to collect and study mosses have access to the various publications in which the species new to our flora have been described. We have thought it best, therefore, at the risk of adverse criticism, to append to the keys collected descriptions of all species not found in Lesquereux and James' Manual. For the specialist this may be looked upon as wasted energy; but these keys are prepared chiefly for amateurs, who will doubtless be glad to have these descriptions brought to hand.

The source of the descriptions reprinted in the Appendix is always cited. The descriptions are not always the original ones, though generally they are if the species is one recently named. We have not thought it necessary in other cases even to cite the original description which can be found readily from the clue given.

KINDBERG'S NEW SPECIES.

A great number of new species have been described by Dr. N. C. Kindberg, of Linköping, Sweden, and by Dr. C. Müller, of Halle, in collaboration with Kindberg, from the collections brought together by John Macoun, botanist of

the Dominion of Canada. There is good reason to believe that a majority of these are not well founded.

It is, of course, true that species as such do not exist in nature, and, therefore, that there will be diverse judgments as to what individuals should be grouped to form a species. But there is a general agreement that changes induced by the immediate action of the environment upon the individual can not furnish a proper basis for specific distinctions. Many of Kindberg's species are established upon such slight differences in size, shape or habit as may readily be induced by the immediate action of deficient or excessive moisture, light or shade, etc.

Other species are based upon wholly insufficient material. When immature or barren specimens of *Barbula* and *Bryum* are described as new species, one who knows the remarkable variability of the vegetative parts of plants can not but doubt the value of distinctions based upon them. Only the repeated collection of barren specimens with some persistent peculiarities can justify the establishment of new species upon such material.

Moreover, critical examination of Kindberg's new species in several genera have been made by a number of bryologists, among whom may be named Mrs. Britton, Best, Grout, Barnes, True, Cheney, Renauld, and Cardot. Without exception these students have declared a considerable number of the plants described as new to be referable to those already described, of which they are either slight varieties or forms unworthy a separate name. In a revision of the genus *Dicranum* (ined.), for example, Barnes and True have been compelled to reject seventeen out of eighteen species described by Kindberg.

These species are in many cases not only ill founded. Few of the descriptions are either accurate or sufficient. Very many are so brief and so purely comparative that it is impossible to obtain a definite idea of the diagnostic characters.

SCOPE OF THE KEYS.

In the keys we have endeavored to include all the species reported or described as belonging to our flora, unless a later special study of the genus has shown the addition to be untenable. Such special studies are cited in the keys. The incompleteness of many descriptions, and the lack of diagnostic characters have seriously hampered us in rearranging the keys, and they will fail, therefore, in many cases to differentiate described species. We have been at considerable pains to include as many of the barren and insufficiently described species as possible, in order that these may be recognized, if they exist, or may be referred to their appropriate place. Material which will enable students either to diagnose them clearly or to overthrow them would be of great value.

The keys do not generally discriminate varieties, but it is very important that collectors and amateurs keep in mind the variability of the mosses and seek to bring to light as many facts as possible bearing on this problem, so that the range of variability may be ascertained. To facilitate this we have also collected descriptions of varieties not appearing in the Manual. In these varietal descriptions the comparisons, unless otherwise stated, are with the characters of the species.

NOMENCLATURE.

It seemed to us highly desirable to avoid the making of new names in a compilation like this. We have therefore used, as a basis for our work, Renauld and Cardot's *Musci Americæ Septentrionalis.*[1] In basing our keys upon that list we do not thereby express our adherence to the nomenclature employed. Of many species therein neither the

[1] Published in the Revue Bryologique **19**: 65–69. 1892 and **20**: 1–32. 1893. Afterward this was issued as a separate and, most unfortunately, e-paged and revised.

present names nor the autonomy can be maintained. But it enables us to avoid constructing new names in this publication, so that it need not be cited in the future literature of taxonomy.

This list also saved us much labor of compilation, both of names and of geographical distribution. Only such changes were made in the species included as seemed warranted by the special studies before mentioned. To the species therein enumerated we have added those described since its publication up to January 1, 1896.

We have departed from this list and published monographs in only two genera. In *Dicranum* we have used the results of the study of Barnes and True, and in *Amblystegium* those of Cheney (both at present unpublished), so far as the omission of certain species of these genera is concerned. We have not included some new species yet in MSS., believing that this bulletin is not a suitable place for publishing them.

It is scarcely necessary to add that no attention has been paid to *nomina nuda.*

CITATIONS.

For the sake of brevity we have cited *Macoun's Catalogue of Canadian Plants, Part VI. Mosses,* by Macoun and Kindberg, simply as Mac. Cat., to which its independent paging lends itself. Likewise *Rabenhorst's Kryptogamen-Flora von Deutschland, Œsterreich und der Schweiz, Part IV. Die Laubmoose,* by Limpricht, is cited as Limpr. Laubm. Other citations are given in full or with abbreviated accurate titles. In all cases we have cited the original publication of Renauld and Cardot's *Musci Americæ Septentrionalis* in the Revue Bryologique.

ACKNOWLEDGMENTS.

Upon Mr. Heald has fallen the bulk of the work of collating the list of species to be included and selecting the descriptions to be reprinted. Many of the latter are trans-

lated from Latin, French, or German, with most of which he is also to be credited. Perhaps his most difficult task was in preparing the new part of the key to the genera of Hypnaceæ, and the keys to the species of *Hypnum*. The incorporation of the many new species in the keys to the larger genera, such as *Sphagnum*, *Barbula*, *Grimmia* and *Bryum*, was also a difficult task, made doubly difficult by imperfect descriptions and want of figures. There is scarcely a key which he has not altered more or less to permit these insertions, and some are completely rearranged.

In this work advantage has been freely taken of the suggestions, and sometimes of the very characters, in the keys found in Limpricht's *Laubmoose*, Braithwaite's *British Moss Flora*, Husnot's *Muscologia Gallica*, and Warnstorf's *Characteristik und Uebersicht der nord-, mittel-, und südamerikanischen Torfmoose.*

For the key of *Dicranum* thanks are due to Professor R. H. True and for that of *Amblystegium* to Professor L. S. Cheney, both of the University of Wisconsin.

The first draft of the manuscript prepared by Mr. Heald I have carefully edited, revised, and, in some parts, re-arranged. In the absence of Mr. Heald from the country, the not inconsiderable labor of attending to the details of publication has fallen upon me.

For corrections to the previous edition acknowledgments are due to Mrs. E. G. Britton, Miss Clara E. Cummings, Mr. E. A. Rau, Dr. C. W. Swan, Mr. Marshall A. Howe, Mr. Edo Claassen, Professor L. S. Cheney and Professor R. H. True.

The unfailing kindness of Mrs. E. G. Britton in supplying specimens, information as to particular species, and copies of several inaccessible descriptions receives also our grateful recognition.

Professor Conway MacMillan has also put us under obligations by the loan of periodicals not accessible here.

We shall be grateful for notice of errors or omissions in the present edition.

USE OF THE KEYS.

Upon page 157 is a key to the four orders of Musci. The first three orders each have a single genus only. To the genera of the fourth order, BRYALES, the key upon the following twelve pages is devoted.

In this key there are always at least two choices presented, whose equivalence is indicated by similar numbers or signs preceding the line, or by equal indention of the lines, which usually begin with the same word or its opposite. When the second member does not follow on the same page a reference to the page upon which it does occur follows the first. For an example see page 158. When there are more than two choices offered, all except the first and last are followed by a number or sign to indicate that a succeeding one is to be sought. For an example see page 160.

When the accepted choice is followed by a dotted line leading to the name of a genus, the description of that genus will be found in Lesquereux and James' Manual of the Mosses of North America on the page indicated by Arabic figures of ordinary face (999). The key to the species of that genus will be found on the page of this work indicated by the bold face figures (**999**) following. If the genus be not described in the Manual it will be found described in the Appendix, on the page indicated by italic figures (*999.*)

In the keys to species the correlative choices are indicated in the same way. Arabic figures (999) following the name of a species show that the species will be found described in the Manual on the page named. If followed by italic figures (*999*), a description will be found in the Appendix on the page indicated.

APOLOGIA PRO LABORE SUO.

No one realizes more clearly than the writer that such work as that which is now presented to students is in one

sense "dead work." Yet in another it is vital. It is in itself of only temporary value. It perishes with the using. The user may soon get beyond the need of a crutch.

The only justification for such work is its usefulness to amateurs, who may by its help put bryologists in possession of facts regarding the distribution, variation, and relationships of our moss flora which could not be gained without their aid. These keys are published, therefore, purely as an encouragement to the study of our mosses, which with the Hepaticæ are more neglected than any other group of which we have accessible descriptions.

An earnest student equipped with patience, some skill in dissection, a compound microscope, and the Manual, ought to be able with the assistance of these keys to determine the names of most of the mosses which he can collect. Those which remain uncertain he can refer to those who possess the illustrations and exsiccati which are often indispensable for identification.

CHARLES R. BARNES.

University of Wisconsin,
December 15, 1896.

ANALYTIC KEY

TO THE

GENERA OF MOSSES.

ORDER I.— **Sphagnales.**

Capsule dehiscing by a deciduous operculum, peristome none, leaves composed of large hyaline cells, with intervening rows of small chlorophyllose ones.
Genus single . . . . . **Sphagnum**, 12. **170.**

ORDER II.— **Andreæales.**

Capsule dehiscing by four (rarely six) longitudinal slits.
Genus single . . . . . **Andreæa**, 25. **175.**

ORDER III.— **Archidiales.**

Capsule bursting irregularly, spores few and very large.
Genus single . . . . . **Archidium**, 49. **176.**

ORDER IV.— **Bryales.**

Capsule bursting irregularly (spores numerous) or generally dehiscing by a deciduous operculum, in the latter case usually furnished with a peristome. Leaves not sphagnoid.
Genera numerous as follows:

I. CLEISTOCARPI.— *Capsule without a deciduous operculum.* (II on p. 158.)

A. *Green protonema persistent.* (B on p. 158.)

Leaves ecostate.
Capsule colorless . . . . . **Micromitrium**, 37. **176.**
Capsule colored . . . . . **Ephemerum**, 37. **176.**
Leaves costate . . . . . **Ephemerum**, 37. **176.**

B. *Green protonema not persistent.*

Margins of leaves flat or incurved.
  Leaves lance-obovate to broad ovate or ovate lanceolate, not abruptly pointed.
    Margins dentate or serrate . . . **Physcomitrella**, 39.
    Margins entire . . . . . **Voitia**, *42*, *43*.
  Leaves linear-lanceolate to subulate or abruptly pointed.
    Calyptra mitrate . . . . . **Bruchia**, 45. **177.**
    Calyptra cucullate . . . . . **Pleuridium**, 43. **177.**

[*Astomum* may be sought here.]

Margins of leaves more or less revolute.
  Capsule spherical . . . . . **Sphærangium**, 40. **176.**
  Capsule short-pointed.
    Calyptra mitrate . . . . . **Microbryum**, 45, *37*.
    Calyptra cucullate . . . . . **Phascum**, 41. **177.**

II. STEGOCARPI.—*Capsule with a deciduous operculum.*

A. Acrocarpi.—*Capsule at the apex of the stem, either the main shoot or a well developed branch.* (B on p. 166.)

1. *Mouth of the capsule naked.* (2 on p. 159.)

[*Weisia viridula vars.* may be sought here.]

* *Leaf-cells isodiametric, at least above the middle of the leaf, often obscure.* (* * on p. 159.)

Lid imperfectly formed, persistent . . . **Astomum**, 51. **178.**
Lid perfect, deciduous.
  Capsule immersed.
    Leaves lamellose . . . . . **Pharomitrium**, 100.
    Leaves not lamellose.
      Apex hyaline or prolonged into a hyaline hair.
        Perichaetial leaves ciliate . . . . **Hedwigia**, 152.
        Perichaetial leaves not ciliate . . . **Grimmia**, 134. **197.**
      Apex obtuse, plants robust, blackish . **Scouleria**, 137. **197.**
  Capsule exserted, ribbed when dry.
    Calyptra cucullate.
      Leaves with long hyaline points . . . **Braunia**, 152.
      Leaves not hyaline pointed.
        Capsule contracted below the orifice **Amphoridium**, 158. **201.**
        Capsule not contracted below the orifice . **Zygodon**, *206*. **201.**
    Calyptra campanulate-mitrate, plicate, usually hairy . . . . . **Macromitrium**, 178. **206.**

Calyptra long clavate-companulate, not plicate nor hairy.
Costa with loose cells in center of section **Encalypta**, 180. **206.**
Costa with central stereid strand . . **Merceya,**[1] *242.*
Capsule exserted, not ribbed when dry.
Calyptra persistent, plicate, twisted . . **Calymperes**, 184. **207.**
Calyptra persistent, smooth, surpassing capsule.
Costa with loose cells in center of section . **Encalypta**, 180. **206.**
Costa with central stereid strand . . **Merceya,**[1] *242.*
Calyptra not persistent, often fugacious.
Leaves ciliate at the base, obtuse, flat **Œdipodium**, *244*, *245.*
Leaves not ciliate at the base, pointed, carinate, distichous . . . . . **Eustichia**, 94.
Leaves not ciliate at the base, pluriseriate.
Linear-lanceolate, margins plane.
Costa filling elongated point, plants minute, **Anodus**, 96.
Costa percurrent.
Capsule on a short lateral branch **Anœctangium**, 54. **179.**
Capsule terminating main axis **Gymnostomum**, 52. **178.**
Ovate lanceolate, margins reflexed . . **Barbula**, 115. **191.**
Broad, often hair pointed, plants minute . **Pottia**, 100. **188.**

** *Leaf cells plainly elongated, distinct.*

Lid small, convex or short-conic, capsule microstome.
Leaves vertically inserted . . . . . **Schistostega**, 188.
Leaves subulate, dentate . . . . . **Bartramia**, 203. **210.**
Leaves broad, entire, calyptra enclosing capsule **Pyramidula**, 196.
Lid large (rarely small), capsule macrostome.
Capsule splitting at the middle . . **Aphanorhegma**, 196.
Capsule dehiscing regularly above the middle, not covered by calyptra . . . . . **Physcomitrium**, 196. **209.**

2. *Mouth of the capsule furnished with a peristome.*

* *Peristome single.* (* * on p. 164.)

+ *Teeth articulate.* (+ + on p. 163.)

++ *Teeth eight.* (++ ++ on p. 160.)

Leaves thick, coriaceous . . . . . **Octoblepharum**, 91.

[*Orthotrichum* and *Ptychomitrium* (§ *Notarisia*) may be sought here.

[1] Genus only known in sterile state; wherefore its place in the key cannot be determined except as its leaves ally it to *Encalypta.*

++ ++ *Teeth sixteen, calyptra mitrate.* (++ ++ ++)

= *Calyptra plicate.*

Teeth cribrose, purple . . . . . **Coscinodon**, 154. **201.**
Teeth filiform, trifid . . . . . **Ptychomitrium**, 156. **201.**
Teeth approximate or connate in pairs.
  Lanceolate to subulate, papillose . . **Ptychomitrium**, 156. **201.**
  Triangular-lanceolate, articles quadrate.
    Basal leaf-cells linear, chlorophyllose . . . **Ulota**, 160. **202.**
    Basal leaf-cells hexagono-rectangular, hyaline **Orthotrichum**, 164. **203.**
Teeth short, pale, fragile . . . . . **Macromitrium**, 178. **206.**

= = *Calyptra not plicate.*

Aquatic, floating.
  Leaves distichous . . . **Fissidens** (§ **Octodiceras**), 89. **186.**
  Leaves pluriseriate . . . . . **Cinclidotus**, 134.
Terrestrial.
  Very small, gregarious.
    Teeth broad, erose-truncate, hyaline . . **Brachyodus**, 98.
    Teeth linear-lanceolate, deeply bifid . . **Campylostelium**, 99.
  Larger, above 1 cm. in height.
    Leaf-cells small, quadrate or punctate, obscure.
      Beak long-clavate . . . . . **Encalypta**, 180. **206.**
      Beak long or short, not clavate.
        Teeth lanceolate, flat, subentire or cribrose or 2—3-fid to the middle . . . . **Grimmia**, 134. **197.**
        Teeth linear-lanceolate, 2—3-fid to below middle, or cleft to base into filiform segments **Rhacomitrium**, 147. **199.**
    Leaf-cells large, very distinct, pedicel with a prominent apophysis.
      Apophysis smaller than the capsule.
        Leaves entire, obtuse . . . . . **Dissodon**, 189. **207.**
        Leaves serrate, acute or acuminate . . **Tayloria**, 190. **208.**
      Apophysis exceeding the capsule . . **Splachnum**, 193. **208.**

++ ++ ++ *Teeth sixteen, calyptra cucullate.* (++ ++ ++ ++ on p. 163.)

= *Leaves distichous.* (= = on p. 161.)

Leaves subulate . . . . . **Distichium**, 93. **187.**
Leaves broader, with a prominent vertical wing . **Fissidens**, 81. **185.**

= = *Leaves pluriseriate.*

¶ *Capsule unsymmetric, cernuous-inclined or arcuate.*

Teeth filiform-bifid from a membranous base . **Desmatodon**, 110. **190.**
Teeth irregularly lacerate or bifid to the middle or below.
  Leaf cells not enlarged at the basal angles, roundish or quadrate above.
    Lid long-beaked, leaves serrulate, peristome equaling half the capsule . . . . . **Dichodontium**, 61. **180.**
    Lid long-beaked, leaves crenulate or denticulate, peristome shorter . . . . . **Cynodontium**, 59. **179.**
    Lid short-beaked . . . . . **Oreoweisia**, 58.
  Leaf-cells not enlarged at the basal angles, oblong above, rectangular at base . . . . . **Dicranella**, 64. **180.**
  Leaf-cells enlarged-quadrate at the basal angles.
    Linear at base, capsule not strumose, dioicous **Dicranum**,[1] 67. **181.**
    Rectangular at base, capsule strumose, monoicous . . . . . **Cynodontium**, 59. **179.**
  Leaf-cells of two kinds, in two or three layers **Leucobryum**, 90. **187.**
Teeth bifid to near the base.
  Lid conic, leaves subulate . . . . . **Trichodon**, 92. **187.**
  Lid conic, leaves lanceolate . . . . . **Ceratodon**, 92. **187.**
  Lid aristate, neck very long . . . . . **Trematodon**, 62. **180.**
Teeth not cleft, short, irregular . . . . . **Catoscopium**, 211.
Teeth not cleft, cohering by their tips . . **Conostomum**, 207.
Teeth not cleft, perforate.
  Neck long, exceeding the capsule . . . **Trematodon**, 62. **180.**
  Neck inconspicuous, plants small . . . **Discelium**, 188.
  Neck inconspicuous, plants large . . . **Oreoweisia**, 58.
Teeth not cleft nor perforate.
  Lid with a short thick oblique beak . . . **Oreoweisia**, 58.
  Lid with a short slender oblique beak . . **Cynodontium**, 59. **179.**
  [***Mielichhoferia*** and ***Funaria*** may be sought here.]

¶ ¶ *Capsule symmetric, pendulous on a flexuous pedicel.*

(¶ ¶ ¶ on p. 162.)

Teeth bifid to the middle . . . . . **Campylopus**, 77. **184.**
Teeth bifid to the base, free . . . . . **Dicranodontium**, 77. **184.**
Teeth bifid to the common membranous base.
  Connivent and slightly twisted . . . . **Desmatodon**, 110. **190.**
  Erect, not twisted . . . . . **Trichostomum**, 108. **190.**
Teeth entire, short, plants minute . . . . **Seligeria**, 96. **188.**

---

[1] The genus *Monocranum* C. Müll. is not included in the key on account of its doubtful nature.

¶ ¶ ¶ *Capsule symmetric, erect.*

Teeth bifid to the common membranous base.
  Leaves subulate to lance-subulate from a broader base . . . . . **Ditrichum**, 105. **189.**
  Leaves broader.
    Lid short, conic or beaked . - . . **Desmatodon**, 110. **190.**
    Lid elongated, conic . . . . **Trichostomum**, 108. **190.**
      [*Barbula* may be sought here.]
Teeth deeply bifid or cleft to the base, free.
  Leaf-cells small, not enlarged at the angles, oblong above . . . . . **Dicranella**, 64. **180.**
  Leaf-cells small, not enlarged at the angles, roundish or quadrate above.
    Lid oblique . . . . . **Cynodontium**, 59. **179.**
    Lid straight . . . . . **Leptodontium**, *116*, *117*.
  Leaf-cells small, enlarged-quadrate at the angles **Dicranum**, 67. **181.**
  Leaf-cells large, distinct . . . . **Aongstrœmia**, 63.
Teeth cribrose, perforate or slightly cleft.
  Leaf-cells enlarged-quadrate at the angles.
    Capsule broad-pyriform . . . . . **Blindia**, 98. **108.**
    Capsule oval to sub-cylindric . . . **Dicranoweisia**, 57. **179.**
  Leaf-cells not enlarged at the angles.
    Teeth large, mostly cribrose.
      Pedicel little exceeding the often hair-pointed leaves . . . . . **Grimmia**, 134. **197.**
      Pedicel long, leaves hair-pointed . . **Desmatodon**, 110. **190.**
      Pedicel long, leaves not hair-pointed.
        Leaves serrate just above sheathing base **Eucladium**, *46*, *47*.
        Leaves entire or crenulate above . . **Didymodon**, 104. **189.**
    Teeth small, often truncate or rudimentary.
      Leaf-margins involute above . . . . . **Weisia**, 55. **179.**
      Leaf-margins revolute or plane.
        Leaves densely papillose in the upper part **Didymodon**, 104. **189.**
        Leaves not papillose.
          Capsule long exserted, lid completely deciduous **Pottia**, 100. **188.**
          Capsule subimmersed, lid adhering to columella . . . . . **Scouleria**, 137. **197.**
Teeth entire.
      [*Cynodontium* and *Eucladium* may also be sought here.]
  Capsule with a long, thick apophysis . . **Tetraplodon**, 191. **208.**
  Capsule oval to subcylindric.
    Not ribbed when dry.
      Teeth short, leaves entire, narrow . . . **Weisia**, 55. **179.**

Teeth short, leaves serrate, broad . . **Syrrhopodon**, 185. **207.**
Teeth linear-filiform, connate at base **Didymodon**, 104. **180.**
Teeth narrowly lanceolate, free . . **Dicranoweisia**, 57. **179.**
Ribbed when dry . . . . . **Rhabdoweisia**, 58. **179.**
Capsule short-pyriform, turbinate when dry.
Teeth blunt . . . . . **Seligeria**, 96. **188.**
Teeth acute . . . . . **Blindia**, 98. **108.**
Capsule pyriform, not turbinate when dry.
Plants gregarious or subcespitose . . **Entosthodon**, 199. **209.**
Plants in deep compact tufts . . **Mielichhoferia**, 214. **211.**
Capsule ovate-globose, lid obliquely long-beaked **Drummondia**, 160. **209.**
Capsule globose, lid beakless, small . . **Bartramia**, 203. **210.**

++ ++ ++ ++ *Teeth thirty-two.*

Teeth cancellate . . . . . **Barbula**. 115. **191.**
Teeth filiform or linear, almost terete, arising from a long or short basilar membrane.
Short, slightly, if at all, twisted.
Leaves (upper) convolute-sheathing at base **Leptobarbula**, *123*, *124*
Leaves not sheathing at base.
Subulate or lance-subulate from a broader base . . . . . **Ditrichum**, 105. **189.**
Broader, lid elongated-conic . . **Trichostomum**, 108. **190.**

[*Barbula rigidula* will be sought here.]

Broader, lid short-conic or short-beaked **Desmatodon**, 110. **190.**
Long, twisted to the left . . . . . **Barbula**, 115. **191.**
Teeth flat, not from a distinct basilar membrane.
Cells of capsule linear-oblong . . . **Dicranodontium**, 77. **184.**
Cells of capsule irregularly polygonal . . **Didymodon**, 104. **189.**

+ + *Teeth not articulate.*

++ *Teeth four, solid.*

Capsule linear-oblong, stems long, conspicuous . **Tetraphis**, 186. **207.**
Capsule ovate, stems very short . . . **Tetrodontium**, 187.

++ ++ *Teeth thirty-two or sixty-four.*

[*Leptobarbula* may be sought here.]

Calyptra cucullate, capsule symmetric or nearly so.
Leaves undulate-crisped when dry, lamellæ few (2—8), straight . . . . . **Atrichum**, 255. **221.**

Leaves sub-tubulose at apex, lamellæ undulate or numerous . . . . . **Oligotrichum**, 258. **222.**
Calyptra cucullate, capsule unsymmetric, arcuate incurved . . . . . **Psilopilum**, 259.
Calyptra mitrate, densely hairy.
Capsule not angular, teeth 32 . . . . **Pogonatum**, 260. **222.**
Capsule 4—6 angled, teeth 64 . . . . **Polytrichum**, 263. **223.**

* * *Peristome double.*

+ *Capsule symmetric, erect (sometimes inclined in age).*

Teeth almost 0, imperfect or rudimentary . **Macromitrium**, 178. **206.**
Teeth perfect, linear or filiform.
Capsule smooth.
Teeth revolute . . . . . **Schlotheimia**, 179.
Teeth not revolute.
Leaves ecostate . . . . . **Fontinalis**, 268. **224.**
Leaves costate.
Leaf-cells oval hexagonal, capsule long exserted . . . . . **Leptotheca**, 251.
Leaf-cells hexagonal-rhombic, capsule immersed **Brachelyma.**[1]
Leaf-cells linear-attenuate, capsule immersed or emergent . . . . . **Dichelyma**, 272. **225.**
Capsule ribbed and twisted.
Costa with loose cells in center of section . **Encalypta**, 180. **206.**
Costa with central stereide band . . . **Merceya**,[2] *242.*
Teeth broadly or narrowly triangular-lanceolate, pale, capsule ribbed, not twisted.
Leaf-cells at base linear, chlorophyllose . . . **Ulota**, 160. **202.**
Leaf-cells at base hexagono-rectangular, hyaline.
Lid straight, conical or acuminate . **Orthotrichum**, 164. **203.**
Lid obliquely rostrate . . . . . **Zygodon**, *206.* **201.**

+ + *Capsule unsymmetric, inclined or oblique or pendulous.*

++ *Inner peristome a plaited cone.* (++ ++ on p. 165.)

Pedicel thick, red, densely verrucose . . **Buxbaumia**, 267. **223.**
Pedicel very short, almost none . . . . **Diphyscium**, 266.

---

[1] Including one species, *B. subulatum* Sch. (*Dichelyma subulatum* Myrin; *Cryphæa inundata* Nees. L. and J. Manual, pp. 274 and 413.)

[2] See footnote p. 159.

++ ++ *Inner peristome a membrane, carinate or cut into sixteen segments; these sometimes separated by cilia.*

= *Cilia very short, rudimentary or none.*

Membrane entire, 16-carinate . . . . . **Cinclidium**, 249. **221.**
Membrane cleft into segments.
Segments entire or interruptedly cleft along the middle line.
Shorter than the teeth or rudimentary . . **Funaria**, 200. **210.**
Equaling the teeth in length.
Leaves squarrose-recurved from the middle . **Paludella**, 213.
Leaves not squarrose.
Pedicel long.
Leaf-cells narrowly rhombic-hexagonal, tending to linear, leaves narrow . . . **Webera**, 215. **211.**
Leaf-cells and leaves broader . . . **Bryum**, 223. **214.**
Pedicel short, neck long . . . . . **Zieria**, 240. **219.**
Far exceeding the teeth in length.
Pedicel long, leaf-cells large, pellucid . **Amblyodon**, 211.
Pedicel long, leaf-cells small, rectangular, chlorophyllose . . . . . **Meesia**, 212. **211.**
Pedicel short, neck long . . . . . **Zieria**, 240. **219.**
Segments bifid, divisions divaricate.
Leaves lanceolate to subulate, large . . **Bartramia**, 203. **210.**
Leaves lanceolate or broader, smaller . **Philonotis**, 208. **211.**
Segments filiform, united by fours at their tips . **Timmia**, 254. **221.**

= = *Cilia present.*

Appendiculate.
Leaves lance-subulate, cells linear . . . **Leptobryum**, 215.
Leaves broader, cells rhombic-hexagonal . . **Bryum**, 223. **214.**
Inappendiculate.
Capsule not ribbed when dry.
Leaves lanceolate, glossy, cells narrowly rhombic-hexagonal, inclining to linear . . . **Webera**, 215. **211.**
Leaves ample, soft, oblong, ovate to obovate or broader, cells round-hexagonal . . . **Mnium**, 241. **219.**
Leaves narrowly lanceolate, rigid . . **Rhizogonium**, 250.
Capsule ribbed when dry.
Oblong or elongated pyriform . . . **Aulacomnium**, 252. **221.**
Sub-globose . . . . . **Philonotis**, 208. **211.**

B. PLEUROCARPI. *Capsule on a very short lateral branch.*

[***Fontinalis, Dichelyma*** and ***Anœctangium*** may be sought here.]

1. *Peristome single (rarely none), teeth eight or sixteen.*

[Species belonging to genera under "**2** *" *infra* may be sought here.]

Leaves distichous, with broad vertical wing . . **Fissidens**, 81. **185.**
Leaves pluriseriate.
  Entire (except perhaps at the apex) and ecostate.
    Perichaetial leaves erose-dentate at apex . **Habrodon**, 296.
    Perichaetial leaves entire . . . . **Leucodon**, 287. **227.**
  Entire and costate.
    Short acuminate, teeth 16, yellowish . **Clasmatodon**, 297.
    Obtuse, teeth 8, red . . . . . **Cryphæa**, 275. **226.**
  Serrate, capsule emergent . . . . **Leptodon**, 278. **226.**
  Serrate to ciliate-dentate, capsule long pedicelled **Fabronia**, 294. **228.**

2. *Peristome double, the inner often imperfect.*

* *Segments none or short, or obscured by adhering to teeth.*
(* * on p. 167.)

+ *Leaves papillose.*

Entire, ovate to ovate-lanceolate.
  Teeth ciliate-papillose . . . . . **Leskea**, 301. **229.**
  Teeth not papillose . . . . . **Anomodon**, 304. **230.**
Entire or cristate-serrate, obovate or spatulate **Pterigynandrum**, 288. **228.**
Spinulose-dentate to fimbriate (rarely entire) deltoid or
  round-ovate . . . . . **Thelia**, 298. **229.**
Serrate, broadly ovate . . . . **Pterogonium**, 289. **228.**

+ + *Leaves not papillose.*

Capsule straight.
  Segments bifid or adherent to the teeth.
    Plants small (1–2 cm.), capsules about 2 mm. . **Pylaisæa**, 308. **230.**
    Plants large (4–6 cm.), capsules about 4 mm. **Cylindrothecium**, 310. **231.**
  Segments not bifid nor adherent.
    Leaves ecostate or obscurely bicostate . . **Neckera**, 281. **226.**
    Leaves costate . . . . . **Antitrichia**, 290. **228.**
Capsule curved or arcuate . . . **Homalothecium**, 309. **230.**

* * *Segments not distinctly keeled, narrow.* (* * *)

+ *Leaves costate.*

Cells isodiametric to oval-rhombic.
  Papillose.
    Stem and branch-leaves similar . . . **Leskea**, 301. **229.**
    Stem-leaves much smaller than branch-leaves **Anomodon**, 304. **230.**
  Not papillose.
    Annulus large, compound, perichaetial leaves costate . . . . . **Cryphæa**, 275. **226.**
    Annulus simple, perichaetial leaves ecostate **Lescuræa**, *414*, *416*.
    Annulus none.
      Endostome with cilia . . . . . **Alsia**, 279. **226.**
      Endostome without cilia.
        Teeth erect or incurved when dry.
          Leaf-cells minute, obscure, alar cells elongated . . . . . **Neckera**, 281. **226.**
          Leaf-cells distinct, alar cells quadrate **Myrinia**, *410*, *411*.
        Teeth reflexed when dry . . . **Anacamptodon**, 296.
Cells linear or vermicular.
  Annulus none . . . . . **Neckera**, 281. **226.**
  Annulus present . . . . . **Antitrichia**, 290. **228.**
    [***Cylindrothecium***, with leaves obscurely costate, may be sought here.]

+ + *Leaves ecostate.*[1]

Annulus none . . . . . **Neckera**, 281. **226.**
Annulus present.
  Leaf-cells quadrate at basal angles.
    Plants small, capsules about 2 mm. long **Platygyrium**,[2] 307.
    Plants large, capsule about 4 mm. long **Cylindrothecium**, 310. **231.**
  Leaf-cells not quadrate at the basal angles **Orthothecium**, 315. **232.**

* * * *Segments distinctly keeled, often broad.*

+ *Capsule symmetric, erect.* (+ + on p. 168.)

[Species of ***Hypnum*** with erect or sub-erect capsules will be sought here.]

++ *Leaves papillose.* (++ ++ on p. 168.)

Plants large; branches erect, dendroid . . . **Alsia**, 279. **226.**
Plants long, pendent from trees, branches filiform **Meteorium**, 286. **227.**
Plants small, branches erect, julaceous . . **Myurella**, 300. **229.**

---

[1] ***Taxithelium planum*** (=*Hypnum planum* Brid., L. & J. Man. 411) falls here, but on account of lack of data in regard to the annulus it can not be exactly located.

See also Appendix, no. 416.

++ ++ *Leaves not papillose.*

Leaves costate or ecostate, complanate, pseudo-distichous.
  Middle leaf-cells linear, cilia none or very short **Homalia**, 285. **227.**
  Middle leaf-cells rhomboidal, cilia solitary, ⅔ length of the segments . . . . **Stereophyllum**,[1] 411.
Leaves costate, plants dendroid . . . . **Climacium**, 313. **231.**
Leaves ecostate, annulus large (none in *Cyl. Drummondii*).
  Cells quadrate at basal angles.
    Teeth hyaline margined . . . . **Platygyrium**, 307.
    Teeth not hyaline margined . . **Cylindrothecium**, 310. **231.**
  Cells not quadrate at basal angles . . **Orthothecium**, 315. **232.**
Leaves ecostate, annulus small, narrow . . . **Pylaisæa**, 308. **230.**

+ + *Capsule unsymmetric, often arcuate.*

++ *Leaf-cells large, calyptra mitrate.*

Leaves mucronate or acute or acuminate . . **Hookeria**, 292. **228.**
Leaves obtuse . . . . . **Pterigophyllum**, 293.

++ ++ *Leaf-cells small, calyptra cucullate.*

[***Climacium*** *Ruthenicum* will be sought here.]

¶ *Leaf-cells short (1 : 3 or less).* (¶ ¶ on page 169.)

[***Isothecium*** *Brewerianum* may be sought here.]

Leaves papillose.
  Paraphyllia present.
    Costa short or none or double . . **Heterocladium**, 320. **232.**
      [***Pseudoleskea*** *malacoclada* will be sought here.]
    Costa strong.
      Capsule oval or oblong, lid convex-conic **Pseudoleskea**, 319. **232.**
      Capsule cylindric or if oval oblong then lid long rostrate . . . . . **Thuidium**, 321. **233.**
  Paraphyllia none . . . . . **Claopodium**, 327. **234.**
Leaves not papillose.
  Shortly bicostate.
    Stem leaves filiform pointed . . . **Heterocladium**, 320. **232.**
    Stem leaves not filiform pointed . . **Tripterocladium**, 330. **234.**
  Unicostate or ecostate.
    [***Tripterocladium*** *rupestre* will be sought here.]
    Plants dendroid, leaves coarsely serrate **Thamnium**, 361. **240.**
    Plants creeping, leaves entire or denticulate above . . . . . **Amblystegium**, 371. **242.**

---

[1] *Stereophyllum Wrightii* R. and C. Rev. Bryol. **20**: 23. 1893. (*Hypnum Wrightii* Sull. L. and J. Man. 411.)

¶ ¶ *Leaf-cells long (1 : 5 or more).*[1]

Leaves unicostate half way or more.
  Seta rough.[2]
    Leaves deeply plicate lengthwise . . **Camptothecium**, 331. **234.**
    Leaves not deeply plicate.
      Lid convex conic to long conic (rostellate in *Seler. cæspitosum*).
        Leaf-cells not abruptly enlarged at base, upper usually distinct, elongated rhombic **Brachythecium**, 334. **235.**
        Leaf-cells abruptly enlarged at the base, indistinct, linear-vermicular[3] . . . **Scleropodium**, 346. **237.**
      Lid more or less long rostrate . . **Eurhynchium**, 351. **238.**
  Seta smooth.[4]
    Lid more or less long rostrate.
      Leaves ovate or ovate lanceolate **Rhynchostegium**, 358. **240.**
      Leaves deltoid . . . . . **Eurhynchium**, 351. **238.**
    Lid convex to conic or apiculate.
      Branches fasciculate, stoloniferous, leaves generally papillose, not plicate . . . **Isothecium**, 347. **238.**
      Branches irregularly pinnate, leaves not papillose . . . . . **Brachythecium**, 334. **235.**
      Branches regularly or irregularly pinnate, leaves not papillose, when plicate also falcate-secund . **Hypnum**,[5] **244.**
Leaves ecostate, or costa very short or double.
  Leaves secund.
    Paraphyllia none . . . . . **Hylocomium**,[6] 409. **250.**
    Paraphyllia few or abundant . . . . **Hypnum**, **244.**
  Leaves complanate spreading.
    Lid rostrate.
      Leaves serrulate to the base . . **Rhynchostegium**, 358. **240.**
      Leaves entire or serrulate at the apex **Plagiothecium**, 362. **241.**
    Lid convex or conic . . . . . **Plagiothecium**, 362. **241.**
  Leaves equally spreading [also **Hylocomium** 185–188].
    Lid long subulate-rostrate . . **Raphidostegium**, 355. **239.**
    Lid conic or short rostrate.
      Capsule symmetric, erect or cernuous **Plagiothecium**, 362. **241.**
      Capsule unsymmetric, arcuate . . . **Hypnum**,[5] **244.**

---

[1] ***Amblystegium*** species, especially *riparium* and *vacillans*, may be sought here.

[2] ***Isothecium lentum***, ***Rhynchostegium curvisetum***, and ***Hypnum chloropterum*** will be sought here.

[3] ***Brachythecium populeum*** will be sought here.

[4] ***Camptothecium nitens*** will be sought here.

[5] Including the subgenera XVII to XXVI of L. & J. Man. 407.

[6] Including *Pleurozium* of L. & J. Man. 407.

ANALYTIC KEY

TO THE

SPECIES OF MOSSES.

SPHAGNUM, p. 12.

I. *Cortical cells of stem and branch without spiral fibrils; branch leaves mostly blunt and toothed, rarely acute.*

Branches 7—13 in a fascicle . . . . **§ IV. Polyclada, p. 173.**
Branches 3—6 in a fascicle, or fewer.
  Hyaline cells of stem leaves fibrillose.
    Cortical cells thin walled.
      Border of stem leaves much broader at base, chlorophyllose cells exposed on the inner face **§I. Acutifolia, p. 171.**
      Border of stem leaves not or slightly broader at the base . . . . . **§VI. Subsecunda, p. 173.**
    Cortical cells thick walled . . . . . **§III. Cuspidata, p. 172.**
  Hyaline cells of stem leaves without fibrils.
    Chlorophyllose cells of branch leaves exposed on inner face . . . . . **§I. Acutifolia, p. 171.**

[*S. subsecundum* and *S. contortum* may be sought here.]

    Chlorophyllose cells exposed on both faces, only on outer face, or included.
      Cell membranes of stem leaves resorbed.
        Hyaline cells of branch leaves with few pores on the outer surface (4–6) . . **§II. Squarrosa, p. 172.**
        Hyaline cells of branch leaves with numerous pores on outer surface (12–16+) . . **§V. Rigida, p. 173.**
      Cell membranes of stem leaves not resorbed, cortex thick walled . . . . . **§III. Cuspidata, p. 172.**

II. *Cortical cells of stem and pendent branches always with fibrils and pores; branch leaves not blunt and toothed but cucullate and hyaline bordered* . . . . . **§VII. Cymbifolia, p. 175.**

I. Acutifolia.

A. *Branch leaves toothed only at blunt apex, without resorption furrows on margined border.*

1. *Stem leaves lacerate-fringed at apex.*

a. *Stem leaves with completely resorbed cell membranes in upper part, without fibrils.*

Stem leaves widening upward, spatulate, apex and upper margins lacerate-fringed . . . **S. fimbriatum, 14.**
Stem leaves not widening upward, linguiform and lacerate fringed only at broad round apex . **S. Girgensohnii,**[1] **13.**

b. *Stem leaves with resorbed membranes only at apex, upper ½ to ⅔ with fibrils* . . . . . **S. Bolanderi,** *1.*

2. *Stem leaves usually dentate at apex, nowhere with completely resorbed cell membranes.*

a. *Stem leaves slightly or not at all narrowed upward, linguiform.*

Outer wall of cortical cells always porose . . **S. Russowii,** *2.*
Outer wall of cortical cells without pores.
Branch leaves curved when dry, erect-spreading, stem leaves without fibrils.
Pores of branch leaves very small, near apex, **S. Warnstorfii,** *3.*
Pores of branch leaves of medium size or large **S. Vancouveriense,** *4.*
Branch leaves frequently secund, stem leaves frequently with fibrils, wood-cylinder never brown . . **S. tenellum,** *5.*
Branch leaves densely imbricate, stem leaves without fibrils, wood-cylinder always brown . . . **S. fuscum,** *6.*

b. *Stem leaves distinctly narrowed above.*

Branch leaves when dry plainly 5 ranked . . **S. quinquefarium.** *7.*

---

[1] *S. strictum* Lindb.

Branch leaves when dry not 5 ranked.

Branch leaves with isolated pores on inner face toward apex.

Hyaline cells of stem leaves mostly with fibrils, branch leaves not shining.

Stem leaves extended into a blunt point with involute margins . . . . . **S. tenerum,** *8.*

Stem leaves scarcely pointed, not involute **S. acutifolium,** 13.

Hyaline cells of stem leaves mostly with fibrils, branch leaves silky shining . . . . . **S. subnitens,** *9.*

Branch leaves with numerous pores upon entire inner face . . . . . **S. microphyllum,** *10.*

B. *Branch leaves toothed at apex and upper margins; border with resorption-furrows.*

Stem leaves small (1.14–1.28 mm.), narrow border plainly broadened near the base . . . . **S. Labradorense,** *11.*

Stem leaves larger (2–2.10 mm.), narrow border scarcely broader at the base . . . . . **S. molle,**[1] 18.

II. Squarrosa.

Dioicous, perigonial leaves scarcely different from the leaves of the sterile branches . . . . . **S. teres,** 16.

Monoicous, perigonial leaves smaller, curved, erect spreading . . . . . **S. squarrosum,** 16.

III. Cuspidata.

A. *Branch leaves without fibrils.*

Pits on the outer surface large (10–12μ diam.), 5–16 in a single row in the middle of cell . . . **S. macrophyllum,** 24.

Pits on the outer surface smaller (4–5μ diam.), 40–60 in each hyaline cell . . . . . **S. Floridanum,** *12.*

B. *Branch leaves always with fibrils.*

1. *Branch leaves ovate-lanceolate or lanceolate to almost long linear.*

a. *Stem leaves lacerate-fimbriate in the upper part.*

Stem leaves widened upward, spatulate, fringed at apex **S. Lindbergii,** 15.

Stem leaves triangular linguiform, lacerate two-cleft at the apex . . . . . **S. riparium,** *13.*

---

[1] Including *S. Muelleri* Sch., L. & J. Man. 17.

b. *Stem leaves entire or with isolated gaps at the tip only.*

Chlorophyllose cells on the outer face of the leaf, triangular in cross section.
Cortex plainly distinct from wood-cylinder, branch leaves almost always without pores on the inner face . . . . . **S. Mendocinum**, 20.
Cortex indistinct, branch leaves with numerous rounded pores on the inner face . . . . . **S. recurvum**,[1] 15.
Chlorophyllose cells exposed on both faces, quadrate or trapezoidal.
Borders of the branch leaves involute, pores of the outer face very small, in the upper cell corners . **S. cuspidatum**, 14.
Borders of the branch leaves not involute, pores of the outer face large (6μ), in 1 or 2 rows . . . **S. Dusenii**, *14*.
Borders of the branch leaves not involute, pores generally absent . . . . . **S. Fitzgeraldii**, 23.

2. *Branch leaves small, oval or long ovate* . **S. molluscum**,[2] 20.

IV. Polyclada.

This section has only one species . . . . **S. Wulfianum**, 16.

V. Rigida.

Chlorophyllose cells of the branch leaves spindle-shaped in cross section, hyaline cells with papillae on the wall bordering the chlorophyllose cells . . . **S. Garberi**, 18.
Chlorophyllose cells elliptical in cross section, smooth on the wall bordering the chlorophyllose cells . **S. compactum**,[3] 17.

VI. Subsecunda.

A. *Stem and branch leaves without pores* . . **S. Pylaiei**,[4] 26.

B. *Branch leaves always porose.*

1. *Branch leaves with few pores on both faces, never in uninterrupted rows.*

Stem leaves enlarged from base upwards, upper margins involute, slightly toothed . . . . **S. Mohrianum**, *15*.

---

[1] *S. intermedium* Hoffm., L. & J. Man. 15.
[2] *S. tenellum* Ehrh., L. & J. Man. 20.
[3] *S. rigidum* Sch., L. & J. Man. 17.
[4] Including *S. sedoides* Brid., L. & J. Man. 23.

Stem leaves not enlarged from the base upwards, apex frequently cucullate and fringed.
Hyaline cells not divided . . . . . **S. obesum,** *16.*
Hyaline cells with 1–2 cross walls . . . **S. dasyphyllum,** *17.*

2. *Branch leaves with few pores on the inside, outside with numerous pores in bead-like rows.* (3)

a. *Chlorophyllose cells of branch leaves isosceles-triangular, or trapezoidal in cross section; mostly exposed on the inner face* . . . . . **S. microcarpum,** *18.*

b. *Chlorophyllose cells of branch leaves quadrate or barrel-shaped, central and exposed on both faces.* (c)

Stem mostly simple, rarely a single divergent branch **S. cyclophyllum,** 22.
Stem fasciculate-branched.
Cortex of one or (in part) two cell layers . **S. subsecundum,** 19.
Cortex of two to several cell layers.
Hyaline cells with abundant fibrils, stem leaves large (1.3–1.4 mm. long) . . . . . **S. platyphyllum,** *19.*
Hyaline cells without fibrils, or with fibrils only at apex, stem leaves smaller (.86 mm. long) . . **S. contortum,**[1] 19.

Chlorophyllose cells triangular or trapezoidal, exposed on the outer face.

Branch leaves ovate-lanceolate, plicate . . . **S. plicatum,** *20.*
Branch leaves round ovate, not plicate . . . **S. Orlandense,** *21.*

3. *Branch leaves with abundant pores on both faces.*

Chlorophyllose cells triangular or trapezoidal in cross section, mostly exposed on outer face (sometimes on both).
Hyaline cells much divided, chlorophyllose cells triangular . . . . . **S. Mobilense,** *22.*
Hyaline cells once divided, chlorophyllose cells trapezoidal, free on both faces . . . . . **S. simile,** *23.*
Chlorophyllose cells quadrate or barrel-shaped, central or exposed on both faces . . . . . **S. rufescens,** *24.*

---

[1] *S. laricinum* Spruce, L. & J. Man. 19.

VII. Cymbifolia.

A. *Chlorophyllose cells of branch leaves exposed on the inner face.*

Branch leaves minutely fringed all around . **S. Portoricense**, 22.
Branch leaves not fringed.
  Walls of the hyaline cells adjoining the chlorophyllose cells furnished with a fringe of fibrils . **S. imbricatum**,[1] 21.
  Walls of the hyaline cells adjoining the chlorophyllose cells thickly papillose . . . . . **S. papillosum**, 21.
  Walls smooth . . . . . **S. cymbifolium**, 21.

B. *Chlorophyllose cells of branch leaves exposed on both faces or included.*

[*S. cymbifolium* may be sought here.]

Cortical cells with fibrils.
  Chlorophyllose cells free on both faces, wood-cylinder dark-brown to black . . . . . **S. Waghornei**, *23a*.
  Chlorophyllose cells included, wood cylinder red . **S. medium**, *24a*.
Cortical cells not fibrillose . . . . **S. Ludovicianum**, *25*.

ANDREÆA, p. 25.

I. *Leaves ecostate.*

Leaves papillose beneath.
  Margin hyaline.
    Leaves incurved, minute, rotund obtuse, bi-ventricose . . . . . **A. parvifolia**, *26*.
    Leaves spreading or secund, acuminate, not ventricose . . . . . **A. petrophila**, 25.
    Leaves spreading, obtuse, short-pointed . . **A. papillosa**, *27*.
  Margin not hyaline . . . . . **A. alpestris**, *28*.
Leaves not papillose, upper leaf-cells rhomboid . . **A. obovata**, *29*.

II. *Leaves costate.*

Perichaetial and comal leaves different.
  Costa vanishing below apex . . . . . **A. rupestris**, 25.
  Costa excurrent.
    Subula papillose.
      Costa filling all the subula . . . **A. crassinervia**, 25.
      Costa filling half the subula . . . . **A. Huntii**, *30*.
    Subula smooth . . . . . **A. Blyttii**, *31*.

---

[1] *S. Austini* Sull., L. & J. Man. 21.

Perichaetial and comal leaves similar.
  Leaves faintly papillose, costa narrow, sometimes excurrent . . . . . **A. Macounii**, *32*.
  Leaves strongly papillose, costa 30–40μ wide, percurrent **A. nivalis**, *33*.

ARCHIDIUM, p. 49.

Autoicous.
  Costa reaching to point of leaf . . . . . **A. Ohioense**, 50.
  Costa often long excurrent . . . . . **A. Hallii**, 51.[1]
Paroicous.
  Leaves serrulate . . . . . **A. tenerrimum**, 50.
  Leaves quite entire.
    Cells oval or rhombic . . . . . **A. Ravenelii**, 50
    Cells quadrangular or quadrate . . . **A. longifolium**, 50.

MICROMITRIUM, p. 37.

Spores 63μ diameter, leaves serrate . . **M. megalosporum**, 37.
Spores 25μ diameter, nearly smooth, leaves serrate above **M. Austini**, 37.
Spores a little smaller, papillose, leaves nearly entire **M. synoicum**, 37.

EPHEMERUM, p. 37.

Leaves not costate . . . . . **E. serratum**, 37.
Leaves costate.
  Costa ending below or at apex . . . . . **E. cohærens**, 39.
  Costa excurrent.
    Seta short, capsule acutely beaked . . **E. stenophyllum**, 39.
    Seta wanting, capsule blunt pointed.
      Leaves gradually long-accuminate, slightly and irregularly serrate at apex . . . **E. crassinervium**, 38.
      Leaves with a long hyaline spinulose arista **E. spinulosum**, 38.
      Leaves papillose both sides . . . **E. papillosum**, 38.
      Leaves long-spinulose on both sides . . . **E. hystrix**, 38.

SPHÆRANGIUM, p. 40.

Leaves papillose on both faces . . . **S. Schimperianum**, 41.
Leaves smooth, or papillose on back.
  Margins reflexed, plants triquetrous . . . **S. triquetrum**, 41.
  Margins almost plane, plants round or tetragonal.
    Lower leaves ecostate . . . . . **S. rufescens**, 40.
    Lower leaves costate . . . . . **S. muticum**, 40.

---

[1]See also Appendix, no. 34.

PHASCUM, p. 41.

Capsule sub-globose, apiculate.
  Leaf margins plane or incurved, denticulate . **P. Carniolicum**, 42.
  Leaf margins reflexed, quite entire.
    Capsule immersed . . . . . **P. cuspidatum**, 42.
    Capsule sub-exserted . . . . . **P. subexsertum**, *35*.
Capsule ovate- or oblong-lanceolate . . . **P. bryoides**, 42.

PLEURIDIUM, p. 43.

Inflorescence paroicous.
  Costa reaching the obscurely serrate apex . . **P. subulatum**, 43.
  Costa excurrent into a smooth awl-shaped point . **P. Ravenelii**, 43.
Inflorescence autocious.
  Upper leaves long subulate.
    Entire or apex denticulate or serrulate . **P. alternifolium**, 44.[1]
    Serrulate from middle upward . . . . **P. Bolanderi**, 44.
  Upper leaves abruptly short pointed . . . **P. Sullivantii**, 44.

BRUCHIA, p. 45.[2]

I. *Collum none* . . . . . **B. palustris**, 45.

II. *Collum present.*

A. *Exceeding the sporangium* . . . . **B. longicollis**, *38*.

B. *Shorter than or equaling sporangium.*

1. *Capsule exserted.*

Leaves short, not subulate.
  Spores papillose . . . . . **B. Hallii**, 47.
  Spores pitted.
    Costa percurrent . . . . . **B. brevifolia**, 48.
    Costa vanishing below apex . . . . . **B. fusca**, *39*.
Leaves subulate.
  Smooth or sub-papillose.
    Costa filling point . . . . . **B. curviseta**, 47.
    Costa not filling point, apex serrulate.
      Spores spinose.
        Capsule ovoid, neck short . . . . **B. flexuosa**,[1] 46.
        Capsule elongated, neck long . . . **B. Sullivantii**, 46.

---

[1] See also Appendix, no. 36.

[2] See revision by Eliz. G. Britton, Bull. Torr. Bot, Club 21: 243. 1894.

Spores reticulate . . . . . **B. Texana**, 48.
Spores papillose . . . . . **B. Bolanderi**, 46.
Distinctly papillose . . . . . **B. Donnellii**, 48.

2. *Capsule immersed.*

Spores pitted . . . . . **B. Carolinæ**,[2] *40*.
Spores reticulate.
Calyptra popillose . . . . . **B. Ravenelii**, 49.
Calyptra smooth . . . . . **B. Drummondii**,[3] 48.

B. Beyrichiana Müll. is rejected as mixed and uncertain; *B. Hampeana* Müll. is a Chilian species.

ASTOMUM, p. 51.

Leaves not crispate when dry.
Capsule chestnut-brown, ovoid . . . . . **A. nitidulum**, 52.
Capsule orange, oval . . . . . **A. nitidulum**, var., 52.
Leaves crispate when dry.
Capsules often clustered (2–3), oblong oval . **A. Ludovicianum**, 52.
Capsule solitary.
Brown globose, capsule immersed . . . **A. crispum**, 51.
Brown globose, capsule exserted . . . **A. Drummondii**, *41*.
Orange, sub-globose, immersed . . . **A. Sullivantii**,[4] 52.

GYMNOSTOMUM, p. 52.

Lid long remaining attached to columella, capsule thick-walled, with 6–8 rows of transversely elongated cells at the mouth . . . . . **G. curvirostre**, 53.
Lid falling early, capsule thin-walled, with 3–4 rows of transversely elongated cells at mouth.
Plants 1–2 mm. high, lid conic . . . . . **G. tenue**, 54.
Plants 5–10 mm. high, lid subulate, costa 24—35μ wide at base with 2 guides[1] . . . . . **G. calcareum**,[5] 53.
Plants 1–7 cm. high, costa 70μ wide at base, with 4–6 guides[6] . . . . . **G. rupestre**, 53.

---

[1] Incl. *B. brevicollis* L. & J. Man. 47.

[2] *B. Ravenelii mollis* L. & J. Man. 49. Fuller description, Appendix no. 40.

[3] *B. brevipes* L. & J. Man. 48. *B. brevipes* Hook. is African.

[4] *A. Sullivantii* is probably a variety of *A. crispum*. Most American specimens seem to be referable to *A. Sullivantii*. (Ren. & Card.)

[5] As far as can be determined *G. platyphyllum* Kindb. (Appendix no. 44) falls here.

[6] See explanation under *Dieranum*, p. 181.

ANŒCTANGIUM, p. 54.

Leaves long-lanceolate, subulate pointed . . . **A. Peckii**, 55.
Leaves lanceolate, acute . . . . . **A. compactum**, *45*.

WEISIA, p. 55.

Inflorescence autoicous.
  Leaf margins involute, costa stout, excurrent . **W. viridula**, 55.[1]
  Leaf margins not involute, costa thin, vanishing in the acumen . . . . . **W. convoluta**, *48*.
Inflorescence dioicous.
  Teeth large, lacunose and bifid, capsule 8-sulcate **W. longiseta**,[2] 56.
  Teeth truncate, capsule not sulcate . . . . **W. Wolfii**, 57.

DICRANOWEISIA,[3] p. 57.

Leaf cells at base thick-walled, linear (1 : 6–10) . . **D. crispula**, 57
Leaf cells at base thin-walled, rectangular (1:2–3) . . **D. cirrhata**, 57.

RHABDOWEISIA, p. 58.

Leaves minutely denticulate or entire; teeth filiform, smooth, fugacious . . . . . **R. fugax**, 59.
Leaves coarsely dentate; teeth linear, obliquely crossed-striate . . . . . **R. denticulata**, 59.

CYNODONTIUM, p. 59.

Annulus very narrow and persistent or none.
  Teeth bifid or trifid, pale . . . . . **C. subalpestre**, *51*.
  Teeth bifid, red to purple.
    Collum indistinct or none . . . . . **C. gracilescens**, 60.
    Collum short, inflated and strumose . . . **C. virens**, 61.
  Teeth not bifid, purple . . . . . **C. Schisti**, 59.
Annulus distinct.
  Leaves long taper-pointed, apex serrate . . **C. polycarpum**, 60.
  Leaves more obtuse, apex crenulate . . **C. strumulosum**, *52*.

---

[1] See also Appendix, nos. 49, 50.

[2] From the examination of specimens of this species from Florida and Louisiana, Renauld & Cardot conclude that it is only a variety of the most variable and polymorphous *W. viridula*.

[3] *D. obliqua* Kindb. Mac. Cat. 256 is *nomen nudum*.

DICHODONTIUM, p. 61.

Capsule strumose . . . . . **D. Olympicum,** *54.*
Capsule not strumose.
  Costa vanishing below apex, seta yellow . . **D. pellucidum,**[1] 62.
  Costa percurrent, seta red . . . . . **D. Canadense,** 62.

TREMATODON, p. 62.

Leaves lance-subulate.
  Collum equaling or somewhat exceeding the oval oblong sporangium, teeth deeply bifid . . . **T. ambiguum,** 63.
  Collum greatly exceeding the cylindric sporangium, teeth perforate . . . . . **T. longicollis,** 63.
Leaves ovate, short pointed, teeth entire or perforate **T. brevicollis,** *55.*

DICRANELLA, p. 64.

I. *Cells of the exothecium rectangular quadrate; seta red; costa usually narrow and well defined below.*

A. *Leaves not sheathing, erect-spreading.*

Costa percurrent or excurrent.
  Annulus none, peristome papillose.
    Leaves short acuminate, blunt, costa ¼ width of leaf at base . . . . . **D. Langloisii,** *58.*
    Leaves long acuminate, costa ¼ width of leaf at base **D. Howei,** *61.*
    Leaves long acuminate, acute, costa ⅓ width of leaf at base.
      Capsule cernuous . . . . . **D. varia,** 65.
      Capsule erect, symmetric . . . . **D. rufescens,** 66.
  Annulus present, peristome not papillose.
    Teeth orange, pale at the apex, costa excurrent . **D. parvula,** *57.*
    Teeth purple, costa percurrent . . **D. leptotrichoides,** *59.*
Costa ceasing within the apex, annulus large, simple [2] **D. debilis,** 66.

B. *Leaves from a sheathing base, squarrose.*

Broad, obtuse . . . . . **D. squarrosa,** 65.
Abruptly subulate.
  Capsule striate, substrumose, leaf apex entire . **D. Grevilleana,** 64.
  Capsule not striate nor strumose, leaf apex serrulate **D. Schreberi,** 64.[3]

---

[1] See also Appendix, no. 53.
[2] As near as can be determined *D. laxiretis* R. & C. falls here. See Appendix, no. 62, 63.
[3] See Appendix, no. 56.

II. *Cells of the exothecium prosenchymatous; seta often yellow; costa usually broad and indistinct below.*

A. *Seta red.*

Leaves from a sheathing base, squarrose . . . . **D. crispa**, 64.
Leaves not sheathing nor squarrose.
Mostly erect, capsule cernuous . . . . . **D. subulata**, 66.
Secund, capsule erect . . . . . **D. curvata**, 67.

B. *Seta yellowish.*

Capsule symmetric, erect . . . . . **D. Fitzgeraldi**, *60.*
Capsule cernuous.
Strumose . . . . . **D. cerviculata**, 65.
Not strumose . . . . . **D. heteromalla**, 66.

DICRANUM, p. 67.[1]

In this genus the structure of the costa is of diagnostic value. It is either composed of similar cells (*homogeneous*), or composed of large parenchyma cells and small sclerenchyma cells (*stereids*). The large parenchyma cells (*guides* = "Deuter" of Lorentz[2]) form a row (seldom double) in the middle of the costa touching each other tangentially. They are comparatively large, but little thickened and either empty or starch-bearing.[3]

I. *Monoicous, stems radiculose only at base, costa long excurrent, homogeneous.*

Capsule erect, not strumose.
Striate and furrowed when dry . . . . **D. hyperboreum**,[4] *64.*
Neither striate nor furrowed when dry . . **D. fulvellum**, 68.
Capsule cernuous, strumose.
Leaf cells not papillose, capsule oblong-cylindric **D. Starkii**, 68.
Leaf cells with papillæ over partitions, capsule short-ovate.
Leaves falcate-secund . . . . . **D. falcatum**,[5] 68.
Leaves spreading . . . . . **D. Blytii**, 68.

---

[1] Arranged by Dr. Rodney H. True.
[2] Pringsheim's Jahrb. f. wissensch. Bot. 6: 374.
[3] Limpricht: Die Laubmoose 23.
[4] See Appendix, no. 65.
[5] See Appendix, no. 65a.

II. *Monoicous, eradiculose, costa vanishing, guides present.* (III) . . . . . **D. molle,** *66.*

III. *Dioicous, stems subradiculose above, costa very broad, 2–4-stratose, superficial cells thin, without chlorophyll, capsule erect, regular.* (IV.)

Costa one-half leaf-width at base.
  Costa not furrowed at back, smooth . . . **D. albicans,** 71.
  Costa furrowed and toothed at back . . . **D. longifolium,** 70.[1]
Costa one-fifth to one-fourth leaf-width at base . . **D. Sauteri,** *68.*[2]

IV. *Dioicous, stems radiculose, often densely so, costa with median guides.*

A. *Capsule cernuous, more or less arcuate.*

1. *Leaf cells pitted.*

a. *Costa not reaching apex, leaves mostly transversely undulate.*

Leaf cells above elongated.
  Costa serrate at back, not lamellose . . . **D. Bonjeani,** 74.[3]
  Costa with serrate lamellæ.
    Capsules clustered, perichaetial leaves differentiated **D. undulatum,** 76.
    Capsules solitary (?), perichaetial leaves like others . . . . . **D. dipteroneuron,** *75.*[4]
    Capsules solitary, perichaetial leaves tubulose, abruptly narrowed . . . . . **D. Bonjeani,** 74.[3]
Leaf cells above isodiametric.
  Margin smooth to near tip . . . . . **D. brachycaulon,** *88.*
  Margin serrate or denticulate.
    Upper costa and lamina rough at back.
      Capsules clustered, leaf margins sharply serrate **D. Drummondii,** 76.
      Capsules solitary, leaf margins finely denticulate above widened base . . . . . **D. spurium,** 75.
    Costa and lamina smooth at back, capsules solitary, margins irregularly denticulate in upper half **D. Bergeri,** 75.[5]

---

[1] See Appendix, no. 67.
[2] See Appendix, no. 68.
[3] *D. palustre* La Pyl., L. & J. Man. See Appendix, nos. 85–87.
[4] Ex descr. probably =*D. Bonjeani* DeNot.
[5] *D. Schraderi* W. & M., L. & J. Man. 75.

b. *Costa percurrent or excurrent, leaves not undulate.*

[*D. Bonjeani* may be sought here.]

Guides in two rows . . . . . **D. majus**, 74.
Guides in one row.
Margin serrulate to middle of leaf, back of costa lamellose.
Seta yellow, capsule long and narrow (1 : 5–6) **D. consobrinum**, *84*.
Seta red, capsule broader (1 : 4) . . . **D. scoparium**, 73.[1]
Margin entire to near apex, back of costa not lamellose.
Cells above narrow (1 : 5–6) leaves brittle . . **D. neglectum**, *73*.
Cells above isodiametric, leaves not brittle **D. brachycaulon**, *88*.

2. *Leaf cells not pitted or faintly so.*

Leaves quite entire or denticulate, subulate.
Points very brittle, mostly broken . . . **D. fragilifolium**, 73.
Points not broken . . . . . **D. elongatum**, 71.
Leaves entire, upper obtuse.
Cells throughout elongated, thickened, pitted **D. Groenlandicum**, *89*.
Cells short, quadrate above, not pitted . . **D. Miquelonense**, *72*.
Leaves serrulate.
Upper cells very irregular.
Capsules cylindrical, striped or striated.
Costa at point of greatest leaf-width one-sixth or more . . . . . **D. Muhlenbeckii**, 72.[2]
Costa at point of greatest leaf-width one-tenth or less.
Cells of upper third of lamina short (8–10 × 10–17μ) . . . . . **D. pallidum**, *76*.
Cells of upper third of lamina narrower, larger, (15 × 50μ) . . . . . **D. rhabdocarpum**, 73.
Capsules ovate-oblong, not striped or but faintly **D. congestum**, 72.[3]
Upper cells regular, capsule obovate-oblong, striped **D. fuscescens**, 72.

B. *Capsule erect, symmetric.*

Costa without stereids . . . . . **D. strictum**, 69.

---

[1] See Appendix, nos. 77–83.
[2] See Appendix, no. 74.
[3] *D. fuscescens* L. & J. Man. 72 in part.
[4] *D. fuscescens longirostre* and *angustifolium* L. & J. Man. 72. See Appendix, nos. 70, 71.

Costa with two stereid bands.
  Lamina above more or less bi-stratose.
    Margin and costa serrulate . . . . . **D. fulvum**, 70.
    Margin entire, apex usually broken . . . **D. viride**, 69.
  Lamina throughout uni-stratose.
    Upper cells rectangular and mamillose . . **D. montanum**, 69.
    Upper cells less regular, not mamillose . . . **D. flagellare**, 70.

DICRANODONTIUM, p. 77.

Cells at the basal angles enlarged.
  Quadrate, teeth deeply bifid . . . . . **D. Millspaughi**,[1] *90*.
  Rectangular, teeth bifid to base . . . . . **D. longirostre**, 77.
Cells at the basal angles not enlarged . . . **D. Virginicum**, *89*.

CAMPYLOPUS, p. 77.

I. *Costa smooth at back.*

A. *Auricles none.*

[*C. gracilicaulis* may belong here.]

Cells of the costa uniform in transverse section . . **C. Leanus**, 78.
Cells of the costa unlike in transverse section, stereids forming 2–3 dorsal layers.
  Hyaline cells superior, in one row . . . **C. Schimperi**, *91*.
  Hyaline cells superior, in two rows . . . **C. Henrici**, *92*.

B. *Auricles present.*

No lamina except small colored auricles . . . **C. Hallii**, 79.
Lamina distinct.
  Perichætial leaves concolorous.
    Auricles brown, plane, decurrent . . . **C. Tallulensis**, 78.
    Auricles whitish, large.
      Leaves serrulate at apex . . . . . **C. subleucogaster**, 79.
      Leaves spinulose serrate at apex . . . **C. Donnellii**, 79.
    Auricles dirty red . . . . . **C. angustiretis**, 80.
  Perichætial leaves with hyaline points (may include *C. Donnellii* and *C. angustiretis*) . . . **C. gracilicaulis**, 80.

---

[1] *Campylopus flexuosus* L. & J. Man. 78, not of Bridel. *C. flexuosus* Brid. is not found in America.

II. *Costa scabrous or lamellose at back.*

Leaves with pellucid hair points . . . . . **C. introflexus**, 78.
Leaves not hair pointed.
Alar cells round, lamina wanting . . . . . **C. frigidus**, 79.
No auricles . . . . . **C. Virginicus**, 80.

FISSIDENS, p. 81 (*incl. Conomitrium, p. 89.*[1])

I. (EUFISSIDENS.) *Plants terrestrial or submersed but not floating; leaves soft, one layer of cells.*

A. *Fruit terminal.*

1. *Monoicous, male flowers axillary.*

[*F. falcatulus* may be sought here.]

Leaf-cells small, densely chlorophyllose, in distinct rows **F. limbatus**, 82.
Leaf-cells large, not densely chlorophyllose, nor in distinct rows . . . . . **F. bryoides**, 81.

2. *Dioicous or monoicous with the male flowers terminal on a rooting branch at the base of the female stem.*

a. *Leaf-cells* 1½–2 *times as long as wide, large, distinct.*

Plants less than 1 mm. high, leaves two or three pairs **F. Closteri**, 81.
Plants 2–4 mm. high, wholly hyaline, leaves 3–5 pairs **F. hyalinus**, 84.

b. *Leaf-cells almost or quite isodiametric, often obscure.*

[*F. limbatus* may be sought here.]

Leaves with a narrow border, at least on vaginant lamina.
Marginal leaf-cells not papillose.
Leaves acute, costa percurrent.
Vaginant lamina not reaching middle of leaf, peristome arising below the mouth . . . . **F. pusillus**, *94*.
Vaginant lamina reaching middle of leaf, peristome not arising below the mouth . . . . **F. incurvus**,[2] 82.
Leaves obtuse, costa vanishing below apex **F. obtusifolius**, var. *95*.

---

[1] See Barnes: Bot. Gaz. 12: 1. 1882.
[2] See Appendix, no. 93.

Marginal leaf-cells papillose.
Costa percurrent . . . . . **F. Ravenelii**, 85.
Costa ceasing below apex . . . . . **F. Garberi**, 86.
Leaves without a border.
Acute, cells densely chlorophyllose, obscurely papillose **F. Donnellii**, 85.
Acute, almost hyaline, smooth . . . **F. pauperculus**, *99*.
Obtuse, cells pellucid, operculum conic . . **F. obtusifolius**, 86.
Apiculate, operculum with acicular beak . **F. osmundoides**, 87.
Leaves with a thick reddish border. Plants submersed, rigid . . . . . **F. rufulus**, 84.[1]

B. *Fruit lateral.*

1. *Leaves without a border.*

Obtuse, entire, plants 2–5 cm. high, fruit sub-terminal **F. polypodioides**, 88.
Rounded at apex, irregularly serrate, 1–2 cm. high, fruit sub-basal . . . . . **F. sub-basilaris**, 88.
Mucronate, regularly serrulate, fruit basal or sub-basal **F. taxifolius**,[2] 87.

2. *Leaves bordered by several rows of paler, often incrassate, cells.*

Leaf margin serrulate.
Leaf cells obscure (6–9 × 6–12μ) . . **F. cristatus**, Wils.,[3] 87.
Leaf cells distinct (12–15 × 18–24μ) . . . **F. adiantoides**,[4] 88.
Leaves entire or slightly denticulate at the apex.
Inferior lamina bordered, ceasing abruptly at base **F. Floridanus**, 83.
Inferior lamina not bordered, tapering below . **F. falcatulus**, *98*.

II. (PACHYFISSIDENS.) *Leaves rigid, composed of more than one layer of cells, opaque.*

Plants growing in water or very wet places . . **F. gradifrons**, 89.

III. (OCTODICERAS.)[5] *Plants aquatic, filiform, floating.*

Plants large, much branched, pedicel shorter than the capsule . . . . . **F. Julianus**, 89.
Plants small, little branched, pedicel longer than the capsule . . . . . **F. Hallianus**, 90.

---

[1] *F. ventricosus* of L. & J. Man.
[2] See Appendix, no. 96.
[3] *F. decipiens* De Not., L. & J. Man.
[4] See Appendix, no. 97.
[5] *Conomitrium* of Manual.

In the Revision of N. A. species of Fissidens,[1] *FF. inconstans*, *exiguus* and *minutulus* were reduced to *F. incurvus*, the latter two forming varieties. *FF. bryoides cæspitans*, *crassipes*, *Hallii* and *Texanus* are relegated to the list of doubtful species. *FF. Bambergeri* Schimp. I regard as a form of *F. incurvus; F. viridulus* is a form, possibly a subspecies, of the same. It may be known by its thin-walled capsule, with the peristome inserted below the mouth. Neither are worthy of a distinct place in the key. "*F. tamarindifolius* Don" (Mac. Cat. 36), seems to be *F. tamarindifolius* Brid. which is a variety of *F. incurvus*.

LEUCOBRYUM,[2] p. 90.

Capsule apparently lateral (by innovations), leaves ovate lanceolate.
- Robust, tufts 4–6 cm. deep . . . **L. glaucum** (L.) Sch.,[3] 90.
- Smaller tufts scarcely 2 cm. deep . **L. glaucum albidum**,[4] 91.

Capsule exactly terminal, leaves squarrose, very short and very broad . . . . . **L. minus**,[5] 91.

CERATODON, p. 92.

Costa percurrent or vanishing below apex.
- Capsule distinctly strumose, articulations of teeth few . . . . . **C. heterophyllus**, *101*.
- Capsule not distinctly strumose, articulations of teeth many . . . . . **C. purpureus**, 92.

Costa long excurrent, teeth articulate to the middle.
- Leaf margin entire . . . . . **C. conicus**, *100*.
- Leaf margin serrulate toward apex . . . . **C. minor**, 92.

TRICHODON, p. 92.

Cells of the leaf base linear, above rectangular or indistinct . . . . . **T. cylindricus**, 93.

Cells of leaf base rectangular (1 : 2–4), above quadrate **T. flexifolius**, *102*.

DISTICHIUM, p. 93.

Costa long excurrent.
- Capsule erect, spores 17–20μ . . . . . **D. capillaceum**, 93.
- Capsule cernuous, spores 30–44μ . . . **D. inclinatum**, 94.

Costa percurrent or vanishing below the apex . **D. Macounii**, *106*.

---

[1] See Barnes: Bot. Gaz. **12**: 1. 1889.

[2] See E. G. Britton, Bull. Torr. Bot. Club **19**: 189. 1892.

[3] *L. vulgare* L. & J. Man. 90.

[4] *L. albidum* (Brid.) Lindb. *L. minus* Sulliv. non Hampe.

[5] *L. sediforme* L. & J. Man. 91.

SELIGERIA, p. 96.

Seta straight when moist.
  Leaves sharp pointed, cells above rectangular, spores 10–14μ . . . . . **S. pusilla**, 96.
  Leaves blunt-pointed, cells above quadratic, spores 14–18μ . . . . . **S. calcarea**, 97.
  Leaves mostly blunt-pointed, cells rectangular, spores 24–32μ . . . . . **S. tristicha**, 97.
Seta arcuate when moist.
  Leaves long-subulate, costa excurrent . . . **S. recurvata**, 97.
  Leaves sub-linear, obtuse, costa not excurrent **S. campylopoda**, *107*.

POTTIA, p. 100.

I. *Peristome wanting or rudimentary.*

Costa with 2–4 lamellæ above . . . . . **P. cavifolia**, 101.
Costa not lamellate.
  Leaf margins more or less revolute.
    Lid conic obtuse, spores echinate . . . **P. minutula**, 101.
    Lid rostellate, spores papillose.
      Calyptra smooth.
        Capsule obovate spherical (1 : 1) or sub-hemispherical . . . . . **P. truncata**, 101.
        Capsule oblong-oval (1 : 2).
          Leaves minutely papillose toward apex, basal cells 1 : 4 . . . . . **P. intermedia**, *110*.
          Leaves smooth, basal cells 1 : 5–6 . . **P. littoralis**, *111*.
      Calyptra scabrous . . . . . **P. Wilsoni**, 101.
  Leaf margins plane or involute.
    Lid abruptly rostrate, leaves sharply serrate above **P. Heimii**,[1] 102.
    Lid conic, leaves distantly denticulate above . **P. riparia**, 102.
    Lid conic-subulate, leaves slightly crenulate above **P. Barbula**, 102.

II. *Peristome distinct.*

Leaves oblong-lanceolate, margins revolute . . **P. Starkeana**, 103.
Leaves rounded or round-spatutate, margins plane **P. latifolia**, 103.

---

[1] *P. heimioides* Kindb. (Appendix, no. 109), evidently falls here. The great resemblance of the two makes the specific value of *P. heimioides* extremely doubtful.

DIDYMODON, p. 104.

Leaf cells throughout quadratic . . . . . **D. luridus**, 104.
Leaf cells below rectangular.
  Inflorescence synoicous . . . . . **D. rubellus**, 104.
  Inflorescence dioicous.
    Lid conic, leaves denticulate . . . **D. Baden-Powellii**, *113*.
    Lid rostrate.
      Basal cells thick-walled.
        Lamina and costa long papillose . . . **D. rufus**, *115*.
        Lamina and costa minutely papillose . **D. Hendersoni**, *114*.
      Basal cells thin walled.
        Perichætial leaves gradually narrowed . **D. cylindricus**, 105.
        Perichætial leaves abruptly attenuate . **D. Canadensis**, *112*.

DITRICHUM, p. 105.[1]

Dioicous.
  Leaves slightly twisted.
    Stem leaves spreading, perichætial leaves hardly sheathing . . . . . **D. tortile**, 105.
    Stem leaves imbricate, perichætial leaves long sheathing . . . . . **D. vaginans**, 106.
  Leaves not twisted.
    Plants short (1–2 cm.), not radiculose.
      Teeth without a basilar membrane . . **D. homomallum**, 107.
      Teeth with a broad basilar membrane . **D. ambiguum**, *104*.
    Plants long (to 10 cm.), densely radiculose. . **D. flexicaule**, 107.[2]
Monoicous.
  Plants short (5–10 mm.).
    Teeth cylindric, legs unequal, nodose-articulate, leaves spreading . . . . . **D. pallidum**, 107.
    Teeth cylindric, legs equal, obscurely and distantly articulate, leaves spreading . **D. montanum**, *103*.
    Teeth flattened, linear, trabeculate, perforate, leaves secund . . . . . **D. Schimperi**, 108.
  Plants longer (2–3 cm.), glaucous . . . **D. glaucescens**, 108.

---

[1] *Leptotrichum* Hampe, L. & J. Man. 105.

[2] *Leptotrichum brevifolium* Kindb., Mac. Cat. 46, is described as a subspecies of *L. flexicaule* Hampe. The characters given however are not sufficient to justify a place in this key. See Appendix, no. 105.

TRICHOSTOMUM, p. 108.

I. *Lamina composed of one layer of cells, papillose.*

Margin reflexed or undulate, entire.
  Annulus wanting . . . . . **T. tophaceum, 109.**
  Annulus large, compound . . . . . **T. pyriforme, 109.**
Margin plane or incurved.
  Costa reaching apex or excurrent; serrate above.
    Base of leaf yellowish, with thick walled rectangular cells . . . . . **T. crispulum, 109.**
    Base of leaf hyaline.
      Abruptly mucronate or obtuse, with long papillæ **T. flavo-virens, 109.**
      Gradually acuminate, papillæ low . . . **T. nitidum,** *118.*
  Costa ceasing far below apex; entire . . **T. Coloradense, 413.**

II. *Lamina of two layers, upper surface mamillose, lower smooth.*

Costa excurrent, leaves denticulate above . **T. Vancouveriense,** *119.*
Costa percurrent or vanishing below apex, serrate above.
  Peristome not twisted, seta arcuate or variously bent **T. flexipes, 110.**
  Peristome twisted, seta subflexuous . . . **T. anomalum, 110.**

DESMATODON, p. 110.

I. *Capsule erect or nearly so.*

A. *Leaves without a hyaline or thickened border.*

1. *Costa excurrent into a hair.*

a. *Papillose.*

Capsule oblong (1 : 2 or 1 : 3 excl. lid), 16 teeth divided nearly or quite to base.
  Plants of mountainous regions; calyptra reaching base of capsule . . . . . **D. latifolius, 111.**
  Plants of lowlands; calyptra reaching half way to base of capsule . . . . . **D. Guepini, 114.**
Capsule cylindric (1 : 5–6); teeth divided half way or entire.

[*D. obliquus* may be sought here.]

  Dioicous . . . . . **D. plinthobius, 112.**
  Monoicous . . . . . **D. Neo-Mexicanus, 113.**

b. *Not papillose* . . **D. Systilius, 111.**

2. *Costa vanishing at apex or forming a short point.*

Leaves hyaline ¾ of their length . . . **D. obtusifolius, 114.**
Leaves hyaline only at base.
Margins revolute.
Capsule long cylindric, leaves crenulate . . **D. arenaceus, 111.**
Capsule elliptic, leaves entire . . . . . **D. nervosus,[1] 113.**
Margins inflexed above . . . . . **D. Garberi, 112.**

B. *Leaves with a pellucid border* **D. Porteri, 112.**

II. *Capsule nodding, or pendent, or arcuate.*

Leaves with a thickened border below.
Seta straight, capsule nodding or horizontal . **D. cernuus,[2] 114.**
Seta reflexed, capsule pendent . . . . **D. Laureri, 115.**
Seta flexuous, capsule arcuate . . . **D. camptothecius,** *121.*
Leaves without a border . . . . . **D. obliquus, 115.**

BARBULA, p. 115.

I. *Leaves with jointed dichotomous filaments on the costa.*

Costa broad (½ leaf), flattened, leaves thick, rigid **§I. Aloidellæ, p. 192.**
Costa narrow, round, leaves thin, broad . **§II. Chloronotæ, p. 192.**

II. *Leaves not filamentose.*

Teeth from a low membrane, scarcely projecting from the mouth [excl. *B. brevipes*].
Plants small.
Leaf cells distinct . . . . . **§III. Cuneifoliæ, p. 192.**
Leaf cells small.
Perichætial leaves little different from the foliage. **§IV. Unguiculatæ, p. 193.**
Perichætial leaves long sheathing or convolute **§V. Convolutæ, p. 195.**
Plants robust [excl. *B. cæspitosa*].
Leaves entire; stems radiculose . . **§VI. Tortuosæ, p. 195.**
Leaves serrate, stems not radiculose . **§VII. Squarrosæ, p. 195.**
Teeth from a high tesselated membrane **§VIII. Syntrichiæ, p. 195.**

---

[1] *D. subtorquescens* C. M. & Kindb. (Appendix, no. 120) appears to be identical with *D. nervosus* B. & S.

[2] See Appendix, no. 122.

§I. Aloidellæ.

Synoicous . . . . . **B. brevirostris**, 115.
Dioicous.
  Annulus broad, revoluble, lid ½ to ⅔ length of capsule.
    Peristome twice twisted.
      Leaves round-ovate, obtuse . . . **B. macrorhyncha**, *125*.
      Leaves oblong, obtuse or apiculate . . . **B. rigida**, 116.
    Peristome straight or slightly twisted . . **B. aloides**, *162*.
  Annulus small, persistent, lid ⅓ length of capsule **B. ambigua**, 116.

§II. Chloronotæ.

Leaves with hair points.
  Tip of leaf hyaline . . . . . **B. membranifolia**, 116.
  Tip of leaf concolorous.
    Hair smooth, leaves acute or somewhat obtuse **B. chloronotos**, 116.
    Hair serrate, leaves rounded obtuse . . . **B. Henrici**, *126*.
Leaves without hair points . . . . . **B. Manniæ**, *127*.

§III. Cuneifoliæ.

Leaves bordered by 2–4 rows of thickened cells . **B. marginata**, 118.
Leaves bordered by 1 row of round yellowish cells with
  prominent papillæ, aristate . . . . . **B. Vahliana**, 117.
Leaves with a broad yellowish border, not pointed **B. Egelingi**, *128*.
Leaves without a border.
  Costa excurrent into a hoary hair . . . . **B. muralis**, 119.
  Costa forming a short point or ceasing below apex.
    Leaf cells smooth.
      Margins plane.
        Upper leaves opaque at the margins . **B. cuneifolia**, 117.
        Upper leaves pellucid at the margins **B. subcarnifolia**, *130*.
      Margins recurved above and below the middle at
        one side . . . . . **B. carnifolia**, *129*.
    Leaf cells papillose [incl. *B. amplexa?*]
      Peristome membrane long . . . . . **B. brevipes**, 119.
      Peristome membrane short.
        Inner perichætial leaves short . . **B. Bolanderi**, 118.
        Inner perichætial leaves long-sheathing, abruptly
          reflexed . . . . . **B. amplexa**, 118.

§IV. Unguiculatæ.

[*B. cæspitosa* may be sought here.]

I. *Peristome wanting* . . . . . **B. rubiginosa**, 126.

II. *Peristome present.*

A. *Teeth straight or scarcely twisted.*

Basal leaf cells rectangular.
  Teeth cancellate . . . . . **B. cancellata**, 122.
  Teeth nodose, separate.
    Leaves long lanceolate, costa dark . . . **B. rigidula**, 123.
    Leaves ovate lanceolate, costa pale . . **B. sparsidens**, *133*.
Basal leaf cells elongate-oval . . . . . **B. spadicea**, *139*.

B. *Teeth plainly twisted.*

1. *Leaves blunt or mucronate by the excurrent costa.*

Leaves short, ovate, the very apex obtuse.
  Capsule cylindric, calyptra reaching middle . **B. brachyphylla**,[1] 123.
  Capsule ovate, calyptra reaching base . . **B. purpurea**, 123.
Leaves longer, narrower, sharp pointed.
  Cells at base rectangular and pellucid.
    Teeth twisted 2–3 times, purple or red.
      Capsule oblong-elliptic to subcylindrical, sub-incurved . . . . . **B. unguiculata**, 120.
      Capsule oblong, small, erect . . . **B. Jooriana**, 120.
    Teeth once loosely twisted, pale . . **B. tortellifolia**, *144*.
  Cells at the base quadrate, chlorophyllose . **B. Cruegeri**, 122.

2. *Leaves gradually pointed.*

a. *Leaves not papillose* [incl. *B. artocarpa?*]

Leaf border plane.
  Annulus none, teeth reddish . . . . . **B. gracilis**, 127.
  Annulus large, simple, persistent, teeth whitish **B. artocarpa**, 126.
Leaf border reflexed all around or revolute below.
  Leaves long-subulate, costa percurrent or excurrent, red . . . . . **B. subgracilis**,[2] *135*.

---

[1] See Appendix, no. 131.
[2] See Appendix, no. 136.

Leaves long lanceolate, costa filling the acumen, brown . . . . . **B. pseudo-rigidula,** *140.*

b. *Leaves papillose.*

i. *Cells at base roundish, quadrate, or short-rectangular.*

Annulus none or indistinct.
  Leaves twisted when dry.
    Costa 70μ wide at base and tapering gradually . **B. fallax,** 121.
    Costa 50μ wide, of equal breadth to middle **B. recurvifolia,** 122.
  Leaves not twisted when dry.
    Costa pale, percurrent . . . . **B. subicmadophila,** *137.*
    Costa brown, short excurrent . . . **B. melanocarpa,** *138.*
Annulus pale, compound . . . . . **B. elata,** 125.

ii. *Cells at base rectangular, often elongated.*

[*B. fallax* may be sought here.]

Leaves erect-incurved, imbricate when dry.
  Cells (above) 5–7μ diameter . . . . . **B. vinealis,** 124.
  Cells twice as large . . . . . **B. virescens,** 124.
Leaves squarrose-spreading or reflexed, twisted when dry.
  Perichætial leaves open, sheathing only at base, revolute on edges . . . . . **B. subfallax,** 121.
  Perichætial leaves half sheathing.
    Annulus simple, narrow, persistent.
      Leaves erect, half clasping at base . . **B. semitorta,**[1] 126.
      Leaves recurved, deeply concave . . **B. circinnatula,** *141.*
    Annulus double or triple.
      Cells 5–7μ in diameter . . . . . { **B. cylindrica,** 125. **B. flexifolia,** 124.
      Cells twice as large . . . . . **B. virescens,** 124.

BB. vinealis, flexifolia, virescens, cylindrica, with possibly *semitorta* and *circinnatula,* are doubtless forms of one species, so that the key will probably break down here.

BB. decursivula, Dieckii, horridifolia, robustifolia, and *subcylindrica,* belonging to this section, are described from sterile specimens and therefore cannot be included in the key, but descriptions will be found in the Appendix nos. 132, 134, 142, 143, and 145.

---

[1] In L. & J. Man. 126, in note under *B. semitorta,* read "Comparable to *B. vinealis*" instead of *B. brachyphylla.* See Pacif. R. R. Rept. 4: 186.

§V. Convolutæ.

Leaves involute on margin.
  Aristulate by excurrent costa . . . . . **B. agraria**, 128.
  Acute or submucronate . . . . . **B. Donnellii**, 128.
Leaves plane on margin or recurved.[1]
  Capsule costate when dry . . . . . **B. Raui**, 128.
  Capsule smooth.
    Leaves acute, costa percurrent . . . **B. convoluta**, 127.
    Leaves with hyaline point . . . . . **B. Closteri**, 127.
    Leaves obtuse.
      Perichætial leaves rounded or truncate at apex **B. chrysopoda**, *148*.
      Perichætial leaves obtuse or short apiculate **B. convoluta** var. *147*.

§VI. Tortuosæ.

Leaf margin plane or undulate when moist.
  Leaves long linear, acute, abruptly mucronate . **B. cæspitosa**, 129.
  Leaves very long acuminate, cuspidate.
    Twisted crispate when dry, above of one layer of cells **B. tortuosa**, 129.
    Not crispate, brittle, two layers of cells above . **B. fragilis**, 129.
Leaf margin involute, cucullate above . . . **B. inclinatula**, *149*.

§VII. Squarrosæ.

Includes but one species . . . . . **B. squarrosa**, 130.

§VIII. Syntrichiæ.

[*B. brevipes* may be sought here.]

I. *Leaves with a border of thickened cells.*

Leaves with a distinct border, sometimes absent at the apex, plane.
  Marginal cells elongated . . . . . **B. subulata**,[2] 130.
  Marginal cells roundish . . . . . **B. lævipila**, 132.
Leaves with a narrow border at the base only.
  Basal cells faintly chlorophyllose . . . **B. lato-excisa**, *160*.
  Basal cells strongly chlorophyllose . . **B. papillinervis**, *156*.

---

[1] *B. platyneura* C. M. & Kindb., described from barren specimens falls here. See Appendix, no. 146.

[2] See Appendix, no. 150.

II. *Leaves not bordered.*

Cells smooth . . . . . **B. mucronifolia,** 131.
Cells papillose.
  Monoicous.
    Costa percurrent . . . . . { **B. inermis,** 131. / **B. subulata mutica,** 130.
    Costa excurrent into a long (mostly smooth) hyaline hair; on trees . . . . . **B. lævipila,** 132.
    Costa excurrent into a short point; on rocks . **B. alpina,** *151.*
  Polygamous, costa excurrent into a hyaline spinulose hair . . . . . **B. Muelleri,** 133.
  Dioicous.
    Costa percurrent or ceasing below apex . . **B. latifolia,** 132.
    Costa short-excurrent, clothed above with gemmæ **B. papillosa,** 133.
    Costa naked, excurrent into a hyaline, spinulose hair.
      Hair white throughout.
        Tube of peristome nearly equaling purple teeth in length.
          Peristome twice twisted.
            Costa abruptly excurrent.
              Hair point spinulose . . . . . **B. ruralis,**[1] 132.
              Hair point nearly smooth . . . **B. leptotricha,** *159.*
            Costa gradually excurrent . . . **B. ruraliformis,** *153.*
          Peristome once twisted . . . . . **B. intermedia,** *157.*
        Tube of peristome much shorter than the pale teeth . . . . . **B. læviuscula,** *155.*
      Hair red at the base or throughout.
        Leaves not sheathing, patent when moist . . . . . **B. rotundo-emarginata,** *161.*
        Leaves sheathing, squarrose-spreading, all the margin recurved . . . . . **B. aciphylla,** *158.*
        Leaves sheathing, curved, margin slightly recurved in the middle . . . **B. brachyangia,** *154.*

The very great similarity of *BB. ruraliformis*, *branchyangia*, *læviuscula*, *papillinervis*, *intermedia*, *aciphylla*, *leptotricha* and *lato-excisa* renders it more than probable that they are all forms of the extremely variable and polymorphic *B. ruralis*, as *B. megalocarpa* Kindb. is; wherefore the key is likely to prove useless in distinguishing them.

---

[1] See Appendix, no. 152.

SCOULERIA, p. 137.[1]

Leaves bordered by slightly larger, thick walled cells, peristome present . . . . . **S. aquatica,**[2] 137.
Leaves bordered by larger denser cells, peristome absent **S. marginata,** *164.*

GRIMMIA, p. 134.

Capsule longer than the seta.
  Straight, capsule symmetric . . . . . **§I. Schistidium.**
  Crooked, capsule ventricose . . . . . **§II. Gasterogrimmia.**
Capsule shorter than the seta.
  Seta arcuate . . . . . **§III. Eugrimmia.**
  Seta straight . . . . . **§IV. Guembelia.**

§I. Schistidium.

Leaves with hyaline points.
  Capsule oblong . . . . . **G. ambigua,** 135.
  Capsule ovate-globose.
    Leaves erect or appressed when dry.
      In small, dense cushions, soft lurid green . **G. conferta,**[3] 135.
      In lax cushions, coarse, fuscescent.
        Peristome distinct, orifice dilated . . **G. sphærica,** *191.*
        Peristome rudimentary, orifice not dilated **G. apocarpa,** 136.
    Leaves spreading when dry . . . . **G. heterophylla,** *168.*
Leaves muticous.
  Margin plane.
    Entire or slightly serrate at the apex.
      Ovate-oblong, short . . . . . **G. atricha,** *169.*
      Linear lanceolate . . . . . **G. maritima,** 137.
    Coarsely dentate at the apex . . . . . **G. Agassizii,** 136.
  Margins recurved or revolute . . . . { **G. conferta** / **G. apocarpa** } vars.[4]

---

[1] *Grimmia* § *Scouleria*, L. & J. Man. 137. This genus has lately been revised by Mrs. Elizabeth G. Britton, Bull. Torr. Bot. Club **22**: 36. 1895. *S. Muelleri* Kindb. and *S. aquatica catilliformis* Müll. are reduced to *S. aquatica* Hook. *S. Nevii* is referred to *S. aquatica nigrescens* Kindb.

[2] *Grimmia Scouleri* Müll. See Appendix, no. 163.

[3] *G. chloroblasta* Kindb. (Appendix, no. 167) falls here.

[4] See Appendix, nos. 165, 166. *G. platyphylla* Mitt. (L. & J. Man. 136) = *G. apocarpa latifolia* Zett. *sec.* Ren. & Card. Rev. Bryol. **19**: 85. 1892. A barren species, *G. pachyneurula* C. M. & Kindb., Mac. Cat. 65 (see Appendix, no. 170), evidently belongs to this section.

§II. Gasterogrimmia.

Peristome wanting, lamina bistratose near apex . . **G. anodon**, 138.
Peristome present, lamina unistratose throughout **G. plagiopoda**, 138.

§III. Eugrimmia.

Capsule costate when dry.
  Leaves homomallous-falcate when dry . . . **G. hamulosa**, 139.
  Leaves spirally twisted on stem when dry . . **G. torquata**, 140.
  Leaves incurved-cirrhate when dry . . . . **G. contorta**, 139.
  Leaves imbricate or slightly twisted when dry, hair pointed.
    Lamina of one layer of cells . . . . **G. pachyphylla**, *181*.
    Lamina 2–4-stratose in the upper part or at the margin.
      Hair point rough . . . . . **G. Muhlenbeckii**, 140.
      Hair point smooth.
        Annulus simple, monoicous . . . **G. pulvinata**, 138.
        Annulus compound (3–4), dioicous.
          Costa narrow, capsule 8-striate or costate.
            Lid short . . . . . **G. funalis**, *179*.
            Lid long, straight . . . . **G. trichophylla**, 141.
          Costa strong, capsule 10-striate . . **G. elatior**, *172*.
Capsule not costate (or obscurely) when dry.
  Leaves falcate-reflexed when moist . . . **G. Watsoni**, 141.
  Leaves not reflexed.
    Margin plane, capsule elliptic, collum none . **G. Olneyi**, 142.

[*G. Muhlenbeckii* may be sought here.]

    Margin reflexed.
      Leaves gemmiferous, capsule oval-oblong.
        Teeth papillose, leaf cells at base scarcely sinuous . . . . . **G. Philbertiana**, *171*.
        Teeth smooth, leaf cells at base strongly sinuous . . . . . **G. Hartmanii**, *174*.
      Leaves not gemmiferous.
        Open, erect, lanceolate . . . **G. Californica**, 142.
        Arcuate, ovate-lanceolate . . . . . **G. depilata**, *175*.

Only incomplete descriptions of the following species can be obtained and they are therefore not included in the key: *GG. arcuatifolia* Kindb., *Arizonæ* Ren. & Card., *prolifera* C. M. & Kindb., *tortifolia* Kindb., and *Hendersonii* Ren. & Card. See descriptions in Appendix, nos. 173, 176, 177, 178, 180.

§IV. Guembelia.

Lamina above 2–4-stratose.
  Calyptra cucullate.
    Leaves hair pointed.
      Basal cells quadrate . . . . . **G. tenerrima**, *188*.
      Basal cells rectangular . . . . . **G. commutata**, 145.
    Leaves not hair-pointed, blunt or hyaline apiculate.
      Teeth entire, annulus simple, indistinct . . **G. sulcata**, *186*.
      Teeth irregularly lacerate or bifid, annulus compound, triple . . . . . **G. unicolor**, 146.
  Calyptra mitrate.
    Leaf margins plane.
      Hair point very rough, lid straight beaked **G. leucophæa**, 144.
      Hair point faintly denticulate, lid obliquely beaked . . . . . **G. sarcocalyx**, *190*.
    Leaf margins recurved.
      Walls of basal cells sinuate . . . **G. Pennsylvanica**, 144.
      Walls of basal cells smooth . . . . . **G. ovata**, 143.
Lamina having only the margin 2–4-stratose.
  Leaves muticous or hyaline, apiculate.
    Costa reaching the hyaline apex, dioicous . . **G. elongata**, *185*.
    Costa vanishing far below apex, monoicous **G. Coloradensis**, 143.
  Leaves hair-pointed.
    Annulus wanting.
      Calyptra mitrate, covering whole capsule **G. calyptrata**, 144.
      Calyptra cucullate . . . . . **G. montana**, 145.
    Annulus present.
      Cells of leaf base elongated (1 : 4 to 1 : 8) . **G. Donniana**, 142.
      Cells of leaf base short (1 : 2), borders plane **G. alpestris**, 146.
      Cells of leaf base short, borders recurved **G. microtricha**, *187*.
Lamina of a single layer of cells . . . . . **G. mollis**, *189*.

The descriptions of *GG. cinclidodontea* C. Müll., *crassinervis* C. Müll., *tenella* C. Müll., and *Manniæ* C. Müll. are incomplete and as no authentic material is at hand they are not included in the key. See Appendix, nos. 182, 183, 184, 184a.

RHACOMITRIUM, p. 147.

I. *Branches fastigiate.*

Leaves with a short hyaline point . . . **R. Sudeticum**, 149.
Leaves muticous.
  Costa with 2–4 lamellæ at back . . . . . **R. patens**, 147.

Costa not lamellose.
Leaves with quadrate cells at the base, decurrent and semi-auricled . . . . . **R. depressum**, 148.
Leaves with linear cells at the base, neither decurrent nor auricled.
Obtuse.
Perichætial leaves costate, seta long . . **R. aciculare**, 148.
Perichætial leaves ecostate, seta short . . **R. Nevii**, 148.
Acute.
Capsule oblong, not striate, teeth orange **R. Macounii**,[1] *193*.
Capsule oval, striate or plicate when dry, teeth purple . . . . . **R. robustifolium**, *195*.

II. *Branches fasciculate.*

A. *Leaves muticous.*

Cells elongated above . . . . . **R. fasciculare**, 150.
Cells quadratic above.
Costa percurrent.
Leaf cells smooth . . . . . **R. varium**,[2] 150.
Leaf cells rough, simple papillæ over the lumen **R. canescens**, 151.
Costa vanishing below apex, cells with geminate papillæ over the partitions . . . . **R. protensum**, *192*.

B. *Leaves with a hyaline point.*

Cells linear at least above.
Hyaline point not papillose . . . . **R. microcarpum**,[3] 150.
Hyaline point strongly erose-serrate and papillose **R. lanuginosum**,[4] 151.
Cells quadratic above.

[*R. micropus* may be sought here.]

Strongly papillose on both sides . . . . **R. canescens**,[5] 151.
Smooth or nearly so.
Annulus broad.
Alar cells of leaf linear . . . **R. heterostichum**,[6] 149.

---

[1] *R. alternatum* C. M. & Kindb., described from barren specimens, seems to be referable to this species. See Appendix, no. 194.

[2] *R. Oreganum* Ren. & Card., Bot. Gaz. 13: 198. *pl. 15.* 1888, is this species (*fide* J. Cardot *in litt.*) which seems to be *R. canescens lutescens* L. & J.; *fide* Mrs. E. G. Britton *in litt.*

[3] See Appendix. no. 200.

[4] See Appendix, no. 202.

[5] See Appendix, nos. 203, 204.

[6] See Appendix, nos. 196–198.

Alar cells of leaf quadrate . . . . . **R. micropus**, *199*.
Annulus none . . . . . **R. speciosum**, *201*.

COSCINODON, p. 154.

Costa not entering the hyaline point, which is less than the leaf in length.
Dioicous, leaves oblong lanceolate . . . . **C. pulvinatus**, 154.
Autoicous, leaves obovate . . . . . **C. Raui**,[1] 155.
Costa forming a rough hyaline point twice as long as the leaf . . . . . **C. Wrightii**, 155.

PTYCHOMITRIUM, p. 156.

Plants large (3 cm. +), leaves acuminate, sharply dentate **P. Gardneri**, 156.
Plants small (1 cm. —), leaves not acuminate, nearly or quite entire.
Collum none.
Teeth subulate (1 : 10), entire . . . . . **P. incurvum**, 157.
Teeth lanceolate (1 : 4), bi- or trifid . . . . **P. Drummondii**, 157.
Collum equalling one-third sporangium . . . . **P. pygmæum**, 157.

AMPHORIDIUM, p. 158.

Leaf margins plane, entire . . . . . **A. Lapponicum**, 158.
Leaf margins recurved or revolute.
Leaves remote, recurved-spreading, serrate . **A. Sullivantii**, 159.
Leaves close.
Costa excurrent, seta arcuate . . . . **A. Californicum**, 159.
Costa vanishing below apex.
Entire . . . . . **A. Mougeotii**, 159.
Serrulate . . . . . **A. cæspitosum**, 160.

ZYGODON.[2]

Capsule without a peristome . . . . . **Z. viridissimus**, *207*.
Capsule with double peristome . . . . . **Z. conoideus**, *208*.

---

[1] Including *C. Renauldi* Card., Bot. Gaz. 15: 41. 1890.
[2] See appendix, no. 206.

ULOTA,[1] p. 160.

I. *Leaves rigid, not crispate when dry.*

[*U. Drummondii* may be sought here.]

Costa percurrent . . . . . **U. Hutchinsiæ,**[2] 163.
Costa ceasing below apex . . . . . **U. Barclayi,** 164.

II. *Leaves crispate when dry.*

Capsule not constricted below the mouth when dry.
  Costate only at the mouth . . . . . **U. Ludwigii,** 161.
  Costate for its whole length.
    Stems creeping, leaves slightly crispate, cilia 0 **U. Drummondii,** 161.
    Stems not creeping, leaves strongly crispate, cilia present.
      Capsule short oval, neck short.
        Upper leaves tipped with gemmæ . . **U. phyllantha,** 163.
        Upper leaves not tipped with gemmæ . . **U. Bruchii,**[3] 162.
      Capsule cylindric, neck long . . . **U. maritima,**[4] *211.*
Capsule constricted below the mouth when dry.
  Cells uniform throughout the leaf . . **U. megalospora,**[5] *210.*
  Cells different at the angles.
    Teeth lacunose at the apex . . . . . **U. curvifolia,**[6] 161.
    Teeth not lacunose.
      Neck very long, teeth confluent . . . **U. crispa,**[7] 162.
      Neck shorter, teeth separated at apex . . . **U. crispula,** 163.

---

[1] It seems best, while retaining for convenience the generic name *Ulota* (without expressing any opinion as to its validity), to utilize Mrs. Britton's careful study of our American species. The nomenclature used is also derived in part from her paper in Bull. Torr. Bot. Club 21: 65-76. 1894.

[2] See Appendix, no. 212.

[3] From the description given (Mac. Cat. 82) I am unable to separate *U. obtusiuscula* C. M. & Kindb.

[4] Renauld and Cardot think that *U. maritima* and *U. phyllantha* resemble each other so closely that *U. maritima* should not stand as a distinct species.

[5] Including *U. subulata* and *U. subulifolia* C. M. & Kindb., Mac. Cat. 82, *sec.* Eliz. G. Britton.

[6] Including *U. Americana* Mitt., Man. 162, and probably *U. scabrida* Kindb., Mac. Cat. 83. (E. G. B.)

[7] Including *U. camptopoda* and *U. connectens* Kindb., Mac. Cat. 85. (E. G. B.)

ORTHOTRICHUM, p. 164.

I. *Stomata superficial.*

1. *Peristome simple.*

Capsule entirely smooth.
  Wholly exserted . . . . . **O. lævigatum**, 165.
  Immersed . . . . . **O. Schlotthaueri**, *218*.
Capsule strongly costate.
  Leaves densely papillose.
    Capsule wholly exserted, abrupt at base, teeth 8 **O. Douglasii**, 167.
    Capsule immersed or emergent, defluent into seta, teeth 16.
      Leaf bistratose in the upper part . . . **O. Sturmii**, 166.
      Leaf unistratose . . . . . **O. rhabdophorum**, *227*.
  Leaves almost smooth . . . . . **O. bullatum**, *222*.
Capsule ribbed only near the mouth.
  Teeth striolate, capsule exserted . . . . . **O. Roellii**, *217*.
  Teeth papillose, capsule immersed . . . . . **O. Shawii**, *213*.

2. *Peristome double.*

[*OO. lævigatum, Sturmii, Roellii* and *Schlotthaueri* may be sought here.]

a. *Capsule entirely smooth.*

Immersed, papillæ simple . . . . . **O. striatum**,[1] 174.
Exserted, papillæ bifurcate.
  Alar cells thick walled, quadrate to hexagonal **O. arcticum**, *228*.
  Alar cells not thickened, rectangular.
    Leaf margin revolute, capsule cylindrical when moist . . . . . **O. Macounii**, *228a*.
    Leaf margin reflexed, capsule obovate when moist **O. Kingianum**, 170.

b. *Capsule strongly costate.* (c)

Leaves beset with clavate gemmæ, teeth reflexed, cilia 16 **O. Lyellii**,[2] 177.
Leaves not gemmiferous.
  Teeth erect when dry, cilia 16 . . . . . **O. Texanum**, 166.
  Teeth reflexed when dry, cilia 8.
    Cilia of two rows of cells, broad.
      Leaf margins plane, cilia broad throughout **O. obtusifolium**, 177.
      Leaf margins revolute, cilia broad at base . **O. sordidum**, 170.

---

[1] *O. leiocarpum* B. & S.
[2] See Appendix, no. 221.

Cilia of a single row of cells or double at the base.
Capsule immersed or emergent.
Teeth papillose, not vermicular striate . . **O. affine**, 168.
Teeth vermicular striate, not papillose **O. fastigiatum**, *214*.
Capsule exserted.
Teeth not papillose . . . . . **O. Blyttii**, *229*.
Teeth minutely papillose . . . . **O. praemorsum**, *226*.

c. *Capsule ribbed only near the mouth.*

Teeth erect when dry.
Papillæ of leaves simple, minute . . . . . **O. rupestre**, 167.
Papillæ of leaves bifurcate, salient . . . **O. Killiasii**, *225*.
Teeth reflexed when dry.
Upper part of leaf bistratose, teeth transversely lineolate . . . . . **O. Bolanderi**, 167.
Upper part of leaf unistratose, teeth very papillose.
Teeth when dry reflexed and applied to capsule **O. elegans**, *224*.
Teeth when dry touching capsule only with tip **O. speciosum**,[1] 169.

Three little known and unimportant species from Greenland (Mac. Cat. 88): *OO. Breutelii* Hpe., *Barthii* Sendtn., and *Groenlandicum* Bergg., belonging to the division with superficial stomata are not included in the key. According to Venturi in Husn. Musc. Gall. 175, the first two are only forms of *O. Blyttii*.

II. *Stomata immersed.*

1. *Peristome simple, capsule costate.*

Leaves obtuse, capsule immersed or emergent **O. Jamesianum**, 177.
Leaves acute or acuminate.
Capsule long exserted, teeth erect when dry . **O. anomalum**, 164.
Capsule half-emergent, teeth spreading when dry **O. cupulatum**, 165.

[*O. Hallii* may be sought here.]

2. *Peristome double.*

a. *Capsule smooth when dry.*

Cilia wider than teeth . . . . . **O. exiguum**, 174.
Cilia narrow.
Capsule gradually narrowed to seta . . . . . **O. pallens**, 175.
Capsule abruptly contracted to seta . . **O. pusillum** Mitt.[2] 173.

---

[1] See Appendix, no. 223.
[2] *O. psilocarpum* James.

b. *Capsule costate when dry.*

* *Leaves hyaline pointed.*

Cilia of a single row of cells, teeth equidistant . **O. diaphanum**, 176.
Cilia of two rows of cells, teeth bigeminate . . . **O. canum**, 176.

* * *Leaves obtuse.* (* * *)

[*OO. tenellum, pumilum, pallens* and *strangulatum* may also be sought here.]

Capsule exserted . . . . . **O. cylindrocarpum**, 173.
Capsule immersed.
Abruptly contracted to the seta, collum not evident.
Teeth papillose . . . . . **O. euryphyllum**, *219*.
Teeth vermicular striate . . . . . **O. Hallii**, 170.
Gradually narrowed to seta with evident collum.
Teeth 8, bigeminate, reflexed when dry.
Punctulate, cilia of 2 rows of cells . . . **O. Ohioense**, 170.
Papillose, cilia double at the base only.
Cilia 8, shorter than the teeth . . . **O. Sprucei**, *215*.
Cilia 16, eight as long, eight shorter than the teeth **O. rivulare**, 176.
Teeth 16, separate, erect when dry . . . **O. nudum**, *220*.

* * * *Leaves acute.*

Capsule exserted.
Abruptly contracted to seta, collum not evident.
Cilia 16, single series of cells . . . **O. ulotæforme**, *235*.
Cilia 8, double row of cells . . . . **O. consimile**, 173.
Gradually narrowed to the seta with evident collum,
cilia 16, appendiculate . . . . **O. pulchellum**,[1] 175.
Capsule immersed or nearly.
Leaves with salient furcate papillæ.
Teeth 16, separate . . . . . **O. urnigerum**, *216*.
Teeth 8, bigeminate.
Cilia of a double row of cells.
Teeth papillose throughout, split along the median
line . . . . . **O. pumilum Americanum**, *230*.
Teeth punctate, yellowish white . . . **O. Watsoni**, 168.
Teeth finely papillose below, paler above with long-
itudinal sinuous lines, somewhat perforate **O. alpestre**, 168.
Cilia double at the base, single above . **O. Schimperi**,[2] 171.

[1] See Appendix, nos. 233, 234.

[2] *O. fallax* Schimp.

Leaves with simple often weak papillæ.

[*OO. Schimperi* and *pumilum* may be sought here.]

Cilia of a single row of cells . . . . . **O. Hendersoni,** *232.*
Cilia of a double row of cells.
Teeth granulose, not papillose, capsule obovate, contracted below the mouth when dry **O. strangulatum,** 172.
Teeth papillose, capsule sub-cylindric, little contracted below mouth when dry.
Calyptra hairy, teeth pale brown . . **O. tenellum,** 172.
Calyptra naked, teeth reddish . . . **O. Rogeri,** *231.*

"Notes on North American Species of Orthotrichum" by E. G. Britton, Bull. Torr. Bot. Club **20**: 393. 1893 and **21**: 1, 137. 1894, have been followed in many points. *O. psilothecium* C. M. & Kind. is reduced to *O. strangulatum; O. Pringlei* C. Müll. to *O. Lyellii; O. brachytrichum* Schimp. to *O. Schimperi; O. stenocarpum* Vent. to *O. Macounii* Aust. *O. stellatum* Brid. and *O. anomalum Americanum* are rejected as doubtful.

MACROMITRIUM, p. 178.

Capsule plicate at mouth and base only . . **M. Sullivantii,** 178.
Capsule costate its whole length.
Lid conic, blunt, peristome wanting . . . **M. Fitzgeraldi,** 178.
Lid subulate, peristome present . . . **M. rhabdocarpum,** 179.
Capsule smooth . . . . . **M. mucronifolium,** 179.

ENCALYPTA, p. 180.

I. *Capsule spirally striate and sulcate when dry.*

Capsule twisted to the right when dry, leaves with hyaline hair points, teeth glabrous . . . . . **E. Selwyni,** 183.
Capsule twisted to the left when dry.
Leaves cucullate . . . . . **E. cucullata,** *238.*
Leaves not cucullate.
Leaves acute or apiculate, teeth papillose, with a median line . . . . . **E. procera,** 182.
Leaves muticous, usually obtuse, teeth filiform, nodose, minutely papillose . . . **E. streptocarpa,** 183.

II. *Capsule vertically striate and sulcate when dry, or smooth.*

Distinctly striate.
  Leaves plane or slightly concave.
    Oblong or lanceolate above, calyptra scabrous **E. rhabdocarpa**, 181.
    Short, often subspatulate, calyptra not scabrous **E. leiomitra**, *237*.
  Leaves revolute all around, narrow . . . **E. Alaskana**, *240*.
Smooth or faintly striate.
  Calyptra entire or lacerate at the base.
    Smooth at the apex . . . . . **E. commutata**, 180.
    Papillose or spinose at the apex.
      Costa long excurrent . . . . **E. subspathulata**, *236*.
      Costa percurrent or vanishing.
        Capsule minutely wrinkled lengthwise . **E. vulgaris**, 181.
        Capsule smooth when dry . . . . **E. leiocarpa**, *239*.
  Calyptra fringed at base, peristome present.
    Leaves apiculate-acuminate . . . . . **E. ciliata**, 183.
    Leaves muticous . . . . . **E. Macounii**, 182.

E. apophysata N. & H., *sec.* Schimper Synop. Musc. Europ. 345 [ed. 2] collected by Drummond is probably an error. See Appendix, no. 241.

CALYMPERES, p. 184.

Leaves oblong or broad-ovate.
  Upper leaves very obtuse, often filamentose at apex **C. Richardi**, 184.
  Upper leaves acute, often filamentose in middle **C. disciforme**, 184.
Leaves narrowly panduriform, obtuse or retuse **C. (?) crispum**, 184.

SYRRHOPODON, p. 185.

Leaf margins bilamellate upwards . . . . **S. Floridanus**, 185.
Leaf margins single throughout . . . . . **S. Texanus**, 185.

TETRAPHIS, p. 186.

Pedicel straight . . . . . **T. pellucida**, 186.
Pedicel geniculate at middle . . . . . **T. geniculata**, 187.

DISSODON, p. 189.

Seta short (5 mm.), thick, capsule erect, chestnut brown . . . . . **D. Hornschuchii**, 189.

Seta longer (1.5 cm.), plants 1–2 cm. high, capsule often inclined, orange . . . . . **D. Froelichianus**, 190.
Seta longer (3–4 cm.), plants 4–12 cm., capsule erect, orange . . . . . **D. splachnoides**, 190.

TAYLORIA, p. 190.

Teeth cleft along the middle line or split to the base.
Columella long exserted, lid long conic . **T. splachnoides**, 191.
Columella scarcely exserted, lid suddenly obliquely beaked . . . . . **T. acuminata**, *243*.
Teeth neither cleft nor split but sometimes lacunose.
Columella scarcely exserted, rhizoids with gemmæ **T. serrata**, 191.
Columella long exserted, rhizoids without gemmæ **T. tenuis**, 191.

TETRAPLODON, p. 191.

Leaves sharply serrate, narrowed to filiform point **T. angustatus**, 192.
Leaves distantly incised-serrate, gradually acuminate **T. australis**, 192.
Leaves entire, more or less abruptly filiform-apiculate.
Costa sub-excurrent, empty sporangium constricted in middle . . . . . **T. mnioides**, 192.
Costa ceasing below point, empty sporangium not constricted in middle . . . . . **T. urceolatus**, 193.

SPLACHNUM, p. 193.

Apophysis ovate or subglobose.
About the size of the sporangium.
Costa excurrent, apophysis red . . . . **S. sphæricum**, 194.
Costa ceasing below apex, apophysis at first green then brown . . . . . **S. Wormskioldii**, 194.
Greatly exceeding the sporangium . . . **S. vasculosum**, 194.
Apophysis pyriform, exceeding the sporangium **S. ampullaceum**, 194.
Apophysis campanulate.
Purple . . . . . **S. rubrum**, 195.
Yellow . . . . . **S. luteum**,[1] 195.

---

[1] See also Appendix, no. 254.

PHYSCOMITRIUM, p. 196.

Capsule or seta immersed.

[*P. Hookeri* may be sought here.]

Capsule subglobose . . . . . **P. immersum**, 196.
Capsule pyriform when fresh . . . . **P. Coloradense**, *250*.
Capsule and seta exserted.
Leaves entire or nearly so.
Seta short, but little exceeding leaves . . **P. Hookeri**, 198.
Seta much longer (5–20 mm.).
Leaves very acute, bordered . . . **P. acuminatum**, 198.
Leaves oblong-lanceolate, more obtuse, not bordered . . . . . **P. Californicum**, *253*.
Leaves serrate at least above the middle.
Mouth of capsule bordered by 4–8 rows of cells.
Seta straight.
Leaves oblong acuminate, annulus double **P. pygmæum**, 197.
Leaves lanceolate, annulus apparently single **P. Drummondii**, *251*.
Leaves ovate-acuminate, annulus apparently single . . . . . **P. Kellermanii**, *249*.
Seta curved . . . . . **P. australe**, *252*.
Mouth of capsule bordered by 8–12 rows of cells.
Capsule turbinate, 1–2 mm., mouth flaring **P. turbinatum**,[1] 198.
Capsule pyriform, 2–3 mm. mouth not flaring **P. megalocarpum**, *248*.

The revision of the genus by Mrs. E. G. Britton, Bull. Torr. Bot. Club **21**: 189. 1894, has been followed. *P. pyriforme* Brid. is a European species and does not occur in America; American specimens called *pyriforme* are referable to *P. turbinatum* Müll. *P. strangulatum* Kindb., Ott. Nat. **4**: 62, is reduced to *P. turbinatum*. *P. platyphyllum* Kindb., Mac. Cat. 269, is rejected, as the species is founded upon such very immature specimens that it probably can not stand.

ENTOSTHODON, p. 199.

Leaves acute, capsule short-pyriform.
Costa percurrent, teeth dark red, striolate . **E. Drummondii**, 199.
Leaves acuminate, capsule long-pyriform.
Costa reaching middle, teeth whitish, granulose **E. Bolanderi**, 199.
Costa subpercurrent, teeth red, nodose, papillose **E. Templetoni**, 200.

---

[1] See also Appendix, nos. 245–247.

FUNARIA, p. 200.

Annulus wanting.
- Leaves entire or nearly.
  - Capsule arcuate, leaves acuminate.
    - Costa excurrent . . . . . **F. Americana**, 201.
    - Costa vanishing . . . . . **F. Mediterranea**, 201.
  - Capsule erect, leaves acute . . . . **F. Californica**, 201.
- Leaves sharply serrate.
  - Short-pointed, lid convex, mamillate . . . **F. serrata**,[1] 201.
  - Long acuminate, lid short conic . . . . **F. calcarea**, 201.

Annulus large, revoluble.
- Capsule irregularly plicate and furrowed.
  - Leaves with involute margins . . . . **F. convoluta**, 202.
  - Leaves with plane margins . . . . **F. flavicans**, 202.
- Capsule distinctly striate-costate.
  - Leaves short-acuminate, lid large, spores 12–17μ **F. hygrometrica**, 202.
  - Leaves long-acuminate, lid small, spores 24–28μ **F. microstoma**, 203.

BARTRAMIA, p. 203.

Capsule erect, peristome simple or none.
- Leaves lance-subulate, ovate at the base.
  - Margin reflexed, capsule rugose when dry . **B. Menziesii**, 204.
  - Margin plane, capsule furrowed when dry.
    - Capsule exserted, basal cells alike . . . **B. subulata**, 204.
    - Capsule immersed, basal cells shorter towards the margin . . . . . **B. breviseta**, *256*.
- Leaves linear, gradually tapering to subulate apex, capsule ribbed . . . . . **B. stricta**, 205.

Capsule curved, lid oblique, peristome double.
- Seta short (= capsule), fruit pseudo-lateral . **B. Halleriana**, 206.
- Seta exceeding stems.
  - Leaves smooth . . . . . **B. Œderiana**,[2] 205.
  - Leaves papillose only on upper surface . . **B. radicalis**, 206.
  - Leaves papillose on both surfaces.
    - Abruptly narrowed and bent above the hyaline base . . . . . **B. ithyphylla**, 205.
    - Gradually tapering to apex, not hyaline at base.
      - Leaves straight, autoicous.
        - Margined, borders revolute . . **B. pomiformis**, 206.

---

[1] See also Appendix, no. 255.

[2] *B. Œderiana minor* Kindb., Mac. Cat. 105, is *nomen nudum*.

Not margined, sheathing . . . **B. glauco-viridis,** *257.*
Leaves circinate, long sheathing . **B. circinnulata,** *258.*

PHILONOTIS, p. 208.

Leaves plicate lengthwise.
Leaf cells linear, costa excurrent . . . **P. Mohriana,** 210.
Leaf cells rectangular or oval, costa percurrent or vanishing . . . . . **P. seriata,** *262.*
Leaves not plicate lengthwise.
Leaf cells quadrate, slightly papillose . . . **P. Macounii,** 208.
Leaf cells oblong hexagonal, slightly papillose **P. glabriuscula,** *263.*
Leaf cells rectangular to linear.
Cilia two, rudimentary . . . . . **P. Muhlenbeckii,** 208.
Cilia two, half as long as or equaling segments.
Mouth of capsule with 8 rows of transversely elongated cells . . . . . **P. fontana,**[1] 209.
Mouth of capsule with 4 rows of transversely elongated cells . . . . . **P. calcarea,** 209.

MEESIA, p. 212.

Leaves entire, margins reflexed or revolute.
Synoicous, costa very thick ($\frac{1}{3}$ leaf base) . . **M. uliginosa,** 212.
Autoicous, costa narrow ($\frac{1}{7}$ leaf base) . . **M. Albertinii,** 213.
Leaves entire, margins plane . . . . . **M. longiseta,** 212.
Leaves serrate . . . . . **M. tristicha,** 213.

MIELICHHOFERIA, p. 214.

Leaves lanceolate, sharply serrate at apex . . . **M. nitida,** 214.
Leaves broad ovate, entire, or slightly crenulate above **M. cuspidifera,** *264.*

WEBERA, p. 215.

[***Bryum Froudei*** and ***B. angustirete*** will be sought here.]

I. *Leaves with a reddish border, distinct to apex* **W. Tozeri,** 222.

II. *Leaves not bordered, or indistinctly.*

---

[1] See Appendix, nos. 259–261.

A. *Annulus present.* (B on p. 213.)

1. *Segments and cilia of endostome imperfect, often only a laciniate membrane* . . **W. camptotrachela,** *278.*

2. *Segments of endostome not widely open along the keel, cilia none or short* (excl. *W. longicolla*). (3)

Inflorescence autoicous . . . . . **W. acuminata,** 216.
Inflorescence synoicous or dioicous.
Costa very broad, ⅓–¼ of leaf base . . . **W. Cardoti,** *265.*
Costa narrow.
Plants less than 1 cm., seta 5–8 mm., capsule wide mouthed when dry . . . . . **W. nudicaulis,** 220.
Plants small, seta longer, mouth of capsule constricted when dry . . . . . **W. Bolanderi,** 220.
Inflorescence paroicous.

[*W. nudicaulis* may be sought here.]

Neck shorter than sporangium, cilia none . **W. polymorpha,** 216.
Neck equaling sporangium, cilia more or less developed.
Tufts low, 1 mm.–2 cm. high . . . . . **W. elongata,** 216.
Tufts higher, 2–5 cm. . . . . **W. longicolla,** 217.

3. *Segments of endostome split and gaping along keel, cilia well developed.*

Inflorescence paroicous or polygamous.
Capsule pendent, touching seta, not contracted under mouth . . . . . **W. cucullata,** 218.
Capsule horizontal or pendent, not touching seta, contracted below mouth.
Costa excurrent, comal leaves revolute on the borders . . . . . **W. canaliculata,** *271.*
Costa vanishing below apex, comal leaves plane on the borders.
Tufts 1–2 cm. high, basal membrane of the endostome ⅓ to ½ height of teeth . . . **W. nutans,**[1] 217.
Tufts 2–4 cm. high, basal membrane of the endostome ¼ height of teeth . . . . . **W. cruda,**[2] 218.

---

[1] See Appendix, nos. 269, 270.
[2] See Appendix, no. 267.

Inflorescence dioicous.
  Leaves with plane or slightly curved borders.
    Antheridia in the axils of the perigonial leaves.
      Upper leaves lance linear (1 : 8–50) seta 3–4 cm. **W. sphagnicola,** 219.
      Upper leaves lanceolate (1 : 4–5) seta 1–2 cm. **W. gracilis,** *275.*
    Antheridia in a terminal cluster . . . **W. Lescuriana,** 221.
  Leaves with mostly revolute borders.
    Costa vanishing below apex.
      Leaves of sterile shoots ovate, obtuse; comal leaves broad pointed, margin entire . . **W. Ludwigii,** *274.*
      Leaves narrow, linear lanceolate, sharp pointed, plainly toothed near the apex.
        Seta twisted to right, membrane of the inner peristome ½ length of teeth, capsule oval, short necked.
          Annulus revoluble, costa red . . **W. Columbica,** *279.*
          Annulus remaining attached to lid, costa green **W. pulchella,** 222.
        Seta twisted to left, membrane ⅓ length of teeth, capsule pyriform, longer necked . **W. commutata,** 220.
    Costa reaching the apex.
      Capsule oval, long necked, leaves serrate at apex **W. annotina,** 219.
      Capsule obovate, short-necked, leaves denticulate above . . . . . **W. pycnodecurrens,** *277.*

B. *Annulus none.*

Leaves nearly entire, cilia very short . . **W. Drummondii,** 219.
Leaves nearly entire, cilia 3 . . . . . **W. Bigelovii,** 223.
Leaves sharply serrate.
  Stem red, leaves glaucous-green . . . . **W. albicans,**[1] 222.
  Stem and leaves green . . . . . **W. carnea,** 221.

[*W. pulchella* may be sought here.]

A number of species have been described from sterile and immature specimens, whence it is impossible to determine their place in the key. They are *W. longibracteata* Broth., 268; *W. microapiculata* C. M. & Kindb., 281; *W. polymorphoides* Kindb., 266; *W. microcaulon* C. M. & Kindb., 272; *W. subcucullata* C. M. & Kindb., 273; *W. microdenticulata* C. M. & Kindb., 276. The first two are sterile, the remaining four are immature. The numbers attached refer to corresponding descriptions in the Appendix.

---

[1] See Appendix, no. 280.

BRYUM, p. 223.

Upper leaf cells rhombic to hexagonal (sublinear in *BB. Froudei* and *angustirete*).
  Plants not from stolons.
    Cilia none, or inappendiculate . . . . . **§I. Cladodium.**
    Cilia 2–4, appendiculate . . . . . **§II. Eubryum.**
  Plants from stolons . . . . . **§III. Rhodobryum.**
Upper leaf cells linear (1 : 10–15), branches julaceous **§IV. Anomobryum.**

§I. Cladodium.

A. *Autoicous.*

Leaves broad (1 : 2) costa vanishing . . . **B. calophyllum,** 227.
Leaves ovate-lanceolate or long acuminate.
  Cilia 2, long, smooth . . . . . **B. Brownii,** 224.
  Cilia 3, short . . . . . **B. mamillatum,** *288.*
  Cilia none, or rudimentary.
    Capsule symmetric, pyriform, collum ½ sporangium.
      Leaves faintly bordered, serrate above, slightly revolute . . . . . **B. Warneum,** 226.
      Leaves faintly bordered, margin entire, distinctly revolute . . . . . **B. Edwardsianum,** *291.*
      Leaves very distinctly bordered, broadly revolute . . . . . **B. Biddlecomiæ,** 226.
    Capsule usually unsymmetric, elongate, collum = sporangium . . . . . **B. uliginosum,** 227.

B. *Synoicous, or heteroicous.* (C)

Costa long excurrent.
  Endostome attached to peristome.
    Spores verruculose . . . . . **B. arcticum,** 224.
    Spores smooth, about 30μ . . . . . **B. pendulum,** 225.
    Spores smooth, 20–25μ.
      Teeth orange red . . . . . **B. angustirete,** *284.*
      Teeth pale . . . . . **B. Roellii,** *285.*
  Endostome free, or slightly attached.
    Seta 3–4 cm. long, capsule 1 : 2.5–3.
      Upper leaf cells long hexagonal . . **B. inclinatum,**[1] 225.

[1] *B. stenotrichum* C. Müll. will be sought here; and I am unable from the description alone to discover any essential difference between it and *B. inclinatum.* See Appendix, no. 290.

Upper leaf cells sublinear . . . . . **B. Froudei,** *282.*
Seta 1 cm. long, capsule 1.2 : 2 . . **B. Archangelicum,** *287.*
Costa short excurrent or percurrent.
Leaves not bordered . . . . . **B. Knowltoni,** *292.*
Leaves bordered.
Decurrent, seta 1 cm. long . . . **B. brachyneuron,** *286.*
Decurrent, seta 2–3 cm. long . . . **B. Labradorense,** *289.*
Not decurrent.
Costa excurrent, leaves reddish, margin scarcely revolute . . . . . **B. purpurascens,** 224.
Costa vanishing or barely excurrent, margin strongly revolute . . . . . **B. lacustre,** 226.

[*B. flexuosum* may be sought here.]

C. *Dioicous.*

Collum smooth or rugose when dry.
Endostome adherent to peristome, cilia none . **B. flexuosum,** 227.
Endostome free, cilia present.
Costa percurrent, teeth bright purple . **B. Californicum,** 237.
Costa short excurrent, teeth orange . **B. subpurpurascens,** *283.*
Collum longitudinally sulcate when dry.
Leaf cells pitted, perichætial leaves costate, . . **B. œneum,** *294.*
Leaf cells not pitted, inner perichætial leaves ecostate **B. fallax,** *293.*

§II. Eubryum.

A. *Synoicous.*

Costa not excurrent.
Leaf margin serrate above, apex straight . . **B. Oreganum,** 230.
Leaf margin entire, apex recurved . . . **B. nitidulum,** *305.*
Costa excurrent into a smooth point.
Margins recurved . . . . . **B. torquescens,**[1] 230.
Margins plane . . . . . **B. microstegium,** *302.*
Costa excurrent into a serrate point.
Leaves not decurrent, long cuspidate.
Not bordered, entire . . . . . **B. intermedium,**[2] 228.
Not bordered, serrate or denticulate above **B. synoico-cæspiticium,** *316.*
Bordered . . . . . **B. cirrhatum,**[3] 228.

---

[1] See Appendix, no. 344. On account of the imperfect description I cannot place *B. sanguilentum* in the Key.
[2] See Appendix, no. 295.
[3] See Appendix, no. 296.

Leaves decurrent.
With a broad border.
Leaves short-pointed . . . . . **B. bimum,**[1] 229.
Leaves long-cuspidate . . . . . **B. cuspidatum,** *297.*
Without a border . . . . . **B. lonchocaulon,** 229.

B. *Polygamous.* (C)

Leaves long cuspidate by excurrent costa, not bordered **B. provinciale,** 230.

C. *Autoicous.* (D)

Leaves bordered, costa percurrent or excurrent.
Border wide, 5–6 rows of cells, distinctly revolute **B. pallescens,**[2] 231.
Border narrow, faintly revolute . . **B. anœctangiaceum,** *328.*
Leaves not bordered.
Costa excurrent . . . . . **B. subrotundum,** 231.
Costa vanishing below the apex . . . . . **B. teres,** *306.*

D. *Dioicous.*

1. *Costa not excurrent, or when excurrent forming a short point only* (2 on p. 218.)

a. *Leaves obtuse.*

Distant, broadly ovate or oblong, rounded . **B. cyclophyllum,** 237.
Thickly clothing stem, generally imbricate, narrower.
Not bordered.
Leaves strongly decurrent . . . **B. obtusifolium,** *325.*
Leaves not decurrent . . . . . **B. capitellatum,** *313.*
Bordered, sometimes indistinctly.
Dull olive-green, margins strongly revolute.
Membrane of endostome ½ length of peristome **B. Muhlenbeckii,** 233.
Membrane of endostome low . . **B. rubicundulum,** *314.*
Yellowish or dull green or purplish.
Costa vanishing below apex, tips of branches crimsoned.
Cells polygonal, thick walled . . . **B. miniatum,** 233.
Cells rhombic, sub-quadrate below . **B. Atwateriæ,** 234.
Costa percurrent, red, branch tips green **B. percurrentinerve,** *312.*

---

[1] See Appendix, nos. 298, 299.
[2] See Appendix, nos. 303, 304.

b. *Leaves pointed, costa percurrent or excurrent.* (c)

i. *Capsule short (1:2), abrupt at base.*

Capsule blood-red or dark purple, teeth red at base **B. atropurpureum,** 232.
Capsule pale, teeth pale throughout . . **B. microglobum,** *307.*

ii. *Capsule longer (1:3+), tapering at base.*

* *Blood red to dark purple.*

Plants short (5–15 mm.) in small lax, yellowish-green tufts.
Collum half length of sporangium . . **B. erythrocarpum,** 232.
Collum equaling or exceeding the sporangium in length . . . . . **B. micro-erythrocarpum,** *308.*
Plants larger (3–5 cm.), in large tufts.
Tufts shining red or purplish . . . . . **B. alpinum,** 233.
Tufts greenish, costa yellow, percurrent or excurrent . . . . . **B. hæmatocarpum,** *311.*

* * *Yellowish-brown.*

Slightly incurved.
Constricted below mouth . . . . . **B. meesioides,** *336.*
Not constricted . . . . . **B. pallens,** 237
Symmetric.
Strongly constricted below mouth.
Stems about 1 cm. high . . . . . **B. turbinatum,** 238.
Stems 4–10 cm. high . . . . . **B. Schleicheri,** 239.
Slightly constricted below mouth.
Leaves long decurrent . . . . . **B. extenuatum,** *323.*
Leaves not decurrent or only slightly.
Leaf margin plane.
Pale on the borders . . . . . **B. Sawyeri,** *322.*
Red on the borders . . . . . **B. erubescens,** *324.*
Leaf margins revolute.
Margin serrate at the apex . . **B. pseudotriquetrum,**[1] 238.
Margin quite entire.
Cilia single . . . . . **B. acutiusculum,** *321.*
Cilia 2–3 . . . . . **B. crassirameum,** *329.*

c. *Leaves pointed, costa vanishing.*

[*B. extenuatum* and *B. crassirameum* may be sought here.]

Leaves distinctly margined . . . . . **B. capillare,**[2] 235.

---

[1] See Appendix, nos. 330–332.
[2] See Appendix, nos. 317, 318, 344.

Leaves not margined or only indistinctly.
  Closely appressed, imbricate.
    Broadly ovate or obovate, abruptly apiculate **B. argenteum**, 234.
    Ovate or lanceolate, not abruptly pointed . . **B. Blindii**, *309*.
  Spreading, distant . . . . . **B. Duvalii**,[1] 238.

2. *Costa excurrent, leaves long-cuspidate.*

a. *Capsule short (1:2 or less).*

Constricted between sporangium and collum . . **B. versicolor**, 233.
Not constricted between sporangium and collum **B. coronatum**, 232.

b. *Capsule longer (1:3+).*

i. *Collum long, ½ sporangium or more.*

Leaves bordered with two or more rows of cells.
  Strongly twisted when dry, revolute . . . **B. capillare**,[2] 235.
  Erect and straight when dry.
    Capsule scarcely constricted under the mouth, collum costate, leaf margin revolute. . . . **B. obconicum**, 236.
    Capsule constricted under the mouth, collum smooth, leaf margin plane . . . . . **B. elegans**, *319*.
Leaves not or very indistinctly bordered.
  Abruptly cuspidate, oblong spatulate or obovate lanceolate . . . . . **B. Hendersoni**, *301*.
  Gradually cuspidate, lanceolate or ovate-lanceolate.
    Capsule constricted below the mouth . . **B. cæspiticium**, 235.
    Capsule not constricted . . . **B. Vancouveriense**, *315*.

ii. *Collum short (¼ sporangium or less)* . **B. occidentale**, 236.

§III. Rhodobryum.

Costa stout, excurrent, leaf margins revolute ⅔ to ¾ length . . . . . **B. Ontariense**, *337*.
Costa vanishing, leaves plane . . . . . **B. lucidum**, *338*.

§IV. Anomobryum.

Costa subexcurrent . . . . . **B. concinnatum**, 240.
Costa vanishing below apex . . . . . **B. bullatum**, *339*.

The following species, described from sterile or immature specimens, are not included in the key, since the meager descriptions render it impossible

[1] See Appendix, nos. 334, 335.
[2] See Appendix, no. 317, 318, 344.

to determine their position. *B. leucolomatum* C. M. & Kindb., 300; *B. alpiniforme* Kindb., 310; *B. Floridanum*, R. & C., 320; *B. erythrophyllum* Kindb., 326; *B. erythrophylloides* Kindb., 327; *B. denticulatum* Kindb., 332; *B. hydrophyllum* Kindb., 333; *B. hæmatophyllum* Kindb., 340; *B. oligochloron* C. M. and Kindb., 341; *B. microcephalum* C. M. & Kindb., 342; *B. pygmæo-alpinum* C. M. & Kindb., 343. Two other species, *B. Baueri* Hampe (California) and *B. Wrightii* Sull. (Behring Straits) are listed by Ren. & Card.

ZIERIA, p. 240.

Costa vanishing, collum twice sporangium . . **Z. julacea**, 240.
Costa excurrent, collum = sporangium . . . **Z. demissa**, 241.

MNIUM, p. 241.

I. *Leaves serrate.*

A. *Teeth of leaves single.*

Stems dendroid . . . . . **M. Menziesii**, 249.
Stems simple or branched, not dendroid.
  Basilar branches stoloniform.
    Leaves acuminate, serrate to middle, lid convex or mamillate, membrane of endostome lacunose **M. cuspidatum**,[1] 242.
    Leaves acuminate, serrate to base.
      Lid apiculate . . . . . **M. medium**, 242.
      Lid mammiform . . . . . **M. affine**, 244.
    Leaves rounded at apex, mucronate, lid rostrate **M. rostratum**, 243.
  Basilar branches erect, or stems simple.
    Capsule warty-papillose at base . . . **M. venustum**,[2] 242.
    Capsule smooth at base.
      Leaves nearly entire not decurrent . **M. affine rugicum**, 244.
      Leaves serrate to base, long decurrent . . **M. insigne**,[3] 244.
      Leaves serrate above, entire below.
        Border distinct, yellowish-brown or red.
          Capsules clustered (2–3), leaf cells large and rectangular at the base . . . **M. Drummondii**, 243.
          Capsules solitary, leaf cells uniform . . **M. Blyttii**, *353*.
        Border none or faint . . . . . **M. stellare**, 247.

---

[1] See Appendix, no. 345.

[2] *M. macrociliare* is insufficiently distinguished by Müller from this species. See Appendix, no. 346.

[3] See Appendix, no. 347.

B. *Teeth of the leaves in pairs.*

[*M. Blyttii* may be sought here.]

Costa vanishing below the apex . . . . . **M. hornum**, 245.
Costa percurrent or excurrent.
  Capsules solitary.
    Synoicous.
      Leaves decurrent . . . . . **M. serratum**,[1] 245.
      Leaves not decurrent or only indistinctly so . **M. Niagaræ**, *352*.
    Dioicous.
      Costa excurrent in upper leaves, leaf cells 18–30μ,[2]
        plants 1.5–2 cm. high . . **M. pseudolycopodioides**, *351*.
      Costa percurrent.
        Lid not rostrate.
          Capsule with long neck, wide mouthed **M. inclinatum**, *350*.
          Capsule oval, inclined . . . . . **M. decurrens**, *349*.
        Lid rostrate.
          Leaf cells small, about 15μ[3] . . **M. orthorrhynchum**, 246.
          Leaf cells very large, 50–60μ[4] . . . **M. umbratile**, 246.
  Capsules clustered.[5]
    Dioicous, leaves strongly crispate, capsule horizontal
      or inclined . . . . . **M. spinosum**, 246.
    Synoicous, leaves not crispate, capsule pendent **M. spinulosum**, 247.

II. *Leaves entire.*

Upper leaf-cells with long diameter oblique to costa.
  Leaves bordered.
    Costate to apex, dioicous, capsule oblong . **M. punctatum**, 248.
    Costa vanishing, synoicous, capsule subglobose, leaves
      distinct and few . . . . . **M. subglobosum**, 248.
    Costa vanishing, dioicous, leaves more abundant and
      closer . . . . . **M. hymenophyllum**, *354*.
  Leaves not bordered, costa vanishing, dioicous, capsule
    ovate-oblong . . . . . **M. cinclidioides**, 248.
Upper leaf-cells isodiametric, costa vanishing **M. hymenophylloides**, 249.

M. heterophyllum Schw. is mentioned as occurring in America (Bryol. Eur. Mnium, p. 24), but no locality is given and for this reason it is not included in the key and descriptions.

---

[1] See Appendix, no. 348.
[2] As determined from Can. Musci, no. 197.
[3] *Fide* Husnot: Muscol. Gall. 255.
[4] Cells four times as large as *M. orthorrhynchum*, *fide* Mitten, Journ. Linn. Soc. 8: 30.
[5] *M. macrociliare* may be sought here See footnote 2, p. 219.

CINCLIDIUM, p. 249.

Leaf margin of 4–5 rows of cells, laminal cells irregularly disposed . . . . . **C. stygium**, 250.
Leaf margin of 2 rows of red cells, laminal cells in rows oblique to costa . . . . . **C. subrotundum**, 250.

AULACOMNIUM, p. 252.

Leaves coarsely serrate to middle, autoicous . **A. heterostichum**, 253.
Leaves serrulate near apex, acute or acuminate, dioicous.
Stem leaves long acuminate, very roughly papillose **A. papillosum**, 253.
Stem leaves acute.
Stems commonly prolonged and gemmiferous, male flowers terminal, gemmiform . . **A. androgynum**, 252.
Stems commonly not gemmiferous, male flowers discoid . . . . . **A. palustre**,[1] 252.
Leaves entire, obtuse . . . . . **A. turgidum**, 253.
[The leaves of *A. palustre* are entire when young, but soon become erose crenulate.)

TIMMIA, p. 254.

Leaves larger above, sheath papillose on the back.
Not hyaline at the insertion, monoicous . **T. Megapolitana**, 254.
Hyaline at the insertion, dioicous . . . **T. Norvegica**, *358*.
Leaves uniform, sheath smooth on the back.
Base hyaline, costa not toothed on back **T. Megapolitana Bavarica**, *357*.
Base orange, costa toothed above on the back . **T. Austriaca**,[2] 254.

ATRICHUM, p. 255.

Leaves margined, costa lamellose on upper side only.
Lamellæ 2–6, entire, lamina with teeth on surface.[3]
Lamellæ 4-6 cells high.
Leaves serrate for ¾ length . . . **A. undulatum**,[4] 256.
Leaves serrate above middle only.
Teeth double, aculeate . . . . . **A. angustatum**, 256.
Teeth single, short . . . . . **A. xanthopelma**, 257.

---

[1] See Appendix, nos. 355, 356.
[2] See Appendix, no. 359.
[3] Excluding *A. xanthopelma?*
[4] See Appendix, no. 360.

Lamellæ 9–13 cells high . . . . . **A. Selwyni**, 256.
Lamellæ 4–8, serrate . . . . . **A. Lescurii**, 257.
Lamellæ 1–3, 1–3 cells high, lamina smooth . **A. crispum**, 257.
Leaves not margined.
Costa lamellose on both sides . . . . . **A. parallelum**, 258.
Costa lamellose on upper side only . . . **A. leiophyllum**, *361*.
Costa nearly smooth . . . . . **A. rosulatum**, *362*.

OLIGOTRICHUM, p. 258.

Costa lamellose on both surfaces.
Capsule rough when dry, leaf margin plane . **O. aligerum**, 258.
Capsule furrowed when dry, leaves nearly tubular by the incurved margin . . . . . **O. hercynicum**,[1] *363*.
Costa only lamellose on upper surface . . . **O. Lyallii**, 259.

POGONATUM, p. 260.

I. *Plants simple, mostly short, leaves straight when dry.*

[***P. alpinum simplex*** will be sought here.]

Lamellæ with marginal cells smooth.
Leaves entire . . . . . **P. brachyphyllum**, 261.
Leaves serrate . . . . . **P. brevicaule**, 260.
Lamellæ with marginal cells papillose.
Teeth of leaves very long, often reflexed, marginal cells of lamellæ subquadrate . . . . . **P. dentatum**, 261.
Teeth moderate, 2 rows of marginal cells of lamellæ transversely rectangular . . . . . **P. capillare**, 261.

II. *Plants large (4–15 cm.), leaves twisted when dry.* (III)

Leaves strongly contorted when dry, lamellæ 20–30.
Less than 1 cm. long, short sheathing, capsule smooth.
Leaves scarcely enlarged at the base, acute **P. contortum**, 262.
Leaves enlarged at the base, abruptly pointed **P. atrovirens**, 262.
More than 1 cm. long, not sheathing, capsule papillose . . . . . **P. erythrodontium**, *365*.
Leaves spreading or patulose when dry, lamellæ about 60 . . . . . **P. Macounii**, *367*.

[1] See Appendix, no. 364.

III. *Plants usually robust (4–15 cm.), rarely small, often much branched above, leaves straight when dry.*

Capsule papillose, marginal cells of lamellæ round in section . . . . . **P. urnigerum**, 262.
Capsule smooth, marginal cells of lamellæ ovate in section **P. alpinum**,[1] 263.

POLYTRICHUM, p. 263.

Leaves entire, margins inflexed.
  Obtuse at apex . . . . . **P. sexangulare**, *369*.
  Aristate at apex.
    Awn colored, short.
      Leaves spreading when moist, subrecurved **P. juniperinum**,[2] 265.
      Leaves erect-open, strict . . . . . **P. strictum**, 265.
    Awn hyaline, long . . . . . **P. piliferum**, 264.
Leaves serrate.
  Marginal cells of lamellæ like rest, oval, higher than broad in section.
    Capsule ovate, obscurely angled, lid rostrate . **P. gracile**, 264.
    Capsule oblong, 4–6 angled, lid acutely conic **P. formosum**,[3] 264.
  Marginal cells of lamellæ enlarged, broader than high (2 : 1) . . . . . **P. Ohioense**, *370*.
  Marginal cells of lamellæ semilunar, with two prominent papillæ at corners . . . . . **P. commune**,[4] 266.

P. polare C. Müll., 373; *P. hyperboreum* R. Br.; *P. boreale* Kindb.; *P. lævipilum* Hpe., are not included in the key since no authentic material is at hand, and the descriptions are not sufficient to determine their position. The first three are arctic species and their omission is comparatively unimportant.

BUXBAUMIA, p. 267.

Outer peristome simple, spores 5–9μ.
  Capsule little longer than broad . . . . . **B. aphylla**, 268.
  Capsule much longer than broad (1 : 2–2.5) . . . **B. Piperi**, *376*.
Outer peristome quadruple or triple, spores 10–16μ **B. indusiata**, *375*.

---

[1] See Appendix, no. 366.
[2] See Appendix, no. 374.
[3] *P. conorhynchum* Kindb., evidently falls here. See Appendix, no. 368.
[4] See Appendix, nos. 371, 372.

FONTINALIS, p. 268.[1]

I. *Leaves of branches unlike stem leaves (dimorphous).*

Branch leaves 8–16 times as long as broad . **F. chrysophylla,** *383.*
Branch leaves 2.5–5 times as long as broad . **F. Kindbergii,**[2] *381.*

II. *Leaves homomorphous.*[3]

A. *Leaf cells rhombic-hexagonal (1: 6 or less).*

Plants shining with golden or copper luster.
  Stem robust, little branched . **F. antipyretica gigantea,**[4] 269.
  Stem soft, much branched . . . . . **F. Californica,** 269.
Plants dull, yellowish to dirty green.
  Leaves with one edge reflexed near base . **F. antipyretica,** 268.
  Leaves with margin plane.
    Female flowers abundant, in most leaf axils **F. Novæ-Angliæ,**[5] 270.
    Female flowers rare, at base of stems . . **F. biformis,** 270.

B *Leaf cells long linear (1: 7–30).*

1. *Leaves auricled.*

[*F. Lescurii* and *F. Neo-Mexicana* may be sought here.]

Alar cells very large . . . . . **F. flaccida,** *393.*
Alar cells moderately enlarged.
  Leaves inflexed on the borders.
    Gradually acuminate . . . . . **F. dichelymoides,** *395.*
    Cucullate and terminated by an acumen . . **F. involuta,** *389.*
    Obtuse, neither acuminate nor cucullate . . **F. Cardoti,** *388.*
  Leaves plane on the borders, acuminate.
    Transverse bars of the endostome complete . . **F. tenella,** *391.*
    Transverse bars of the endostome incomplete . . **F. nitida,** *390.*

---

[1] Revised by Cardot, Mem. Soc. Nat. d. Sci. Nat. et Math. de Cherbourg 28: 1–152. 1892.

[2] It has not been deemed advisable to maintain *F. Howellii* as a distinct species. Following the suggestion of Cardot, Monog. Fontin. 67, it is ranked as a variety of *F. Kindbergii.* See also Appendix, no. 382.

[3] In *F. biformis* the summer leaves are unlike the vernal, so that specimens collected just as the vernal are falling might deceive.

[4] See Appendix, nos. 377, 378.

[5] See Appendix, nos. 386, 387.

2. *Leaves not auricled.*

* *Tubulose or sub-tubulose.*

Apex obtuse and cucullate . . . . . **F. Langloisii,** *397.*
Apex acute and not cucullate . . . . **F. filiformis,**[1] 271.

** *Concave and incurved on the borders.* (***)

Perichætial leaves round-obtuse, entire or lacerate.
  Teeth of 14–20 articulations, leaves oblong lanceolate **F. Delamarei,** *384.*
  Teeth of 28–32 articulations, leaves broadly oval . **F. mollis,** *385.*
Perichætial leaves abruptly pointed, entire . . **F. Dalecarlica,** 270.

*** *Plane or concave but not incurved.*

Alar cells very large . . . . . **F. Sullivantii,** 271.
Alar cells scarcely enlarged or only moderately.
  Transverse bars of the endostome complete throughout.
    Leaves decurrent, teeth not lacunose . **F. Neo-Mexicana,**[2] 269.
    Leaves not decurrent, teeth generally lacunose.
      Capsule contracted below mouth when dry **F. hypnoides,** 272.
      Capsule not contracted below mouth when dry **F. Duriæi,** *392.*
  Transverse bars of the endostome not complete.
    Articulations of the teeth 12–20.
      Endostome rudimentary, transverse bars not complete at any point . . . . **F. microdonta,** *394.*
      Endostome better developed, transverse bars complete above . . . . . **F. disticha,** 272.
    Articulations of the teeth 20–25 . . . . **F. Lescurii,** 271.

DICHELYMA, p. 272.[3]

Costa percurrent or vanishing.
  Capsule exceeding perichætium . . . . **D. falcatum,** 273.
  Capsule not exceeding perichætium . . **D. pallescens,**[4] 274.

---

[1] See Appendix, no. 396.

[2] *F. maritima* C. Müll., falls here, and is probably only a variety of *F. Neo-Mexicana.* See Appendix, no. 380; also no. 379.

[3] Revised by Cardot, *l. c.*

[4] Including *D. Novae-Brunswiciae* Kindb., and *D. obtusulum* Kindb. (Mac. Cat. 159), *sec.* Cardot, *ibid.* 143.

Costa excurrent.
Endostome a cancellate cone . . . . . **D. uncinatum,**[1] 273.
Endostome of appendiculate cilia, united only at the tips . . . . . **D. capillaceum,**[2] 273.

D. subulatum Myrin is *Brachelyma subulata* Sch. of which *Cryphæa inundata* Nees is also a synonym, *sec.* Cardot, *ibid.* 131.

CRYPHÆA, p. 275.

Costa percurrent or excurrent . . . . . **C. nervosa,** 277.
Costa vanishing near middle.
Costa of perichætial leaves excurrent into a thick point **C. glomerata,** 276.
Costa of perichætial leaves vanishing in or below apex **C. pendula,** 276.
Costa of perichætial leaves vanishing far below apex **C. Ravenelii,** 277.

LEPTODON, p. 278.

Leaves ecostate.
Leaf cells not pitted, capsule 2 mm. long . **L. trichomitrion,** 278.
Leaf cells pitted, capsule 1 mm. long . . **L. Floridanus,** 414.
Leaves costate.
Leaf cells round-oval, capsule exserted, oblong-oval **L. Ohioensis,** 278.
Leaf cells narrowly rhomboidal, capsule immersed, subglobose . . . . . **L. nitidus,** 279.

ALSIA, p. 279.

Annulus none.
Costa vanishing at middle, smooth(?), margins reflexed . . . . . **A. Californica,** 280.
Costa vanishing near apex, dentate on back, margins plane . . . . . **A. longipes,** 280.
Annulus compound, revoluble, leaves papillose at back **A. abietina,** 280.

NECKERA, p. 281.

Leaves very obtuse.
Plants slender (shoots 2 mm. wide), leaves loosely imbricate, rounded, concave . . . . . **N. disticha,** 281.
Plants robust (shoots 4 mm. wide), leaves densely imbricate, truncate, not concave . . . **N. undulata,** 281.

---

[1] Including *D. cylindricarpum* Aust. as a variety *sec.* Cardot, *ibid.* 139.
[2] See Appendix, no. 398.

Leaves rounded, abruptly apiculate.
  Revolute at base on one side, capsule immersed . **N. Menziesii,**[1] 282.
  Not revolute, capsule exserted . . . . . **N. complanata,** 283.
Leaves acute or acuminate.
  Ecostate or nearly so.
    Capsule immersed or half exserted.
      Shoots obtuse . . . . . **N. pennata,** 282.
      Shoots attenuate to apex . . . . **N. oligocarpa,**[2] 283.
    Capsule exserted.
      Segments as long as the teeth and similar . **N. Douglasii,**[3] 283.
      Segments shorter, abruptly narrowed from a broad carinate plicate base . . . . . **N. pumila,** 284.
  Costate to the middle or beyond.
    Margins broadly revolute . . . . . **N. Floridana,** 284.
    Margins not revolute.
      Alar cells fawn-color, costa thin, percurrent **N. Ludoviciæ,** 284.
      Alar cells opaque, costa vanishing . . **N. cymbifolia,** 284.

HOMALIA, p. 285.

Costa single, vanishing above the middle, leaves serrate { **H. Macounii,** *403.* / **H. Jamesii,**[4] 285.
Costa double, very short or none, leaves entire . **H. gracilis,** 286.

METEORIUM, p. 286.

Leaves serrulate . . . . . **M. pendulum,** 286.
Leaves minutely crenulate . . . . . **M. nigrescens,** 287.

LEUCODON, p. 287.

Capsule exserted.
  Leaves entire, open-erect, lid exactly conic . **L. sciuroides,** 288.
  Leaves serrulate at apex, squarrose, lid obliquely rostrate . . . . . **L. julaceus,** 288.
Capsule surpassed by perichætial leaves, leaves secund **L. brachypus,** 288.

---

[1] See Appendix, nos. 399, 400.

[2] See Appendix, no. 401.

[3] See Appendix, no. 402.

[4] Including *H. trichomanoides* L. & J. Man. 285 (not Bruch. & Schimper), *H. obtusata* L. & J. (not Mitten). I am unable to detect from the descriptions alone any character which will separate *H. Jamesii* from *H. Macounii.* If type specimens show *H. Jamesii* to be the same its priority will make it the name for the type instead of *H. Macounii.*

PTERIGYNANDRUM, p. 288.

Branch leaves acute, serrate or denticulate at the apex only . . . . . **P. filiforme,**[1] 280.
Branch leaves acute or acuminate, denticulate nearly all around . . . . . **P. papillosulum,** *405.*

PTEROGONIUM, p. 289.

Leaves broadly oblong-ovate or obovate, acute, smooth **P. gracile,** 290.
Leaves broadly deltoid-ovate, narrowly acuminate, papillose . . . . . **P. brachypterum,** 290.

ANTITRICHIA,[2] p. 290.

Capsule oval (1 : 2–2.5), leaf cells fusiform . **A. curtipendula,** 291.
Capsule cylindric (1 : 6), leaf cells oval . . **A. Californica,**[3] 291.

HOOKERIA, p. 292.

Leaves bicostate to middle (not papillose?) . . **H. varians,** 292.
Leaves bicostate to apex, papillose . . . . **H. cruceana,** 292.
Leaves ecostate, entire (not papillose?) . . . **H. Sullivantii,**[4] 293.

FABRONIA, p. 294.

Leaves ciliate-dentate.
Peristome of 16 teeth, costa none or very short . **F. pusilla,** 294.
Peristome none, leaves costate to middle . **F. gymnostoma,** 294.
Peristome of 8 geminate teeth, leaves costate nearly to middle . . . . . **F. octoblepharis,** 295.
Leaves serrate to subentire.
Sharply serrate, teeth orange, spores about 11μ . **F. Wrightii,** 295.
Obscurely serrate, teeth brown, spores about 17μ **F. Ravenelii,** 295.
Obscurely serrate, teeth with prominent articulations on back . . . . . **F. Donnellii,** 295.

---

[1] See Appendix, no. 404.

[2] A sterile species, *A. tenella*, Appendix, no. 406a, is probably referrable to one of the two species here given.

[3] See Appendix, no. 406.

[4] "Die *Hookeria Sullivantii* mihi unterscheide ich auch heute noch von *H. lucens* und ebenso von *H. acutifolia* aus Indien."—C. Müller, in litt. ad E. G. Britton, 18 Jul. 1888.

THELIA, p. 298.

Papillæ of leaves simple.
  Horn shaped, curved . . . . . **T. hirtella**, 299.
  Globose . . . . . **T. robusta**, 299.
Papillæ 2–4 furcate.
  Usually bifurcate, leaves ciliate . . . . . **T. asprella**, 299.
  Usually 4-furcate, leaves not ciliate . . . **T. Lescurii**, 299.
  Usually 3–4 furcate,[1] leaves ciliate . . . **T. compacta**, *407*.

MYURELLA, p. 300.

Leaves serrulate, obtuse (rarely short apiculate) . **M. julacea**, 300.
Leaves serrulate, abruptly apiculate-acuminate . **M. apiculata**, 300.
Leaves spinulose-dentate, abruptly long-acuminate **M. Careyana**, 300.

LESKEA, p. 302.

I. *Costa reaching to or beyond the middle.*

Percurrent . . . . . **L. nervosa**, 302.
Not percurrent.
  Leaves entire.
    Endostome divided into segments.
      Cleft between articulations, leaves bluntish.
        Leaves ovate at base, and narrowed above **L. obscura**, 301.
        Leaves oblong or broadly ovate . . **L. subobtusifolia**, *408*.
      Not cleft, leaves acute . . . . . **L. polycarpa**, 301.
    Endostome a short undivided membrane . . **L. Austini**, 303.
  Leaves crenulate . . . . . **L. tristis**, 303.

II. *Costa very short or none.*

Leaf cells linear oblong . . . . . **L. denticulata**, 302.
Leaf cells rotundate . . . . . **L. cyrtophylla**, *409*.

MYRINIA, App., no. 410.

Leaves with faint traces of a costa at the base . **M. pulvinata**,[2] 303.
Leaves with broad costa, sometimes bifurcate, ceasing below apex . . . . . **M. (?) Dieckii**, *411*.

---

[1] No. 248 Canadian Musci shows this character.
[2] *L. pulvinata* Wahl., L. & J. Man. 303.

ANOMODON, p. 304.

Leaves not papillose . . . . . **A. Toccoæ**, 306.
Leaves papillose.
  Base with large fimbriate-papillose auricles.
    Margins reflexed near apex, replicate below middle **A. Californicus**, 306.
    Margins not at all reflexed . . . . **A. apiculatus**, 306.
  Base not auriculate.
    Leaves filiform acuminate.
      Decurrent, paraphyllia broad . . . **A. heteroideus**, *413*.
      Not decurrent, paraphyllia none . . . **A. rostratus**, 305.
    Leaves obtuse or apiculate.
      Branches attenuate . . . . . **A. attenuatus**,[1] 305.
      Branches not attenuate.
        Leaves open-erect, teeth nodose . . **A. obtusifolius**, 305.
        Leaves secund, teeth not nodose . . **A. viticulosus**, 306.

PYLAISÆA, p. 308.

Segments free, split below, leaves quite entire or denticulate at apex.
  Leaves ecostate or faintly costate at the base.
    Plants glossy green . . . . . **P. polyantha**, 308.
    Plants pale yellowish green . . . **P. heteromalla**, 308.
  Leaves distinctly bicostate . . . **P. pseudoplatygyrium**, *417*.
Segments for ½ or less adherent to the teeth.
  Leaves ovate lanceolate, acuminate, margin not recurved . . . . . **P. intricata**,[2] 309.
  Leaves filiform acuminate . . . . **P. filari-acuminata**, *419*.
  Leaves short acuminate, one or both edges recurved **P. Selwynii**, *418*.
Segments wholly adherent . . . . . **P. velutina**, 309.

HOMALOTHECIUM, p. 309.

Costa short, simple or forking, vanishing below middle.
  Teeth red, operculum rostrate . . . **H. subcapillatum**, 310.
  Teeth yellow, operculum short apiculate . . **H. corticolum**, *422*.

---

[1] See Appendix, no. 412.

[2] From the description given I am unable to separate *P. Ontariensis* C. M. and Kindb. See Appendix, no. 419a.

Costa narrow, vanishing at point.
  Alar cells quadrate.
    Leaves lanceolate, secund, carinate by the costa **H. Nevadense,**[1] 332.
    Leaves long subulate or filiform acuminate, neither secund nor canaliculate . . . . **H. sericeum,**[2] *420.*
  Alar cells not differing from the rest . **H. pseudosericeum,** 310.

CYLINDROTHECIUM,[3] p. 310.

Capsules clustered (3 or 4) . . . . . **C. Floridanum,** 312.
Capsules solitary.
  Plants densely pinnately branched, leaves muticous **C. concinnum,** 313.
  Plants loosely pinnately branched, leaves pointed.
    Gradually narrowly acuminate . . . **C. brevisetum,** 311.
    Acute or abruptly acuminate-apiculate.
      Almost entire, only alar cells quadrate or rectangular.
        Leaves acuminate-apiculate, teeth with 14–17 articulations, capsule 1 : 3.5–4 . **C. cladorrhizans,** 310.
        Leaves abruptly short apiculate, teeth with 6–8 articulations, capsule 1 : 5–5.5 . . **C. seductrix,** 310.
        Leaves not apiculate, teeth with 22–26 articulations, capsule 1 : 2.5–3 . . . . **C. compressum,** 312.
      Distinctly serrulate, all basal cells rectangular.
        Annulus none, teeth obliquely striolate **C. Drummondii,** 312.
        Annulus large, teeth vertically striolate . **C. Sullivantii,** 313.

CLIMACIUM, p. 313.

Capsule straight, lid rostrate.
  Ovate-oblong (1 : 2.5–3), leaves slightly decurrent and hollowed at basal angles . . . . . **C. dendroides,**[4] 314.
  Cylindric (1 : 5–6), leaves long decurrent and broadly auriculate . . . . . **C. Americanum,**[5] 314.
Capsule arcuate, lid conic . . . . . **C. Ruthenicum,** 314.

---

[1] *Hypnum* (Camptothecium) *Nevadense* L. and. Man. 332. See also Appendix, no. 421.

[2] A closely allied but barren species is *H. sericeoides* C. M. and Kindb. See Appendix, no. 420a.

[3] Three species belonging to this genus are described by Müller & Kindberg from barren specimens under the name *Entodon* Müll. *C. Macounii* is closely related to *C. Drummondii;* the others are *C. aciculare* and *C. expallens.* See Appendix, nos. 423–425.

[4] See Appendix, no. 426.

[5] See Appendix, no. 427.

ORTHOTHECIUM, p. 315.

Leaves lanceolate, long and narrowly acuminate . **O. rufescens**, 315.
Leaves exactly ovate, apex flexuous, not plicate . **O. rubellum**, 315.
Leaves lanceolate to ovate lanceolate, plicate, not acuminate . . . . . **O. chryseum**, 316.
Leaves long subulate . . . . . **O. intricatum**, *428*.

PSEUDOLESKEA,[1] p. 319.

Costa percurrent, leaves serrate at apex . . **P. rigescens**,[2] 320.
Costa short, double, or none, leaves entire.
Alar cells transversely elongated . . . . . **P. tectorum**, *435*.
Alar cells quadrate . . . . . **P. malacoclada**, *436*.
Costa single, vanishing below apex, leaves serrate and entire.
Leaves long decurrent . . . . . **P. falcicuspis**, *433*.
Leaves not decurrent.
Lanceolate from an ovate base . . . **P. atrovirens**,[3] 319.
Narrowly lanceolate . . . . . **P. stenophylla**, *434*.

P. oligoclada Lindb., has been reduced by Ren. & Card. to *P. atrovirens* Sch. *Hypnum radicosum* Mitt. is identified by them with *P. rigescens* Lindb. to which *P. sciuroides* Kindb. has also been added as a synonym. See Mac. Cat. 180, and Ren. & Card. Revue Bryol. **20**: 15. 1893.

HETEROCLADIUM, p. 320.

Leaves papillose.
Coarsely toothed, mouth of capsule bordered by three rows of transversely elongated cells . **H. heteropterum**, *437*.
Faintly serrulate, mouth of capsule not bordered **H. dimorphum**, 321.
Denticulate above the middle.
Leaves dimorphous and faintly papillose **H. Vancouveriense**, *438*.
Leaves homomorphous and strongly papillose **H. frullaniopsis**, *439*.
Leaves smooth.
Auriculate and squarrose . . . . . **H. aberrans**, *440*.
Not auriculate, divergent . . . . . **H. procurrens**, 321.

---

[1] *P. catenulatum* Brid. has never been found in America; the locality given in L. & J. Man. 320, as Mt. Ingleborough, *New* York, is York, *England*.

[2] See also Appendix, no. 432.

[3] See Appendix, nos. 429–431.

THUIDIUM, p. 321.

I. *Plants small (to 5 cm.), delicate, creeping, 1–2 pinnate.*

Costa of stem leaves wide ($\frac{1}{8}$ leaf base).
  Branches papillate, leaf cells 6μ diam. . . **T. pygmæum**, 322.
  Branches papillate, leaf cells 9μ, longer at margin **T. minutulum**, 322.
Costa of stem leaves narrow ($\frac{1}{12}$ leaf base).
  Leaf cells with several minute papillæ . . . **T. scitum**,[1] 323.
  Leaf cells with one papilla (rarely two).
    Branch leaves roundish ovate, short acuminate **T. Virginianum**,[2] 324.
    Branch leaves ovate lanceolate, long acuminate **T. microphyllum**,[3] 324.

II. *Plants larger (to 10 cm.), creeping, 1–3 pinnate, forming extensive flat mats.* (III)

Perichætial leaves ciliate, costa of stem leaves not reaching point . . . . . **T. delicatulum**, 325.
Perichætial leaves not ciliate.
  Costa of stem leaves filling point . . . **T. recognitum**, 325.
  Costa of stem leaves $\frac{2}{3}$ length . . . . **T. Philiberti**, *443a*.

[*T. paludosum* may be sought here.]

III. *Plants large (to 10 cm.), erect or ascending, 1-pinnate, in wide tufts.*

Leaf cells roundish or oblong (1 : 1–2), strongly papillose both sides . . . . . **T. abietinum**, 326.
Leaf cells long rhombic to linear (1 : 3–6), smooth above.
  Stem leaves soft, sub-clasping, decurrent . . **T. Blandovii**, 326.
  Stem leaves rigid, plicate-striate, sub-decurrent **T. paludosum**,[4] 330.

This genus has been revised by G. N. Best, Bull. Torr. Bot. Club **23**: 78–90. 1896, and we have been able to avail ourselves of his suggestions by recalling MS. *T. tamariscinum* Hedw. and *T. remotifolium* Grev. are not N. American; *T. erectum* Duby = *T. delicatulum* L.; *H. calyptratum* Sull. = *T. microphyllum* (Sw.) Best, an earlier name for *H. gracile* B. & S., and to it *T. lignicola* Kindb. is referred as a variety; *T. Alleni* Aust. is probably a sterile form of *T. delicatulum* L.

---

[1] See Appendix, no. 441. Not recognized by Best.

[2] *T. Virginianum* (Brid.) Lindb. = *Hypnum gracile Lancastriense* S. & L., L. J. Man. 324.

[3] *T. microphyllum* (Sw.) Best = *Hypnum gracile* B. & S., L. & J. Man. 324. See also Appendix, no. 442.

[4] *T. paludosum* (Sull.) Rau & Hervey = *Hypnum paludosum* Sull., L. & J. Man. 330. See also Appendix, no. 443.

CLAOPODIUM, p. 327.

Seta smooth . . . . . **C. leuconeurum**, 328.
Seta rough.
  Perichætial leaves costate . . . . . **C. Whippleanum**, 328.
  Perichætial leaves ecostate.
    Bright green, leaves open, loosely imbricate **C. laxifolium**, 329.
    Dirty or yellowish green, leaves subfalcate secund, closely imbricate . . . . . **C. crispifolium**,[1] 329.

TRIPTEROCLADIUM, p. 330.

Leaves shortly bicostate.
  Obscurely denticulate at the apex . . **T. leucocladulum**, 330.
  Distinctly denticulate all around . . . **T. compressulum**, 331.
Leaves ecostate . . . . . **T. rupestre**, *444*.

CAMPTOTHECIUM, p. 331.

Plants regularly pinnate.
  Stems erect, stout (to 15 cm.) . . . . . **C. megaptilum**, 334.
  Stems prostrate.
    Leaf base entire, alar cells abundant.
      Capsule oblong, segments split below . . **C. aureum**,[2] *447*.
      Capsule long cylindric, segments split throughout **C. Amesiæ**, *448*.
    Leaf base denticulate, alar cells few . . **C. Nuttallii**,[3] 332.
Plants irregularly branched, stout, in extensive mats.
  Seta rough.
    Leaves ovate-lanceolate (1 : 3), cilia 3, as long as the segments . . . . . **C. æneum**,[4] 331.
    Leaves long lanceolate (1 : 5), cilia 1–2, long or short, operculum rostrate . . . . . **C. lutescens**, 331.
  Seta smooth . . . . . **C. nitens**, 333.
Plants irregularly branched, slender, cilia 1–2, short operculum obtusely conical . . . . . **C. arenarium**, 333.

---

[1] Including *H. ramulosum* Hpe., L. & J. Man. 328.

[2] *H. pinnatifidum* S. & L., L. & J. Man. 333, is reduced by Ren. & Card. to a variety of *C. aureum* Sch. Hedw. 32: 255. 1893.

[3] *C. hamatidens* Kindb. Mac. Cat. 189, *sec.* Ren. & Card., *ibid.* 256. See also Appendix, no. 449.

[4] See Appendix, no. 446.

BRACHYTHECIUM, p. 334.

I. *Seta smooth.*

[***B. nanopes*** and ***B. mirabundum*** may be sought here.]

* *Cilia rudimentary or none.*

Perichætial leaves costate . . . . . **B. acuminatum,**[1] 336.
Perichætial leaves ecostate.
  Inflorescence synoicous . . . . . **B. Utahense,** 339.
  Inflorescence dioicous or monoicous.
    Capsule oval, cilia none . . . . . **B. Donnellii,** 338.
    Capsule cylindric oblong.
      Leaf costate to middle, basal cells very small **B. biventrosum,** 338.
      Leaf costate ⅔ the length, basal cells dilated **B. lævisetum,** *469.*

* * *Cilia well developed, appendiculate.* (* * *)

Perichætial leaves abruptly long pointed . . . **B. lætum,**[2] 335.
Perichætial leaves gradually long pointed . . **B. Mildeanum,**[3] 337.

* * * *Cilia well developed, not appendiculate.*

Annulus compound . . . . . **B. collinum,** 339.
Annulus simple, narrow.
  Leaves acute or acuminate, serrulate.
    Leaves straight when dry, capsule short (1–1.5), monoicous . . . . . **B. salebrosum,**[4] 336.
    Leaves twisted flexuous when dry, capsule short, (1 : 1.5–2) . . . . . **B. Thedenii,** 338.
  Leaves acute or acuminate, entire or slightly serrate at apex only.
    Open, alar cells oblong.
      Monoicous . . . . . **B. salebrosum,**[4] 336.
      Dioicous . . . . . **B. glareosum,** *458.*
    Appressed imbricate, alar cells quadrate . . **B. albicans,**[5] 337.

---

[1] See Appendix, nos. 455, 456.

[2] See Appendix, nos. 450–452.

[3] *B. Mildeanum* Sch. = *B. salebrosum palustre* L. & J. = *B. acutum* Mitt., *sec.* Ren. & Card. Rev. Bry. **20**: 17. 1893.

[4] See Appendix, nos. 461, 462, 463.

[5] See Appendix, no. 459.

Annulus none.
  Leaves denticulate or sharply serrulate all around.
    Perichætial leaves abruptly pointed . . . **B. Idahense**, *470*.
    Perichætial leaves gradually acuminate **B. sub-erythrorrhizon**, *467*.
  Leaves serrate or denticulate above . { **B. erythrorrhizon**, *466*. **B. digastrum**,[1] *453*.

II. *Seta rough.*

* *Cilia rudimentary (1 or 2), or none.*

Seta rough at the base only, costa vanishing . . **B. Fendleri**, 340.
Seta rough above only, costa percurrent . . **B. populeum**, 345.

* * *Cilia well developed and appendiculate.* (* * *)

Leaves serrate or denticulate.
  Costa percurrent or nearly so.
    Seta rough throughout . . . . . **B. reflexum**,[2] 342.
    Seta faintly rough above . . . . . **B. nanopes**, *477*.
  Costa vanishing far below the apex.
    Alar cells quadrate, enlarged, few . . . **B. Starkei**,[3] 341.
    Alar cells quadrate, numerous . . . **B. œdipodium**,[3] 342.
    Alar cells oblong hexagonal, similar to basal **B. rutabuliforme**, *486*.
Leaves entire . . . . . **B. plumosum**, 345.

* * * *Cilia well developed but not appendiculate.*

Seta rough below only, capsule suberect . . **B. Hillebrandi**, 340.
Seta rough above only, capsule cernuous or arcuate **B. campestre**, 344.
Seta rough throughout.
  Cells of basal angles of leaves scarcely different.
    Leaves scarcely or abruptly acuminate, dioicous.
      Very short acuminate, glossy, not decurrent **B. rivulare**,[4] 344.
      Longer acuminate, not glossy, decurrent **B. Novæ-Angliæ**,[5] 344.
    Leaves gradually acuminate, autoicous.
      Lanceolate to ovate-lanceolate, sub-falcate secund **B. velutinum**, 339.
      Ovate to ovate-lanceolate, straight, spreading.
        Capsule without evident collum . . **B. rutabulum**,[6] 342.

---

[1] I am unable to obtain from the descriptions any characters which will separate these two species.

[2] See Appendix, nos. 479, 480.

[3] *B. curtum* Lindb. (Appendix, no. 482) falls here, if it is not identical with *B. œdipodium*.

[4] See Appendix, no. 474.

[5] See Appendix, no. 471.

[6] See Appendix, no. 485.

Capsule with evident collum . . . **B. glaciale**, *481*.
Cells of basal angles distinct, small or dilated, quadrate or oblong rectangular.
Leaves decurrent.
Broad ovate, faintly striate, dioicous . **B. platycladum**, *475*.
Triangular ovate, deeply plicate, monoicous.
Seta long (1.5 cm.), faintly rough, teeth serrulate . . . . . **B. leucoglaucum**, *484*.
Seta long (2 cm.), very rough, teeth not serrulate . . . . **B. Columbico-rutabulum**,[1] *487*.
Seta short (5–8 mm.), faintly rough . **B. mirabundum**, *489*.
Leaves not decurrent.
Capsule short or roundish oval.
Horizontal, pedicel arcuate above . . **B. Bolanderi**, 341.
Oblique, pedicel straight . . . **B. gemmascens**, *483*.
Capsule oblong cylindric.
Inner perichætial leaves very abruptly pointed . . . . . **B. trachypodium**, *478*.
Inner perichætial leaves gradually acuminate **B. asperrimum**,[2] 343.

The following species are not included in this key, since the descriptions are taken from sterile or immature specimens or are otherwise so incomplete as not to offer sufficient characters for their proper location: *H. Coloradense* Aust., Man. 412; *B. Fitzgeraldi* C. Müll., 454; *B. Rœllii*, R. & C., 457; *B. harpidioides* C. M. & K., 460; *B. pseudoalbicans* Kindb., 464; *B. spurio-acuminatum* C. M. & K., 465; *B. pseudo-collinum* Kindb., 468; *B. latifolium* (Lindb.) R. & C., 472; *B. pseudo-Starkei* R. & C., 473; *B. spurio-rutabulum* C. M. & K., 476; *B. Villardi* R. & C., 490; *B. cirrhosum* Sch., 491.

SCLEROPODIUM, p. 346.

Cilia solitary, rudimentary . . . . . **S. Krausei**, *493*.
Cilia 2–3, as long as the segments.
Seta rough throughout.
Capsule erect or oblique, stem leaves gradually acuminate . . . . . **S. cæspitosum**,[3] 346.
Capsule horizontal, leaves abruptly short acuminate with point recurved . . . . . **S. illecebrum**, 347.
Seta rough and reddish above, smooth and yellow below . . . . . **S. Californicum**, 346.

---

[1] From description I cannot distinguish *B. lamprochryseum*. See Appendix, no. 488.
[2] *Hypnum vallium* S. & L. is identical *sec.* Sull. Ic. Musc. Suppl. 100.
[3] See Appendix, no. 492.

ISOTHECIUM, p. 347.

Leaves papillose on back.
  Cilia solitary, margin of stem leaves reflexed **I. spiculiferum**, 348.
  Cilia 2–3, margin of stem leaves not reflexed **I. stoloniferum**, 348.
Leaves smooth on the back.
  Perichætial leaves costate.
    Upper branch leaves acute or acuminate, entire **I. apocladum**, 350.
    Branch leaves acute or acuminate, serrate all around . . . . . **I. myosuroides**, 347.
  Perichætial leaves ecostate.
    Seta rough . . . . . **I. lentum**, 350.
    Seta smooth.
      Alar cells dark yellow or orange, quadrate or rectangular . . . . . **I. Cardoti**, *494*.
      Alar cells not colored, quadrate or round quadrate or not differing.
      Alar cells obscure, costa vanishing in middle.
        Cilia equaling segments, capsule inclined **I. acuticuspis**, 349.
        Cilia shorter, capsule erect . . **I. Brewerianum**,[1] 349.
      Alar cells distinct, costa ¾ length of leaf **I. myurellum**, *495*.

EURHYNCHIUM, p. 351.

I. *Seta smooth.*

Points of leaves twisted, plants golden yellow . . **E. Boscii**, 352.
Points of leaves straight.
  Leaves not decurrent, cilia not appendiculate.
    Spreading, branches attenuate . . . **E. strigosum**,[2] 351.
    Appressed, branchlets short, julaceous . **E. diversifolium**, 352.
  Leaves long decurrent, cilia appendiculate . **E. substrigosum**, *498*.

II. *Seta rough.*

Leaves with filiform points.
  Stems short, with erect fasciculate branches, stoloniferous . . . . . **E. Vaucheri**, 414.
  Stems long, prostrate, irregular, branched, not radiculose . . . . . **E. piliferum**, 353.

---

[1] Leaves not papillose, *teste* M. A. Howe *in litt.* Including *H. aggregatum*, Mitt., L. & J. Man. 350 *see.* R. & C. Rev. Bryol. 20: 20. 1893.

[2] See Appendix, nos. 496, 497.

Leaves not filiform.
  Leaves serrulate all around.
    Decurrent, excavate at basal angles.
      Perichætial leaves spreading . . . . . **E. Stokesii**, 354.
      Perichætial leaves reflexed . . . . . **E. Oreganum**, 355.
    Not decurrent nor excavate.
      Leaves ovate lanceolate, acuminate, segments split . . . . . **E. Sullivantii**,[1] 353.
      Leaves broad ovate, acute, segments perforate **E. prælongum**, 353.
      Leaves broad ovate, acute, segments split . **E. hians**, 354.
  Leaves entire at the base.
    Decurrent . . . . . **E. semiasperum**, *502*.
    Not decurrent.
      Lid not half as long as the capsule . **E. colpophyllum**, 342.
      Lid nearly as long as the capsule . . . **E. hians**, 354.

E. Dawsoni Kindb., App. 501, and *E. crassinervium laxirete* Kindb., App. 500, are described from sterile specimens; hence they are not included in this key.

RAPHIDOSTEGIUM, p. 355.

I. *Operculum long subulate rostrate.*

Leaf margin entire.
  Ovate or ovate lanceolate, monoicous . . . **R. demissum**, 355.
  Long subulate, dioicous . . . . . **R. subdemissum**, *504*.
Leaf margins serrate or denticulate.
  Filiform acuminate.
    Cilia none or rudimentary . . . . . **R. laxepatulum**, 358.
    Cilia 2, stout, nearly equaling segments . . **R. recurvans**, 356.
  Acute or short acuminate.
    Decurrent . . . . . **R. Roellii**,[1] *508*.
    Not decurrent.
      Capsule short, oval or oblong (1 : 2) . . **R. microcarpum**, 357.
      Capsule longer, cylindric (1 : 4) . . . **R. subadnatum**, *506*.

II. *Operculum short rostrate or conic.*

Leaves filiform acuminate.
  Cilia none, annulus none, capsule cylindric **R. cylindrocarpum**, 356.
  Cilia 1, annulus simple, large, capsule oblong . **R. Jamesii**, 357.

---

[1] See Appendix, no. 503.

Leaves acute or short acuminate.
  Dioicous, leaves obovate or subrotund . **R. Novæ-Cesareæ**, 356.
  Monoicous, leaves broadly ovate to ovate or oblong lanceolate.
    Leaves decurrent . . . . . **R. Roellii,**[1] *508.*
    Leaves not decurrent.
      Margin strongly reflexed . . . . . **R. Kegelianum**, *507.*
      Margin plane . . . . . **R. micans,**[2] 365.

RHYNCHOSTEGIUM, p. 358.

Pedicel rough . . . . . **R. curvisetum**, 360.
Pedicel smooth.
  Costa single, reaching half way or more.
    Leaves apparently 2-ranked, plants of dry woods **R. serrulatum**, 359.
    Leaves spreading every way . . . . . **R. rusciforme**, 359.
  Costa very short or none or double.
    Bicostate, annulus large . . . . . **R. geophilum**, 358.
    Uni- or ecostate, annulus none . . . **R. deplanatum**, 359.

Hypnum Caloosiense Aust., *H. Royæ* Aust., and *H. Brandegei* Aust., insufficiently established and of uncertain relationships, are not included in this key.

THAMNIUM, p. 361.

Branch and stem leaves apparently 2-ranked, complanate.
  Capsule oblong, without collum . . . **T. Holzingeri**, *511.*
  Capsule oval, with a distinct collum . . . **T. Bigelovii**, 362.
Branch and stem leaves equally spreading.
  Perichætial leaves reflexed.
    Cilia equaling teeth . . . . . **T. Leibergii**, *510.*
    Cilia short . . . . . **T. neckeroides**, 362.
  Perichætial leaves erect.
    Teeth with a hyaline, dentate margin . **T. alopecurum**, *509.*
    Teeth not hyaline margined and toothed only at the articulations . . . . . **T. Alleghaniense**, 362.

---

[1] *R. Roellii* is included under both heads since the character of the operculum is unknown to me.

[2] *R. micans* R. & C. Rev. Bryol. **20**: 21. 1893 = *Hypnum micans* Sw. L. & J. Man. 365. See also Appendix, no. 505.

PLAGIOTHECIUM, p. 362.

I. *Leaves complanate.*

* *Lid rostrate.*

Leaves transversely undulate, serrulate at the apex **P. undulatum,** 369.
Leaves not undulate, quite entire . . . . . **P. sylvaticum,** 368.

* * *Lid conic or convex.*

Capsule pendent or sub-pendent, seta arcuate . **P. elegans,** 366.
Capsule suberect, inclined or horizontal, often arcuate.
Sulcate and constricted below the mouth when dry **P. turfaceum,** 366.
Smooth when dry.
Leaves serrulate, capsule sub-cylindric . **P. Sullivantiæ,** 368.
Leaves quite entire.
Capsule obovate, campanulate when dry **P. Muellerianum,** 367.
Capsule oblong, constricted under the mouth when dry.
Costa bipartite, vanishing half way to the middle . . . . . **P. denticulatum,**[1] 367.
Costa simple, short, or none . . . **P. brevipungens,** *515.*

II. *Leaves equally spreading, straight.* (III)

* *Alar cells abruptly enlarged.*

Leaves acute or short acuminate.
Flat, point broad and straight . . . . **P. membranosum,** *514.*
Concave, point needle-like and recurved or patent . . . . . **P. acicularipungens,** *516.*
Leaves filiform acuminate.
Cilia none . . . . . **P. piliferum,** 364.
Cilia 2–3.
Branches erect, leaves serrate . . . **P. Muhlenbeckii,** 370.
Branches intricate, leaves nearly entire . . **P. Fitzgeraldi,** 370.

* * *Alar cells scarcely different, quadrate or oblong, not abruptly enlarged.*

+ *Capsule suberect, smooth when dry.*[2]

Dioicous, cilia none, costa obsolete.
Inner perichætial leaves ovate lanceolate . **P. latebricola,** 363.
Inner perichætial leaves abruptly acuminate . **P. Passaicense,** 363.

---

[1] See Appendix, nos. 512, 513.
[2] *P. pseudo-latebricola* has an inclined capsule.

Autoicous, cilia 2–3, costa double.
  Costa thick, ascending to the middle . . . **P. geminum**, 365.
  Costa thin, reaching half way to the middle **P. denticulatum**, var. 367.

++ *Capsule inclined or pendent, sulcate when dry.*[1]

Leaves oval, narrowly acuminate, monoicous **P. pseudo-Silesiacum**, 370.
Leaves ovate lanceolate, dioicous.
  Suddenly tapering to a long filiform point **P. pseudo-latebricola**, *519*.
  Short acuminate . . . . . **P. decursivifolium**, *517*.

III. *Leaves secund.*

Costæ 2, thick, reaching the middle . . . **P. geminum**, 365.
Ecostate or shortly bicostate.
  Leaves entire, seta straight . . . . . **P. pulchellum**, 364.
  Leaves serrulate above, seta arcuate . . . **P. Silesiacum**, *518*.

P. bifariellum Kindb., App. 520, and *P. attenuatirameum* Kindb., App. 521, described from barren specimens, are not included in the key.

AMBLYSTEGIUM,[2] p. 371.

I. *Leaves ecostate or with obscure traces of a nerve.*

Cilia none.
  Perichætial leaves long and narrow acuminate, entire **A. subtile**, 372.
  Perichætial leaves oval or oblong lanceolate, entire at the apex . . . . . **A. Sprucei**, 372.
Cilia 1–2.
  Plants minute, filiform (1–2 cm.).
    Leaves ovate, long acuminate . . . **A. confervoides**, 372.
    Leaves long lanceolate . . . . . **A. minutissimum**, 371.
  Plants large, in wide flat tufts . . . . . **A. adnatum**, 375.

II. *Leaves plainly costate.*

A. *Leaves with a distinct border* . . . **A. Lescurii**, 376.

---

[1] *P. pseudo-latebricola* has a smooth capsule.

[2] The assistance of Prof. L. S. Cheney, who is engaged upon a revision of this genus is gratefully acknowledged.

B. *Leaves not bordered.*

* *Costate to the apex.*

Leaves acuminate, basal cells abruptly enlarged . **A. irriguum,** 374.
Leaves acuminate, basal cells not enlarged.
Serrate throughout . . . . . **A. compactum,** 375.
Entire or obscurely serrulate above.
Branches mostly erect, leaves loosely spreading when dry . . . . . **A. orthocladon,** 374.
Branches mostly spreading, tufts intricate, leaves imbricate when dry . . . . . **A. varium,**[1] 373.
Leaves not acuminate, ovate to oblong lanceolate . **A. fluviatile,** 375.

* * *Costa ceasing at the middle or above.*

[*A. compactum* may be sought here.]

Cells near middle of leaf 1 : 10–15.
Leaves long acuminate, apex sharp . . . **A. riparium,**[2] 376.
Leaves acute, apex blunt . . . . . **A. vacillans,** 377.
Cells near middle of leaf less than 1 : 8.
Inner perichætial leaves short acuminate (¼ length).
Leaves .65–.85 × .26–.36 mm. . . . . **A. serpens,**[3] 373.
Leaves 1.2–1.6 × .5–.7 mm. . . . . **A. Kochii,** *535.*
Inner perichætial leaves subuliform acuminate, cells vermicular . . . . . **A. porphyrrhizon,** *527.*

Kindberg has described four species belonging to this genus from barren specimens. *A. fenestratum*, App. 522, is probably not an Amblystegium. *A. speirophyllum*, App. 523, may be doubtfully referred from specimens in Can. Musci to *A. irriguum*. *A. distantifolium*, App. 529, is very near *A. irriguum*. *A. dissitifolium*, App. 530, and *A. sub-compactum* C. M. & Kindb., App. 531, are undoubtedly *A. compactum* Müll. *A. Holzingeri* R. & C. is *Hypnum* (Limnobium) *Closteri* Aust. *A. Floridanum* R. & C., App. 534, is so poorly characterized that I am unable to separate it from *A. riparium*. *A. Juratzkanum*, App. 525, *A. hygrophilum* (an Amblystegium?), App. 526, and *A. Schlotthaueri*, App. 528, are subspecies of *A. serpens*, *sec.* Cardot, Hedwigia **32**: 270, 271. 1893. *A. homalostegium* Jgr. & Sauerb., App. no. 536, is so doubtful as an Amblystegium (*ex descr.*) that we omit it.

---

[1] *Hypnum radicale* L. &. J. Man. 373.
[2] See Appendix, no. 532, 533.
[3] See Appendix, no. 524–526, 528.

HYPNUM.[1]

I. *Leaves spreading, or complanate, not secund.* (II on p. 247.)

A. *Leaves costate half way or more.* (B on p. 245.)

1. *Leaves acute or acuminate.*

Margins denticulate.
  Decurrent and auricled, suddenly acuminate **H. chloropterum,** *562.*
  Neither decurrent nor auricled, gradually acuminate.
    Cells uniform throughout . . . . . **H. Columbiæ,** *542.*
    Alar cells dilated, distinct . . . **H. Columbico-palustre,** *588.*
Margins entire.
  Leaves acute or short acuminate.
    Alar cells few.
      Costa ½ length or double and short . . **H. palustre,** 398.
      Costa vanishing just below apex . . . **H. polare,** *589.*
    Alar cells more numerous, reaching costa, large . . . . . **H. pseudo-montanum,** *593.*
  Leaves long acuminate.
    Erect or spreading . . . . . **H. polgamum,**[2] 379.
    Reflexed squarrulose.
      Decurrent . . . . . **H. decursivulum,**[3] *541.*
      Not decurrent.
        Plants in dense tufts . . . . . **H. unicostatum,**[3] *540.*
        Plants in loose, intricate tufts . . **H. chrysophyllum,**[3] 378.

2. *Leaves obtuse,*[4] *entire.*

* *Cells enlarged at the basal angles.*[5] (* * on p. 245.)

Costa sub-percurrent.
  Monoicous, sparingly branched, alar cells gradually enlarged . . . . . **H. cordifolium,** 402.

---

[1] Including subgenera XVII to XXVI of L. & J. Man. 377–406.

[2] See Appendix, nos. 544, 545.

[3] The separation of these three species is very unsatisfactory. *H. chrysophyllum* is a very variable species and from the inspection of barren material of *H. decursivulum* and *H. unicostatum* and comparison with the characters as given by Kindberg, it seems probable that they can not be regarded as distinct species but only as forms of *H. chrysophyllum.*

[4] Sometimes apiculate in *H. sarmentosum.*

[5] *H. torrentis* C. M. & Kindb., Appendix, no. 586, falls here.

Dioicous, profusely branched.
5–10 cm. long, variegated or dark purple, stolons green . . . . . **H. sarmentosum**, 403.
15–30 cm. long, bright to yellowish green . . **H. giganteum**, 403.
Costa reaching middle.
Branches irregularly pinnate, leaves spreading **H. Richardsoni**, 404.
Branches few, leaves imbricate . . . **H. stramineum**,[1] 405.

** * Cells not enlarged at the basal angles.*

Leaf margin serrulate above, leaf cells short . **H. occidentale**, *598*.
Leaf margin entire, leaf cells vermicular, bordered by a row of short cells.
Leaves open . . . . . **H. arcticum**, 400.
Leaves closely imbricate . . . . . **H. trifarium**, 405.

B. *Costa very short or none or double.*

1. *Alar cells abruptly enlarged (often inflated or colored).*[2] (2 on p. 246.)

** Operculum short rostrate.*

Leaves entire . . . . . **H. Haldanianum**,[3] 397.
Leaves sharply serrate . . . . . **H. nemorosum**, 398.

** * Operculum convex or conic.*

Leaves falcate.
[*H. palustre hamulosum* may be sought here.]
Scarcely costate, alar cells orange . . . **H. engyrium**,[4] 401.
Costa reaching middle, alar cells hyaline . . **H. ochraceum**,[5] 401.
Leaves not falcate.
Gradually filiform acuminate, alar cells orange.
Plants irregularly branched . . . **H. Sommerfeltii**,[6] *537*.
Plants sub-dichotomously branched . . **H. stellatum**,[7] 379.

---

[1] See Appendix, no. 595–597.

[2] Three barren species described by C. M. & Kindb. belong to this division: *H. flaccum*, Appendix, no. 580; *H. subflaccum*, Appendix, no. 581; *H. pseudo-drepanium*, Appendix, no. 582.

[3] See Appendix, no. 579.

[4] See Appendix, nos. 590, 591.

[5] See Appendix, no. 592.

[6] See also Appendix, no. 538.

[7] See Appendix, no. 543.

Acute or short apiculate, alar cells few, large . **H. palustre,** 398.
Obtuse, entire, alar cells hyaline . . . **H. cuspidatum,** 403.

2. *Alar cells scarcely different or quadrate or rectangular, not abruptly enlarged.*

* *Leaves thin, glossy, open; plants mostly small, prostrate or with ascending branches.*

Leaves squarrose, acuminate.
Sub-serrulate all around, lid apiculate . . **H. hispidulum,** 378.
Entire except the acumen, lid obtuse . . . **H. Macounii,** *539.*
Leaves loosely imbricate, obtuse or acute.
Serrulate, at least above.
Nearly as broad as long, obtuse or apiculate.
Alar cells small, not forming distinct auricles, others 1 : 8–10 . . . . . **H. molle,** 399.
Alar cells large, forming distinct auricles, others much longer than preceding . . **H. dilatatum,**[1] *601.*
Nearly twice as long as broad, acute, point often half twisted . . . . . **H. alpestre,** 399.
Entire.
Leaves close set, ovate (1 : 2) . . . . **H. Norvegicum,** *587.*
Leaves more distant, rotund . . . . **H. Goulardi,** *585.*

* * *Leaves firm; plants very large, mostly 1–2 pinnate, erect or ascending.*

Paraphyllia none.
Capsule smooth when dry.
Leaves obtuse.
Olive or grayish green, 1–2-pinnate, leaves open **H. Schreberi,** 404.
Dirty green to dark brown, almost simple, leaves closely appressed . . . . . **H. trifarium,** 405.
Leaves abruptly apiculate, plants pale green . . **H. purum,** *594.*
Capsule plicate when dry, plants dark green to reddish brown . . . . . **H. scorpioides,**[2] 406.
Capsule unknown; plants dark yellow and greenish, branches julaceous, few, fastigiate, leaves short apiculate **H. turgescens,** 406.
Paraphyllia present . . . . . **H. Alaskanum,** 405.

---

[1] *H. circulifolium* C. M. & Kindb., Appendix, no. 583, belonging to this division and described from sterile specimens, is related to *H. dilatatum* Wils.

[2] See Appendix, no. 599.

II. *Leaves secund.*

A. *Costa single, reaching to the middle or beyond.* (B on p. 248.)

1. *Leaves transversely rugose and longitudinally plicate* . . . . . **H. adunceum gracilescens**, 381.

2. *Leaves not rugose, often plicate.*

* *Paraphyllia abundant (rarely few).*

Leaves plicate . . . . . **H. commutatum**, 387.
Leaves not plicate.
Smooth . . . . . **H. filicinum**,[1] 386.
Very papillose . . . . . **H. decipiens**, *561.*

* * *Paraphyllia none.*[2]

+ *Annulus none.*

Leaves quite entire, short acuminate . . . **H. palustre**, 398.
Leaves denticulate, subulate acuminate . . . **H. fluitans**,[3] 383.

+ + *Annulus present, often large.*

Leaves acute or bluntish . . . . . **H. ochraceum**, 401.
Leaves subulate by the long excurrent costa . **H. capillifolium**, *551.*
Leaves gradually long acuminate, costa often entering point but not long excurrent.
Broad (1–2 mm.), crumpled and plicate when dry **H. lycopodioides**,[4] 385.
Narrower (0.5–1 mm.), not crumpled when dry.
Auricles none or indistinct.
Leaves usually plicate and denticulate.
Capsule oblique, incurved, subcylindric **H. uncinatum**, 382.
Capsule symmetric, erect, cylindric . . . . . **H. uncinatum symmetricum**, *552.*
Leaves entire.
Plicate, plants pale green or shining yellow **H. vernicosum**, 385.
Smooth, plants brown or purple or blackish **H. revolvens**, 384.

---

[1] See Appendix, no. 560.

[2] *H. conflatum* C. M. & Kindb., Appendix, no. 558, belonging to this division, is not sufficiently described to enable me to determine its position.

[3] Including *H. exannulatum* Guemb., *sec.* Renauld in Husnot's Muscol. Gall. 379. See also Appendix, nos. 553–557.

[4] Including *H. Wilsoni* Sch. (*H. Sendtneri Wilsoni* Sch.) as a sub-species, *sec.* Renauld, *ibid.* 375.

Auricles distinct.
Leaves usually denticulate . . . . **H. uncinatum**, 382.
Leaves entire or obtusely sinuolate.
Falciform, costa 60–120μ broad, capsule cylindric **H. Sendtneri**, 381.
Various, costa 30–60μ broad, capsule oblong **H. aduncum**,[1] 380.

B. *Costa double and short, or none.*

1. *Plants regularly pinnate.* (2 on p. 249.)

* *Capsule costate and arcuate when dry.*

Alar cells short, yellow, thick walled . . . **H. curvifolium**, 396.
Alar cells inflated, hyaline, thin walled . . **H. Patientiæ**,[2] *572*.

* * *Capsule not costate when dry.*

+ *Leaves quite entire.*

[*H. imponens* and *H. subimponens* may be sought here.]

Alar cells dilated, hyaline or yellowish.[3]
Cilia 2, nodulose . . . . . **H. Dieckii**, *577*.
Cilia 3 . . . . . **H. callichroum**, 393.
Alar cells not dilated.
Cells uniform throughout leaf . . . . **H. Watsoni**, 386.
Alar cells subquadrate, rest elongated . . **H. complexum**, 396.

+ + *Leaves serrate or denticulate all around.* (+ + +)

Capsule long cylindric, suberect or slightly incurved **H. imponens**, 393.
Capsule ovate, oblong or obovate, inclined or arcuate.
Paraphyllia subulate, cilia short . . . **H. Canadense**, *568*.
Paraphyllia ovate-lanceolate, cilia equaling the segments . . . . . **H. molluscum**, 389.

+ + + *Leaves serrate or denticulate only above the middle.*

Capsule arcuate or incurved cernuous, stem leaves plicate, plants large (to 15 cm.) . . . . **H. Crista-castrensis**, 389.
Capsule incurved cernuous, stem leaves not plicate.
Plants large (to 10 cm.) . . **H. cupressiforme tectorum**, 395.

---

[1] See Appendix, nos. 546–550.

[2] See Appendix, nos. 573–575.

[3] *H. Renauldii* Kindb., Appendix, no. 571, falls here, but characters given do not allow it to be separated in the key.

Plants small (usually less than 5 cm.).
  Perichætial leaves plicate.
    Inner perichætial leaves costate.
      Alar cells not distinct[1] . . . . . **H. fertile**, 391.
      Alar cells large, hyaline . . . **H. Waghornei**, *565*.
    Inner perichætial leaves ecostate . . . **H. hamulosum**, 391.
  Perichætial leaves not plicate.
    Alar cells not enlarged . . . . . **H. subimponens**, 393.
    Alar cells quadrate or vesicular, enlarged.
      Leaves narrowly acuminate, faintly bicostate **H. depressulum**, 391.
      Leaves long subulate, ecostate . . . **H. circinale**, 392.

2. *Plants irregularly branched.*

[***H. callichroum*** may be sought here.]

* *Leaves quite entire.*

Alar cells not different . . . . . **H. pseudoarcticum**, *584*.
Alar cells enlarged, oblong rectangular.
  Teeth hyaline margined, cilia appendiculate **H. arcuatiforme**, *576*.
  Teeth not hyaline margined, cilia nodose . . **H. pratense**,[2] 397.
Alar cells quadrate.
  Plants erect, fastigiately branched . . . **H. Bambergeri**, 397.
  Plants prostrate, irregularly pinnate . . **H. incurvatum**, *600*.

* * *Leaves serrulate or denticulate above.*

[***H. pseudo-arcticum*** and ***H. incurvatum*** may be sought here.]

Perichætial leaves costate, and plicate or sulcate.
  Costa geminate, reaching middle . . . . . **H. reptile**, 390.
  Costa geminate, short.
    Middle leaf cells long (1 : 12–15) . . **H. cupressiforme**,[3] 394.
    Middle leaf cells shorter (1 : 6–8) . . . **H. Vaucheri**,[4] *570*.
  Costa single, or wanting.
    Inner perichætial leaves long subulate (1 : 12) . **H. Moseri**, *559*.
    Inner perichætial leaves lanceolate (1 : 5) . **H. fastigiatum**, *564*.

---

[1] "Blattflügelzellen sehr gross, aufgeblasen, wasserhell bis gold gelb," *sec.* Milde, Bry. Siles. 359. Not according to Bryol. Eur. pl. 591, from which this character is taken.

[2] See Appendix, no. 578.

[3] See Appendix, no. 569.

[4] The character of the perichætial leaves is unknown to me, but since the species is so closely related to *H. cupressiforme*, it is placed in this position.

Perichætial leaves ecostate.[1]
  Plicate . . . . . **H. plicatile**, 394.
  Not plicate.
    Foliage leaves strongly revolute . . . **H. revolutum**,[2] 566.
    Foliage leaves concave . . . . . **H. Sequoieti**, 392.

HYLOCOMIUM,[3] p. 409.

Leaves secund.
  Sharply serrate at apex, alar cells quadrate . . **H. rugosum**, 388.
  Subserrate at apex, alar cells scarcely different **H. robustum**, 388.
Leaves equally spreading.
  Paraphyllia none.
    Leaves sulcate.
      Ecostate, leaf cells all alike . . . . **H. loreum**, 410.
      Bicostate, leaf cells enlarged at the base **H. triquetrum**,[4] 409.
    Leaves not sulcate . . . . . **H. squarrosum**,[5] 409.
  Paraphyllia present.
    Leaves with a long double costa and deeply sulcate **H. umbratum**, 407.
    Leaves obscurely bicostate.
      Paraphyllia pinnate, branches 2–3 pinnate **H. splendens**, 407.
      Paraphyllia minute, branching irregularly pinnate . . . . . **H. brevirostre**, 408.
    Leaves unicostate to middle, coarsely serrate . **H. Oakesii**, 408.

---

[1] *H. pseudo-fastigiatum* C. M. & Kindb., Appendix, no. 563, and *H. pseudo-pratense* Kindb., Appendix no. 578, both described from sterile specimens, fall here.

[2] See also Appendix, no. 567.

[3] Including *Pleurozium* L. & J. Man. 407.

[4] See Appendix, no. 603.

[5] See Appendix, no. 602. *H. calvescens* (Wils.) Lindb. is closely related to *H. squarosum* and is ranked as a variety by Husnot: Muscol. Gall. 425.

APPENDIX.

DESCRIPTIONS OF SPECIES AND VARIETIES

published since the issue of Lesquereux and James' Manual of the Mosses of North America in 1884, and before January 1, 1896.

1. **Sphagnum Bolanderi** Warnst.—Plants resembling delicate forms of *S. fimbriatum:* stem leaves small, lingulate, mostly delicately fimbriate by resorbed cell membranes; border narrow, equal throughout or broader at base: hyaline cells of upper part abundantly fibrillose, with half-elliptic pores along commissures: branches 3 in a fascicle, two divergent, one pendent: branch leaves very small, ovate lanceolate, narrowly bordered, apex obtuse and toothed, margins involute, densely imbricate and when dry not shining; hyaline cells fibrillose, inner surface in superior half with single large round pores becoming more numerous in marginal regions, outer surface near apex with medium sized round or semi-elliptic pores gradually increasing in size towards base and arranged along commissures; chlorophyllose cells exposed on inner side and not on outside, or only occasionally. Hedwigia **30**: 173. 1891.—California.

2. **Sphagnum Russowii** Warnst.—Plants usually tall and strong; tufts loose and high or compact and low: stem leaves large, broad linguiform, with somewhat undulate margins, only in middle of broad rounded apex dentate or somewhat fimbriate; border much widened below; hyaline cells in upper part of leaf large, broad, rhombic, mostly without cross partitions, but with delicate membrane plaits, all with membrane thinnings, which rarely at edges towards apex change into isolated pores, mostly without fibers and pores but rarely fibrillose near apex: fascicles 4 or 5 branched, distant or crowded; 2 or 3 stouter branches spreading, recurved horizontal, curving upward or erect, longer or shorter; pendent branches very long and closely appressed to stem: branch leaves closely or loosely imbricated, mostly with a somewhat spreading (more rarely nearly squarrose) tip, very seldom almost secund, lanceolate, narrow bordered, the upper margins involute, and at the transversely or roundly truncate apex dentate, two or

three plaits near the base: dioicous, rarely monoicous: perigonial leaves resembling the branch leaves; perichætial leaves as in *S. Girgensohnii;* fruit rare. Bot. Gaz. **15**: 130. 1890. Hedwigia **25**: 225. 1886.—Newfoundland; Labrador; Canada; New Brunswick; Maine; New Hampshire; Rocky Mountains; Washington.

3. **Sphagnum Warnstorfii** Russ.—Tufts mostly loose; plants usually delicate, slender and graceful, and at the same time firmly erect: stem leaves small to medium sized, mostly linguiform, from base very gradually narrowed and then rather abruptly contracted into a roundish pointed dentate or entire apex; border narrow, much widened downwards; hyaline cells of upper half of leaf rhombic to elongate rhombic, mostly divided but nonfibrillose: fascicle of 3–5 branches of which 2–3 are spreading: leaves of the latter ovate in basal half, involute above and subulate, truncate and 3–5 toothed, often regularly 5 ranked, sometimes secund, always with their points diverging from each other; hyaline cells from basal half of spreading branches with numerous pores on outer surface: dioicous: perichætial leaves large, ovate-lanceolate, in lower part consisting of chlorophyllose cells only; hyaline cells of upper part non-fibrillose: capsule comparatively large, dark reddish brown. Bot. Gaz. **15**: 138. 1890.—Damp or wet birch swamps, margins of elevated bogs when adjacent to birch-covered wet meadows, or in springy swamps: Newfoundland; Labrador; Massachusetts; New Hampshire; Connecticut; Minnesota; Montana; Rocky Mountains; Alaska.

4. **Sphagnum Vancouveriense** Warnst.—Stem leaves without fibrils and pores, rounded apex suddenly narrowed to a short often obtuse and toothed acumen, border up to 10 cells broad and very much broadened toward base; membrane of hyaline cells sometimes very thin or (particularly in upper part) resorbed on both sides: branch leaves when dry curved, erect spreading, on inside in region of margins with many large round pores, on outer face with medium sized to large pores along commissures. Hedwigia **33**: 308. 1894.—Vancouver Island.

5. **Sphagnum tenellum** Klingg.—Tufts soft; plants generally quite slender: stem leaves larger or smaller, linguiform, usually cucullate incurved at apex, and sometimes at sides, and afterwards by spreading out flat becoming lacerate dentate or delicately fimbriate; hyaline cells with or without fibrils in upper part of leaf: fascicles of 3–4 branches, 2 diverging: branch leaves loosely or densely imbricate, frequently secund, ovate to ovate-lanceolate, small, dentate at broad rounded apex, margin involute, apical half of inner surface with numerous small pores, especially in upper and lower cell angles, and larger ones in broader part of leaf, especially near margins, outer surface of leaf very porose, pores strongly ringed near apex: dioicous, rarely monoicous: perichætial leaves large, ovate, above abruptly contracted to a narrow truncate emarginate involute point; hyaline cells

without fibrils or pores. Bot. Gaz. **15**: 135. 1890.—In elevated bogs: N. E. United States; Newfoundland; eastern Canada.

6. **Sphagnum fuscum** Klingg.—In extensive, dense or loose, often cushion-shaped patches; stems usually slender and delicate: stem leaves usually small, linguiform, often at rounded apex abruptly contracted to a small cucullate point, which is generally somewhat fimbriate, border broader below; hyaline cells nearly always without fibrils and pores, 2–4-divided by obliquely transverse walls, and with delicate longitudinal plaits in membrane: fascicles of 3–4 branches: leaves small, nearly lusterless when dry, densely or loosely imbricated, from an ovate base extending to a comparatively short round-truncate dentate involute tip; border 3–4 cells wide; hyaline cells on inner side of leaf in upper part with numerous usually ringless pores, especially in upper and lower cell angles, pores in middle of cell, near margin and base, outer surface with numerous pores: dioicous: perichætial leaves large, ovate, slightly emarginate at rounded apex, hyaline cells without fibrils and pores: fruit rare. Bot. Gaz. **15**: 133. 1890.—In elevated bogs: N. United States; Newfoundland; Canada.

7. **Sphagnum quinquefarium** Warnst.—Plants slender and delicate like *S. Warnstorfii* or strong and robust like *S. Russowii:* stem leaves from a broad base deltoid, not linguiform, above at often abruptly contracted apex truncate, dentate, usually involute and bordered at edge, border wider below; hyaline cells in whole middle part of leaf broad, in upper half almost rhombic, often once or several times divided by oblique transverse walls and with membrane plaits, without fibrils and pores oftener than with them: fascicles of 5 branches, 3 spreading; branches 5-angled by 5-ranked leaves: branch leaves loosely or closely imbricate, never secund, small, ovate-lanceolate, at usually round-truncate involute-edged and dentate apex bordered by 2–3 rows of narrow cells, upper part of inner surface porose, pores small, ringed, in upper and lower cell angles, in broader part of leaf and near margins pores larger and not ringed, outer surface with numerous pores along commissures: commonly monoicous, more rarely dioicous: perichætial leaves large, ovate, above drawn out to a longer or shorter emarginate involute-edged apex: fruit not rare: spores fine, smooth. Bot. Gaz. **15**: 189. 1890.—Newfoundland; Canada; E. United States.

8. **Sphagnum tenerum** (Aust.) Warnst.—Stem leaves large, isosceles-triangular, mostly with cut edges and a quite long obtuse toothed acumen with incurved edges; border suddenly broadened at base; hyaline cells often divided by oblique walls and mostly fibrillose to base, inner side porose, pores large, round, outer side with half elliptic pores along commissures: fascicles generally 4-branched: branch leaves quite large, ovate-lanceolate, regularly imbricate; apex obtuse, toothed, margins involute; hyaline cells on inside with large round pores near sides and small pores

near apex in upper and lower cell angles, pores of outside half-elliptic, in rows on commissures. Hedwigia **29:** 194. 1890.—New Jersey: Connecticut.

9. Sphagnum subnitens Russ. & Warnst.—Plants when dry very soft and with more or less of a metallic luster: stem leaves large, elongated, isosceles-triangular, broad at base, not rarely with undulate margins in middle, above abruptly narrowed into a longer or shorter broad-truncate dentate and involute-edged point; border broad, much widened downwards and formed of very narrow pitted tubular cells; hyaline cells in middle of base wide and large, above rather shorter, rhomboidal, at margins narrow, mostly without fibrils and pores, rarely with rudiments of fibrils and pores at apex, longitudinally plaited: branches 3–4 in a fascicle, one or two pendent: leaves of spreading branches larger or smaller, densely or loosely imbricate, often curved, erect-spreading, seldom somewhat secund or squarrose, never distinctly 5-ranked, from an ovate base narrowed upward to a rather long dentate transversely or roundly-truncate involute-edged apex; hyaline cells with numerous fibrils, pores on inner surface almost all near margins, on outer surface more numerous: mostly monoicous, more rarely dioicous: perichætial leaves large, ovate, edge very broadly bordered in upper part and emarginate at rounded truncate apex: fruit very common. Bot. Gaz. **15:** 194. 1890.—Newfoundland; Labrador; Miquelon Is.; Nova Scotia; Maine; New Hampshire; Massachusetts; New Jersey; Connecticut; Virginia; Indiana; California.

10. Sphagnum microphyllum Warnst.—Plants very delicate, very similar to small slender forms of *S. fimbriatum* Wils.: stem leaves large, about 2½ times as long as broad, above narrowed into a distinctly truncate toothed apex; border narrow and broadened slightly below; hyaline cells elongated-rhomboidal, without cross walls in apical half, in upper ⅔ to ¾ abundantly fibrillose, on inner side with many large round ringless pores in middle of cell, on outside with half-elliptic pores along commissures: fascicles 3-branched, 1 pendent: leaves of spreading branches small, ovate lanceolate, densely imbricate or with apex erect-spreading or almost squarrose, apex obtuse, toothed, in upper part margin involute, narrowly bordered, when dry not shining; hyaline cells fibrillose, abundantly porose on inside, pores round, ringless, outside with half-elliptic ringed pores in rows along commissures. Hedwigia **30:** 172. 1891.—California.

11. Sphagnum Labradorense Warnst.—Stem leaves medium sized, lingulate spatulate from a narrowed base, border narrow, broadened at base, margin broadly involute on one or both sides, finely toothed at obtuse apex; hyaline cells broadly rhombic, near base narrower and longer, divided with one to four oblique walls, inner surface with large pores, outer surface with very thin membranes, resorbed in apical part, without fibrils or in apical part just the beginnings: fascicle of 3–4 branches, two spreading: branch leaves ovate, about as large as stem leaves, apex broad, obtuse,

with 4–6 large teeth; margin faintly bordered, toothed above, involute far down, loosely erect spreading; hyaline cells broad rhombic to rhomboidal, inner surface near apex with small faintly ringed pores, towards middle in side regions with few large pores, outer surface with numerous narrow elliptic pores gradually larger towards the leaf base and margins, fibrils very numerous. Hedwigia **31**: 174. 1892.—Newfoundland; New Jersey.

12. Sphagnum Floridanum Card.—Differs from *S. macrophyllum* by more numerous pores of stem leaves (4–10 in each cell); shorter pointed branch leaves, rounded obtuse, not tubulose, canaliculate and cucullate at summit; hyaline cells narrower, pores small and very numerous, 40–60 upon each face in large cells of middle, biseriate, entirely at one end of the cell, or uniseriate; fruit unknown. Cardot, Rév. des Sphaignes de l' Amérique du Nord 22. 1887.—Florida; Louisiana.

13. Sphagnum riparium Aongstr.—Cortex of stem wanting; stem leaves very large, reflexed, triangular lingulate, apex rounded, deeply two cleft by resorption of membranes, always without fibrils, borders entirely of green cells with pits; fascicle of 4–5 branches; leaves narrowly bordered, when dry somewhat crispate, middle ones with squarrosely reflexed points, chlorophyllose cells exposed on both faces, pores on concave leaf surface quite large and numerous along the commissures, membranes resorbed at upper end of cells on convex surface for entire breadth of leaf in middle or side regions, in other cases with 2–4 large pores instead; perichætial leaves with the lower ⅔ composed mostly of pitted chlorophyllose cells. Limpr. Laubm. **1**: 133.—New Hampshire; New Jersey; Canada; Greenland; Alaska; Behring Sea.

14. Sphagnum Dusenii Jensen.—Strong to robust, green or yellowish-green; wood body green or yellow, formed of quite thick-walled cells; cortex of 5 layers of cells with weakly thickened walls; stem leaves triangular lingulate, apex with few large teeth, generally fibrous in upper half, border broad; branches 4 in each fascicle, 2 divergent often long and attenuate; leaves crowded or loosely imbricate, seldom secund, large (2 × 1 mm.), broad oval lanceolate, above with incurved margin; hyaline cells long and narrow, below 15–20 × 2.5–3μ, strongly fibrous, on convex side with numerous round or oval pores (5–7μ diam.) with weakly thickened edges, on concave side with single rather distant round pores along sides of broad part, all pores somewhat distant from chlorophyll cells, often forming 1 or 2 rows; dioicous; ♂ branches acute, with yellowish brown bracts, ♀ branches short or elongated, their leaves broadly oval with hyaline cells at base and fibrous in upper half; capsule brown; spores 2μ diam., yellow and finely papillose; seldom fruiting. *S. majus* Russow; Jensen in De danske Sphagnum-Arter, Festskrift bot. Foren. Copenh. 50-aarsfest 106. 1890. Anticosti; Maine; New Hampshire; New York; Wisconsin.

15. Sphagnum Mohrianum Warnst.—Stem leaves large, narrow at

base, broadening towards middle and then narrowing into an obtuse fine toothed point with involute margins, accordingly nearly lanceolate; border narrow; hyaline cells mostly divided by an oblique wall, abundantly fibrillose to base, inner surface of basal half with large round ringless pores in middle of cell wall, basal cells with a very large opening, in upper half with single pores in the cell angles: fascicle 3-branched: branch leaves ovate to oblong-ovate, apex broadly obtuse and toothed, narrowly bordered margins broadly involute; hyaline cells on inner surface abundantly fibrillose, sparingly porose on both sides, only with single pores in cell angles. Hedwigia **31**: 179. 1892.—Mobile, Alabama.

16. Sphagnum obesum Wils.—Stem leaves large, reflexed, oblong triangular, apex cucullate or simply obtuse, fringed, border narrow, without fibrils below: branches swollen, curving downward, never twisted: leaves soft and loosely placed, in water somewhat pinnately spreading, broad to narrow ovate-lanceolate, broader bordered. apex several toothed, both sides of apical half with small pores in almost all cell angles, especially in upper and lower, rarely almost wanting. *Sphagnum contortum obesum* (Wils.) Limpr. Limpr. Laubm. **1**: 121.—New Hampshire; Massachusetts; Virginia; Connecticut.

17. Sphagnum dasyphyllum Warnst.—Stem leaves quite large, lingulate, concave, border narrow, involute for greater part, apex cucullate, split when spread out; hyaline cells below narrow and long, towards apex rhomboidal, all divided by 1 or 2 oblique walls, upper ¾ abundantly fibrillose, then a space without fibrils and again fibrillose at base; inner surface rarely porose, outer surface with pores at apex only: fascicles of 2–3 spreading and 2 pendent branches: branch leaves quite large, base narrow and greatly broadened towards middle, then suddenly narrowed into a short obtuse finely toothed point, accordingly round-ovate, very concave, border narrow and involute to base; hyaline cells broad rhomboidal, upper half of inner surface with single large pseudo-pores, outer surface with more numerous pseudo-pores and single very small strongly ringed pores in the cell angles. Hedwigia **31**: 176. 1892.—New Haven, Connecticut.

18. Sphagnum microcarpum Warnst.—Stem leaves crowded, very large, broad ovate, apex broadly rounded obtuse, finely toothed; margin broadly involute and narrowly and equally bordered to base; hyaline cells narrow, rhomboidal, abundantly fibrillose to base; pores almost wanting on inner surface, outer surface with very numerous small pores in uninterrupted chains along commissures, decreasing in number towards base: branches single, not fasciculate: branch leaves loosely placed, quite large, ovate to oblong-oval, border narrow, involute for greater part; areolation very similiar to that of stem leaves. Hedwigia **30**: 170. 1891. New Jersey; Florida; Alabama; Mississippi; Louisiana.

19. Sphagnum platyphyllum Sulliv.—Stems lax, quite robust, irregu-

larly branched, sometimes without branches; branches 1–3 in a fascicle, mostly short and thick: stem and branch leaves very similar in form, stem leaves large, oval to obovate, very concave, apex rounded, slightly fringed, below narrowly bordered, fibrillose to base but with very small pores along commissures only in upper half; branch leaves appressed, loosely placed, large, very concave, ovate, rounded above, scarcely toothed, narrowly bordered all around, strongly fibrillose to base, upper ⅔ of outer surface with very small pores along commissures. Limpr. Laubm. **1**: 122. 1890.—Massachusetts; New Jersey; Virginia.

20. Sphagnum plicatum Warnst.—Stem leaves quite large, lingulate, upper margins frequently involute, apex hyaline margined, bordered, border weak, of 4–6 rows of cells, equally broad to base; hyaline cells in apical half about rhombic, in basal portion broader and longer, frequently divided by one or two oblique walls, abundantly fibrillose in upper ¾; pores on inner surface in upper part of leaf in all cell angles, towards margins more numerous; outer surface with pores in often interrupted rows along commissures, towards base almost exclusively in upper cell angles: fascicles mostly 4-branched, 2 spreading: leaves of spreading branches quite large, ovate-lanceolate, coarsely toothed at narrowly obtuse apex, border narrow, involute at apex only or sometimes farther down; hyaline cells broad, rhomboidal, not divided, pores on inner surface only in side regions, outer surface with numerous pores in rows along commissures. Hedwigia **30**: 169. 1891.—Granville, Mass.

21. Sphagnum Orlandense Warnst.—Stem leaves relatively small, lingulate, apex rounded, scarcely toothed, not cucullate, border narrow, involute on one side nearly to base; hyaline cells generally divided by an oblique wall, fibrillose to base, outer surface with small faintly ringed pores in interrupted rows along commissures: fascicles mostly four-branched, 2 spreading: leaves of spreading branches quite large, roundish-oval, finely toothed at obtuse apex, very concave, border narrow, margins broadly involute: hyaline cells broad rhomboidal, abundantly fibrillose, outer surface towards apex with pores in cell angles, in middle side regions with small pores in rows, outer surface with numerous pores in interrupted rows along commissures. Hedwigia **31**: 177. 1892.—Florida; New Jersey.

22. Sphagnum Mobilense Warnst.—Stem leaves relatively small, lingulate, narrowly bordered to base, in upper half one margin sometimes involute; hyaline cells of lower part of leaf not divided or with a single oblique wall, without fibrils or only basal cells with few delicate fibrils, in upper part with parallel oblique cross walls and abundantly fibrillose and porose, towards apex chlorophyll cells ceasing and hyaline cells forming a broad border which is sometimes resorbed: fascicles 4–5-branched, 2 spreading: leaves of spreading branches large, round-ovate, finely toothed on scarcely obtuse apex, narrow bordered, very concave, margins broadly

involute; hyaline cells abundantly fibrillose, not divided or somewhat divided towards margins, inner surface with small pores in almost all cell angles particularly in upper half, outer surface with pores in rows along commissures, less numerous towards base. Hedwigia **31:** 180. 1892.—Mobile, Alabama.

23. Sphagnum simile Warnst.—Stem leaves small, lingulate; hyaline cells at apex only occasionally divided by a cross wall, hyaline border of apex partly resorbed and fimbriate, upper part of leaf fibrillose; branch leaves oval to oblong-ovate, both sides abundantly porose, inner surface with small pores in almost all cell angles, outer surface with pores along commissures; chlorophyll cells in cross section parallel-trapezoidal and free on both faces. Hedwigia **33:** 326. 1894.—Madison, Wisconsin.

23*a*. Sphagnum Waghornei Warnst.—Chlorophyll cells of the branch leaves in cross section broadly isosceles-trapezoidal, the longer side on the inner face, exposed on both faces, walls uniformly thickened; hyaline cells smooth within where they adjoin green cells: wood body dark brown to almost black: cortical cells with spiral fibrils and outer wall with 1 (rarely 2) large pores: otherwise as in all Cymbifolia. Hedwigia **33:** 329. 1894. —Newfoundland.

24. Sphagnum rufescens Bryol. Germ.—Seldom completely submersed: stem leaves large, triangular-linguiform, lateral margins narrowly and uniformly bordered down to base; hyaline cells fibrillose from apex far downward, often quite to base, and with small pores on both sides, on inner side especially in cell angles, on outer side mostly in interrupted rows on commissures: branch leaves large to very large, ovate-lanceolate with numerous small pores on inner side, sometimes in rows near margins, still more numerous on outer side, in rows, like strings of pearls, on commissures; rings strong. Bot. Gaz. **15:** 246. 1890. Hedwigia **33:** 326. 1894.—From Newfoundland, Labrador and Canada to Connecticut; also Washington and California.

24*a*. Sphagnum medium Limpr.—Stem leaves as in *S. cymbifolium*, larger, plicate, rarely in upper half with a few fibrils and few large pores; branch leaves involute all around, pores more numerous on the outer surface, especially in cell angles: dioicous. Laubm. **1:** 104. 1890.—From Newfoundland and Labrador through Canada to Florida.

25. Sphagnum Ludovicianum (Ren. & Card.) Warnst.—Stem leaves very large, broad-lingulate, apex cucullate and the margins there involute, narrowly bordered all around; fibrillose to base, inner surface with pseudo-pores where three cell angles meet, near margin with large or small pores, outer surface with narrow elliptic pores along commissures, larger below; or stem leaves narrow at base and broadened to middle, then narrowed into a broad rounded cucullate apex with involute margins: fascicles 3-4-branched 2 spreading: branch leaves large, ovate, apex hyaline

bordered, cucullate, margins more or less involute; hyaline cells abundantly fibrillose, pores few on inner surface, on outer surface more numerous especially towards apex. Hedwigia **30**: 161. 1891.—New Jersey; Florida: Mississippi; Louisiana.

26. Andreæa parvifolia Müll.—Dioicous: small, slender, filiform, sparingly dichotomous: stem leaves erect-imbricate or slightly secund, minute, when moist from an erect deeply ventricose oval base extended into a spreading oblong more or less roundish-obtuse and recurved more deeply ventricose lamina; ecostate; cells angular, thick walled, fuscous, strongly hyaline-papillose; perichætial leaves convolute into a very narrow-short cylinder, larger, broader, rather broadly oblong from a narrow base, ligulate-acuminate, somewhat obtuse, strongly papillose: capsule short pedicellate, minute. Flora **70**: 219. 1887.—Alaska.

27. Andreæa papillosa Lindb.—Plants elongate (1–2 in. high) rather stout, branched, slightly tufted, dark brown to black: leaves crowded, spreading in all directions, somewhat shining, ovate with short narrow acute point, cells large (3 times as large as in *A. petrophila*[1] while leaves are as short as in that species), coarsely papillose. Hartman, Skand. Flora 122. 1871.

28. Andreæa alpestris Sch.—Monoicous: leaves much smaller than in *A. petrophila*, crowded, spreading from the sheathing base when moist, ovate, oblique, obtuse, margin hyaline, faintly papillose on the back, ecostate; perichætial leaves with long papillæ, cells smaller than in *A. petrophila*, round-hexagonal to oval in upper part of leaf, basal cells elongated rectangular, pits few or absent. Limpr. Laubm. **1**: 142.—On damp rocks: Nova Scotia, near Halifax; Greenland.

29. Andreæa obovata Thed.—Densely pulvinate-cespitose, tufts blackish above, fuscous below: plants tall, robust, much branched, branches fastigiate: leaves densely crowded, spreading from the imbricate base, apex inclined upward, when dry closely imbricate; from ovate-panduriform gradually lanceolate, rather obtuse; minutely papillose or almost smooth; shining, margin very entire; blackish, under a lens golden yellow; cells very thick walled, rhombic above, sinuate-elongate below, the cell cavities really roundish above, rectangular-hexagonal below: male fls. numerous, on special slender branches; autheridia large, paraphyses long: perichætial leaves surpassing the upper cauline leaves, convolute, the outer broadly ovate-lanceolate, internal broadly elongate; apex obtuse, not rarely hyaline or premorse. Schimper Syn. Musc. Eur. 814. 1876.—Disco Is., Greenland.

30. Andreæa Huntii Limpr.—Monoicous: tufts dark, somewhat glossy: leaves strongly falcate-secund, short, broadly ovate, strongly concave base gradually narrowing into a long subulate point; base of lamina made up

---

[1] *A. petrophila* has cells 10-14-17μ in diameter *sec.* Limpricht, Die Laubmoose **1**: 140.

of one layer of cells, upper part of leaf two-layered; costa strong, about one-third width leaf; leaf cells in the lower part round-quadrate, at the base near costa rectangular: conial leaves shorter with the costa often disappearing below apex, margin sometimes irregularly toothed: inner perigonial and perichætial leaves ecostate, margin erenulate, convex surface strongly papillose. Limpr. Laubm. **1**: 145. On rocks, altitude 5,500 ft.—Vancouver Island.

31. **Andreæa Blyttii** Schimp.—Very small slender and densely pulvinate, brownish black to deep black: stem very slender, rather rigid, brittle, fastigiate-branched, rooting: leaves divaricate-homomallous, those near the tips falcate-secund, from an oval or ovate base suddenly subulate, nearly smooth, shining, brittle; costa semi-terete, occupying almost all the subula, terete at apex; cells near apex round, at base all rectangular: ♂ plants gregarious, more slender than ♀, perigonial lvs. 6, the 3 inner united into a bud, acuminate, ecostate; antheridia 5–6, long pedicellate, with longer filiform flexuous paraphyses: perichætium large, far exceeding stem leaves, external leaves erect, costate to apex, internal subconvolute, elongate-obovate, short apiculate, ecostate: capsule very small, conic-ovate. Sch. Syn. Musc. Eur. 821. 1876.—Greenland.

32. **Andreæa Macounii** Kindb.—Dioicous: tufts soft, dark brown or brick red, not glossy: stems about 5 cm. high: leaves narrow, suddenly long acuminate from broader base, distinctly but faintly papillose, more or less curved, uppermost falcate, when dry sub-crispate; cells uniform subquadrate; costa narrow, linear, nearly smooth, in the upper leaves long excurrent and denticulate, sometimes to middle. Bull. Torr. Bot. Club **17**: 82. 1890.—In cushions and flat mats on inclined faces of rocks on mountains and by brooks flowing from perpetual snow, Gold Range, B. C.

33. **Andreæa nivalis** Hook.—Dioicous: tufts broad, thick, soft, dirty greenish brown, reddish brown or black, not glossy: stem 4–10 cm. long: leaves more or less falcate, crispate when dry, uniformly elongated into a sharp point from a somewhat enlarged or auricled base; lamina 1-layered, papillose on both surfaces, irregularly toothed near apex: costa quite strong, uniform in width even to apex; leaf cells quadrate or short rectangular: perigonial leaves ecostate, broadly oval, suddenly long pointed; perichætial leaves quite similar to stem leaves. Limpr. Laubm. **1**: 152.—Mt. Hood, Oregon.

34. **Archidium Hallii minus** R. & C.—Smaller, leaves shorter, costa percurrent or short excurrent. Bot. Gaz. **19**: 237. 1894.—Louisiana.

35. **Phascum subexsertum** Hook.[1]—Stemless, cespitose: leaves lingulate oblong, spreading, apiculate: capsule spherical, sub-exserted, lid acuminate. Mac. Cat. 12.—Northwest Territory.

---

[1] This species is not sufficiently known (Ren. & Card). Wilson states that this is perhaps only a remarkable variety of *P. cuspidatum*.—Hook. Journal Bot. 3: 433. 1841.

36. **Pleuridium alternifolium Howei** Ren. & Card.—Differs from the typical form in the leaves being entire or slightly denticulate at the apex. Revue. Bryol. **19**: 64. 1892.—California.

37. **Microbryum Floerkeanum Henrici** R. & C.—Differs from the typical form in the green color of the plant, and the excurrent costa often hyaline at the point. Bot. Gaz. **14**: 91. 1889.—Sandy ground: Saline Co., Kansas.

38. **Bruchia longicollis** Eaton.—Plants densely clustered, 7–10 mm. high: stem leaves with a broadly ovate clasping base suddenly narrowed a into long excurrent awn like costa, which is bordered below by leaf margin: perichætial leaves lanceolate, somewhat tubulose, gradually acuminate, costa excurrent: flowers monoicous: capsule exserted on a stout seta, orange yellow, collum very long, exceeding sporangium, stomatose beak slender. Bull. Torr. Bot. Club **17**: 100. *pl. 101.* 1890.—Decayed logs in swamp: New Hampshire.

39. **Bruchia fusca** Britt.—Plants gregarious, 2–3 mm. high: leaves few, three to six, erect appressed, short, clasping, often broader than long and tricuspidate, entire or subserrulate, with a narrow border of small retuse cells, apex obtuse, acute or cucullate: costa faint, vanishing below apex or absent in lower leaves, basal cells lax: seta immersed or slightly exserted, straight or curved; capsule large and broad, 1–1.5 mm. long, entirely exserted, ovoid-pyriform, suddenly apiculate: collum shorter than but occasionally equaling the sporangium; calyptra smooth, deeply lobed, half covering the capsule; spores small, brown, angled and pitted. Bull. Torr. Bot. Club **21**: 361. 1894.—Growing around quartz pebbles in sandy soil: Maryland; North Carolina.

40. **Bruchia Carolinæ** Aust.—Plants gregarious, in brown patches, 1–2 mm. high: stems naked and radiculose at base, leaves crowded at the summit, more or less secund, subulate from a broader base; costa channeled, filling the entire or serrulate apex, faintly papillose on the back; basal cells smooth, irregular, upper with thickened walls: seta shorter than the capsule, both immersed, or the capsule occasionally exserted laterally, pyriform, yellow or brown, conic apiculate; collum large, truncate, stomata immersed; calyptra broad, lobed, papillose at the apex; spores small, pitted: flowers monoicous. Bull. Torr. Bot. Club **21**: 365. 1894. *Bruchia Ravenelii* Wils., var. *mollis*, L. & J. Man. 49.—South Carolina.

41. **Astomum Drummondii** Kindb.—Plants cespitose, almost stemless: leaves linear subulate, very entire: seta as long as leaves: capsule globose, lid conic rostrate. Mac. Cat. 12.—Plains of the Saskatchewan.

42. **Voitia** Hsch.—Tufts thick, densely cespitose, below brown tomentose: stems simple or dichotomously branched: leaves somewhat separated, or densely imbricate, long or short, ovate or elongated elliptical, cuspidate; costa thin and weak; cells large, thin-walled, hexagonal or sub-quadrate,

hyaline near the base, chlorophyllose above: flowers monoicous: capsule erect, oval or ovate; apiculate lid not deciduous; calyptra large, cucullate, nearly covering the capsule. Musc. Gall. 69.

43. **Voitia hyperborea** Grev. & Arnott.—Smaller and more slender than the European *V. nivalis:* leaves densely imbricate, erect-appressed, broadly oval or sub-rotund, short acuminate, strongly concave, margin entire; costa vanishing in apex: perichætial leaves long cuspidate, costa excurrent: vaginule long, membranaceous: pedicel short; capsule oval-globose, base subangulate, apex slightly curved; spores minute, smooth. Müller Syn. Musc. Frond. 1: 35.—Greenland.

44. **Gymnostomum platyphyllum** Kindb.—Dioicous: plants green, not glossy: stem not papillose, sparingly radiculose: leaves decurrent, distinctly papillose, short, obtuse, oblong, lanceolate, the comal greater, one border often recurved all around; costa greenish yellow, very papillose. Bull. Torr. Bot. Club 17: 84. 1890.—On the face of a small waterfall, near Kamloops, B. C.

45. **Anœctangium compactum** Schw.—Dioicous: stem fragile, red tomentose: leaves erect spreading, when dry appressed, spirally arranged or with the twisted points incurved, linear-lanceolate, margin plane, faintly crenulate; costa strong, percurrent or vanishing below apex; basal cells short rectangular, the remainder round-hexagonal, papillose on both sides: perichætial leaves sheathing, outer ones small, inner larger, smooth, costa vanishing far below apex: seta straw-colored, twisted to the right; capsule obovate, smooth, neck short, indistinct: two rows of quadrate annular cells which sometimes remain with the capsule and sometimes with the lid. Limpr. Laubm. 1: 244. *fig. 92.*—Greenland.

46. **Eucladium** B. & S.—Genus closely related to *Trichostomum* and *Gymnostomum:* plants cespitose, erect, dichotomously branched, base of the old innovations radiculose: leaves erect-spreading, when dry straight or slightly curved, lanceolate or linear-lanceolate, margin plane, toothed near the middle; costa strong, round: dioicous: capsule generally erect, oval or long oval, with a short indistinct neck; lid obliquely rostrate; annulus simple; peristome of sixteen lanceolate or linear-lanceolate teeth, entire, lacerate or perforated; spores small, smooth.—Bryol. Eur.

47. **Eucladium verticillatum** B. & S.—Tufts thick, 1-4 cm. rarely 14 cm. long, bluish-green, below light or yellowish brown: leaves linear-lanceolate; costa percurrent or rarely excurrent; cells of the lower part of leaf thin-walled, hyaline, long rectangular, marginal cells smaller, the remainder richly chlorophyllose, round quadrate and also rectangular, papillose on both sides: perichætial leaves scarcely different: calyptra cucullate, covering ⅓ the capsule. *Mollia verticillata* Lindb., Braith. Brit. Moss Flora 1: 241.—Santa Ana Cañon, California.

48. **Weisia convoluta** C. M. & Kindb.—Tufts dense, dark green: stem

slender, branching, densely foliate: leaves very patent when moist, flexuous, from a broader oblong base narrowed into the very narrow and long often piliform acumen, margins entire and erect; cells small, quadrate, chlorophyllose, opaque: costa very thin, vanishing in the acumen: perichætial leaves broader, vaginant at base, shorter than the others, densely appressed involving the pedicel: capsule cylindric, very narrow, faintly curved: lid obliquely restorate; pedicel yellowish, elongate, slender, spirally twisted, narrowed to the capsule. Mac. Cat. 14.—Mountains near Silver City, N. W. T., altitude 7,700 ft.

49. Weisia viridula nitida Ren. & Card.—Leaves shorter, capsule narrow, sub-cylindrical, shining as though varnished and distinctly sulcate when dry. Bot. Gaz. **14**: 91. 1889.—On sandy ground: Florida; Louisana.

50. Weisia viridula Rugeliana Ren. & Card.—Calyptra larger, operculum longer rostrate. Revue Bryol. **19**: 73. 1892.—Georgia.

51. Cynodontium subalpestre Kindb.—Tufts green, about 1 cm. high or lower: leaves crisped, from the narrowly ovate-oblong base attenuate-subulate, acute, nearly smooth as also on the costa, entire or distinctly denticulate above; borders recurved to middle at one side; cells pellucid, mostly quadrate, alar much wider, rectangular, hyaline: perichætial leaves with a broader base, inner ones much shorter: capsule small, subcylindric-clavate, wide-mouthed, faintly striate when dry; teeth pale, bifid, not papillose; annulus wanting; lid conic, short rostrate; pedicel yellow, finely bright red. Mac. Cat. 17, 257.—Rocks near water: Labrador; Quebec; Lake Huron; Lake Superior; Lake Nepigon.

52. Cynodontium strumulosum C. M. & Kindb.—Tufts bright green, 1–2 cm. high: leaves crisped, sub-linear, blunt or sub-acute, recurved at the basal margins, crenulate above, nearly pellucid; basal cells linear, the others short, angular; costa very papillose at the back, not percurrent: perichætial leaves short acuminate: capsule small, oblique, oblong-ovate, inclined, when dry furrowed, distinctly strumose; teeth not papillose, cleft to the middle, reddish also in the upper part; annulus distinct; pedicel light red or yellow, straight, 1 cm. long. Mac. Cat. 16.—Limestone rock along a torrent near Hector, B. C.

53. Dichodontium pellucidum fagimontanum Sch.—Plants shorter, more dense, with shorter branches: leaves shorter, more obtuse, scarcely recurved; capsule smaller, less inclined. Braithw. Brit. Moss Flora **1**: 163.—Hector, B. C.

54. Dichodontium Olympicum Ren. & Card.—Differs from much more robust *D. pellucidum* thus: leaves strongly papillose, minutely denticulate almost all around: capsule strumose at base: plants delicate, scarcely 1 cm. high. Bot. Gaz. **17**: 296. 1892.—Olympic Mts., Wash.

55. Trematodon brevicollis Hsch.—Monoicous: tufts small, stems 2–4 cm. high: leaves imbricate, lower smaller and loosely appressed, long and

pointed, upper aggregated, larger, broad ovate, concave, margins plane, netire, suddenly narrowed into a short lance-like point; costa percurrent, broad and flat; cells thin walled, densely chlorophyllose, below rectangular, above rhombic or rhomboidal: perichætial leaves larger, sheathing, short-pointed, costa narrower, vanishing near apex: seta twisted to right when dry; capsule long, neck equaling sporangium, slightly curved, gradually narrowed into seta, when dry faintly costate; calyptra inflated, cucullate; lid ½ as long as capsule, obliquely long rostrate from a broad base; annulus compound, of two rows of cells; teeth lanceolate, undivided, often perforated along middle; spores large, round or oval, papillose. Limpr. Laubm. **1:** 416. *figs. 139, 140.*—Greenland.

56. Dicranella Schreberi lenta (Wils.) Limpr.—Tufts thick, about 4 cm. high: leaves larger and broader, plainly toothed on margin. Limpr. Laubm. **1:** 318.—Moist earth, Washington.

57. Dicranella parvula Kindb.—Allied to *D. varia:* dioicous: plants very short, densely cespitose in small tufts, dark green: leaves crenulate all around, sub-ovate: cells short, oblong quadrate, basal linear: costa very thick and brown, excurrent, denticulate above, forming at least half acumen: perichætial leaves denticulate above: capsule obovate, sub-erect or inclined, without a neck, not striate: beak very short and thick; annulus scarcely loosed; teeth orange, pale at apex, partite, without basilar membrane, not papillose; pedicel pale red yellow, 1 cm. long or shorter, straight or curved only at apex. Mac. Cat. 21.—On the earth: Cathedral Mountain, B. C.

58. Dicranella Langloisii Ren. & Card.—Cespitose, pale or yellowish green: stems short, 4–7 mm. long: leaves small, crowded, erect spreading when moist, appressed when dry, from an oblong base shortly acuminate, blunt at denticulate apex, strongly revolute on one side, slightly reflexed or almost plane on other; costa stout, broad, percurrent, rounded at back; leaf cells short, rectangular or sub-rectangular below, elongated, 4–7 times longer than broad above: perichætial bracts longer, longer acuminate; costa short excurrent: pedicel purple; capsule suberect, oblong, incurved, reddish-brown, constricted under orifice when dry: lid large, highly convex-conic, with an oblique beak; peristome purple, high, teeth bifid to above middle: annulus none. Bot. Gaz. **15:** 39. *pl. 5.* 1890.—On the ground: Saint Martinville, Louisiana.

59. Dicranella leptotrichoides Ren. & Card.—Resembling in habit *Leptotrichum tortile:* dioicous, small, loosely cespitose, green: stems short, erect, simple: leaves erect or sub-secund, lanceolate, acuminate, sub-acute or rather obtuse at the apex, quite entire, borders plane or partly revolute; costa stout, percurrent; leaf cells oblong or sub-linear, shorter, looser, and sub-rectangular below: perichætial bracts scarcely different, a little longer: seta long, yellowish when young, afterwards red-

dish: capsule small, erect, symmetric, ovate-oblong, scarcely constricted under the orifice when dry; lid equaling sporangium, long and obliquely subulate rostrate; peristome purple, teeth trabeculate, striolate lengthwise, cleft to below the middle into 2–3 subulate legs, granulose and partly connected; annulus very broad, deciduous, 2–3 rows of cells: male plants unknown. Bot. Gaz. **19**: 237. *pl. 21.* 1894.—On the ground: Louisiana: Mobile, Alabama.

60. Dicranella Fitzgeraldi Ren. & Card.—Cespitose; yellowish or dirty green: stems long, simple or bipartite: leaves crowded, sub-secund, from a lanceolate base gradually narrowed into a long subulate canaliculate point, denticulate at the apex; costa broad, occupying ⅓ of leaf-base and nearly all of point; cells rectangular or sub-rectangular, firm, more or less elongated: perichætial leaves from a dilated, sinuate-denticulate base abruptly subulate, denticulate at apex: seta yellowish, long, twisted: capsule erect, symmetric, oblong, not constricted under orifice, when dry slightly plicate, brown or yellowish: lid convex, obliquely long rostrate; teeth purple or orange, densely trabeculate, striolate lengthwise, faintly granulose, cleft to below middle into two very long subulate legs, quite free or partly connected: male flowers unknown. Bot. Gaz. **13**: 197. *pl. 13.* 1888.—On sandy ground: Palatka, Florida.

61. Dicranella Howei Ren. & Card.—Closely related to *D. varia:* stem longer: leaves more lax, longer, more flexuous, margin plane throughout; costa broader, cells narrower: capsule longer and more slender, shining green. Revue Bryol. **20**: 30. 1893.—California.

62. Dicranella laxiretis Ren. & Card.—Closely related to *D. debilis:* capsule narrower: leaves narrower and more flexuous, with a denticulate apex; cells larger and shorter. Revue Bryol. **20**: 30. 1893.—Louisiana.

63. *Dicranella cerviculatula* Kindb. (Labrador) and *D. polaris* Kindb. (Alaska) are *nomina nuda.*

64. Dicranum hyperboreum (Gunn.) Smith.—Resembling *D. fulvellum* but more robust, cespitose: leaves patent and sub-secund, when dry incurved, subflexuous, lanceolate and lanceolate-subulate from the lanceolate base, acumen nearly smooth; areolation dense: perichætial leaves narrowly aristate from the long sheathing base: capsule erect or subcernuous, ovate or oval, neck inflated, substriate, when dry and empty cyathiform and plicate; teeth of the peristome broader, short subulate, distinctly strigose, 2–3 divided and perforated to the middle. Müll. Syn. Musc. **1**: 372. —On rocks: Mt. Hood, Oregon.

65. Dicranum hyperboreum papillosum Ren. & Card.—Leaves shorter, deeply canaliculate, papillose on back; costa strongly rugose. Bot. Gaz. **14**: 91. 1889.—Disco, Greenland.

65*a*. Dicranum falcatum Hendersoni Ren. & Card.—Pedicel purple

below, yellow above. Bot. Gaz. **15**: 39. 1890.—Moist sunny rocks: Mt. Hood, Oregon.

66. **Dicranum molle** Wils.—Tufts large, dense, 6–15 cm. high, yellow green or olivaceous above, fuscescent below: stem eradiculose: leaves erect-patent, straight, oblong lanceolate, subulate, entire, very concave or semi-tubulose above by incurved margin, auricled at base; costa narrow, percurrent or excurrent; alar cells large, orange, quadrate, remainder narrow linear: perichætial leaves oval-oblong, sheathing, suddenly subulate, imperfectly denticulate at apex: capsule oblong-cylindric, cernuous incurved, substrumose, not striate, fuscescent; annulus simple; lid short beaked; peristome purple: monoicous, male inflorescence close to perichætium. Braithw. British Moss Flora **1**: 144. *pl. 20.*—Greenland.

67. **Dicranum longifolium compactum** Ren. and Card.—Plants small, in very compact tufts: stems 1–2 cm. long: leaves half as large as type, erect, straight or slightly flexuous; costa very large, ½ or ¾ the width of leaf at base, canaliculate and very rough on back: sterile. Fl. Miq. 42.—Miquelon.

68. **Dicranum Santeri pachytrichum** Kindb.—Stem very tomentose in its whole length: leaves nearly entire; costa very much narrower than type: pedicel short, about 1 cm. long. Mac. Cat. 260.—On sticks in a brook: Selkirk Mountains.

69. **Dicranum Grœnlandicum** Brid.—Dioicous, male plants unknown: appearance of *D. elongatum:* tufts thick, about 6 cm. high, bright yellowish green, slightly radiculose: leaves rigid, when dry densely appressed with slightly bent points, never secund, linear-lanceolate, tubulose near apex, blunt, margins entire; costa weak, $\frac{1}{10}$ greatest width of leaf, percurrent or vanishing below apex; alar cells large, distinct, the remainder elongated, thick walled, pitted: inner perichætial leaves ecostate or with a weak costa: capsule erect, small, about cylindrical, somewhat curved, short and narrow-necked, faintly striate; annulus of one or two rows of cells; lid longer than capsule, obliquely rostrate; peristome orange, teeth divided to below middle, above pale and almost smooth. Limpr. Laubm. **1**: 364.—Miquelon Island; Mansfield Island, Hudson strait; Jupiter River, Anticosti; Labrador; Greenland.

70. **Dicranum fuscescens** Turn.—Dioicous: tufts dense, 1–6 cm. high, mostly brownish green, rarely dark green, not shining, more or less brownish radiculose: stem erect, fasciculately branched, leaves irregularly spreading, rarely secund, when dry somewhat crispate, very long, concave subulate from a narrow lanceolate base, margin toothed above; costa strong, $\frac{2}{5}$–$\frac{1}{5}$ leaf base; leaf cells not or only sparingly pitted, mamillose on under side, elongated rectangular below, rectangular in middle and quadrate above: inner perichætial leaves suddenly narrowed above middle into a

long bristle point: seta straw colored, finally red, twisted to right below and to left above; capsule slightly inclined, obovate, curved, six costate, neck distinct, inflated; annulus compound, of 2–3 rows of cells; lid often longer than capsule, obliquely long rostrate from a broad base; peristome teeth dark purple with yellow thickly papillose points, broad and approximate, bi- or trifid for one-third length; spores brown, papillose. Limpr. Laubm. **1**: 359. *D. fuscescens longirostre* Schimp., and *angustifolium* Schimp., Lesq. and James Man. 72.—Common on old logs across the continent: United States; Canada; Greenland.

71. Dicranum fuscescens falcifolium Braith.—Densely tufted, deep green, fastigiate; leaves all falcate-secund, flexuous-cirrhate toward apex, shorter and less attenuated to point. Braith. Brit. Moss Flora **1**: 153.—Washington.

72. Dicranum Miquelonense Ren. and Card.—In small, compact, yellowish-green tufts: stems dichotomous, radiculose below, 1–3 cm. long: leaves small, short, erect imbricate or slightly incurved, oblong-lanceolate, acute or obtuse, concave, entire or minutely sinuate denticulate at apex, 2–3 mm. long; costa vanishing near apex, smooth or scarcely rugose at back; cells smooth, small, short, quadrate or irregularly angular in upper half, rectangular, 1–3 times longer than broad and thin walled towards base, alar lax, large quadrate or sub-hexagonal, brown or yellowish: fruit unknown. Bot. Gaz. **14**: 93. 1889.—On the ground and on rocks, Miquelon Island.

73. Dicranum neglectum Juratz.—Dioicous, male plants small and delicate, densely tomentose: intermediate in habit and characters between *D. scoparium* and *D. Muehlenbeckii:* tufts thick, 5 cm. high, faintly shining, sparingly radiculose: stem densely foliate, leaves erect spreading, when dry somewhat curved and twisted, scarcely crispate, brittle, from ovate concave base lanceolate-subulate and tubulose, margin entire, obscurely toothed at apex; costa weak, $\frac{1}{9}$ leaf base, percurrent or excurrent, smooth on under side; cells smooth, nearly as in *D. scoparium* but very thick-walled and profusely pitted, lower elongated-rectangular or linear, upper elongated mixed with quadrate cells: perichætial leaves tubulose, abruptly narrowed into a subulate point: capsule, lid, annulus, and peristome as in *D. Muehlenbeckii.* Limpr. Laubm. **1**: 353.—On rocks: Oregon; Mt. Niblock, Mt. Aylmer and near Hector, B. C.

74. Dicranum Muehlenbeckii cirrhatum (Sch.) B. & T. MS.—Similar in appearance to the deep tufted forms of *D. congestum:* tufts to 10 cm. high, slightly radiculose, easily falling apart: leaves notse cund, erect-spre ading strongly curved; costa $\frac{1}{6}$ greatest width of leaf; lamina continued to apex, margin and under side of costa toothed; alar cells very small, well-defined, all leaf cells smaller than in *D. Muehlenbeckii*, slightly thickened, lower rectangular, somewhat porose, above very irregular: seta shorter than in

D. Muehlenbeckii; capsule shorter, cernuous; peristome very low, pale purple, within scarcely barred: teeth divided to middle, legs narrowed. *D. Muehlenbeckii brevifolium* Lindb., Limpr. Laubm. **1:** 355.—Godhavn, Greenland; Digges Island, Hudson Bay.

75. Dicranum dipteroneuron C. Müll.—Tufts rather dense, radiculose, an inch high: stems dichotomous, flexuous: leaves laxly erect, rather broad, small, yellowish green, shining, stiffish, smooth, flexuous, when moist rather strict, broadly lanceolate, stoutly acuminate, involute, coarsely and unequally serrate near apex; costa thicker at base, gradually narrowed, with two parallel serrulate low wings on back above; cells large, elliptical above, longer at base, walls thick, pitted, alar cells numerous, brownish: perichætial leaves similar: seta erect, scarcely an inch long, slender, slightly twisted, red at base, yellowish above; capsule arcuate, very narrow, small, obliquely long rostrate; calyptra very narrow, smooth. Flora **70:** 219. 1887. —Alaska.

76. Dicranum pallidum Bry. Eu. (not Müll.).—In compact green or yellowish tufts: stems 2–4 cm. long, simple or dichotomous, covered below with ferruginous tomentum: leaves erect-patent or subsecund above when moist, flexuous and somewhat crispate when dry, oblong-lanceolate, long narrowed acuminate, generally somewhat inflexed at margins, subcanaliculate, smooth or papillose at back, serrulate above: costa percurrent or excurrent, generally papillose and denticulate at back above, sometimes nearly smooth; cells short, angular, irregular in the upper part, linear, elongated towards base, the alar, large, lax, quadrate or sub-hexagonal, orange brown: outer perichætial leaves from a broad base suddenly constricted into a more or less elongated denticulate point, the inner convolute sheathing, abruptly subulate from the rounded apex: seta yellowish; capsule pale, cernuous or sub-erect, oblong or subcylindric, arcuate, slightly plicate when old, neck small, strumose; lid conic, long subulate rostrate; annulus distinct; teeth purple, cleft to the middle or below into 2–3 free or coherent legs. *D. sabuletorum* R. & C., Bot. Gaz. **14:** 91. 1889. *D. spurium* var. *condensatum* L. & J., not *D. condensatum* Hedw., L. & J. Man. 76. In dry sandy places on hills especially in southern district: Florida: S. Carolina.

77. Dicranum scoparium compactum Ren.—Tufts very compact: leaves slightly homotropous, often broken at point, dentate, acumen short: sterile. Fl. Miq. 44.—Miquelon Island.

78. Dicranum scoparium flexicaule Ren. & Card.—Stems long, slender, decumbent, then erect, flexuous, innovations slender, reaching or exceeding the capsule: leaves erect incurved, slightly flexuous, somewhat long acuminate, entire or sinuolate-crenulate; costa vanishing below apex; cells with delicate sinuate walls not or but slightly pitted: capsule reddish, irregularly rugose-plicate when dry. Fl. Miq. 44.—Miquelon Island.

79. **Dicranum scoparium sulcatum** Ren. & Card.—Tufts yellowish, habit more slender: leaves erect or spreading, sometimes flexuous or even a little twisted, narrower, longer and more slenderly subulate, teeth more salient and pointed; cells delicate, generally chlorophyllose, less pitted: seta slenderer, strongly twisted to the right, pale; capsule dark red, distinctly plicate when dry. Fl. Miq. 44.—Miquelon Island.

80. **Dicranum scoparium spadiceum** Boul.—Nearly identical with European plant: leaves erect, entire or sub-entire, acumen smaller, sub-obtuse, costa vanishing below apex; cells sinuous and pitted. Fl. Miq. 44. *D. spadiceum* Zett.—Miquelon Is.; Rocky Mountains.

81. **Dicranum scoparium orthophyllum** Brid.—Leaves rigidly erect, when dry appressed, coarsely dentate. Limpr. Laubm. 1: 352.—Vancouver.

82. **Dicranum scoparium curvulum** Brid.—Stems arcuate ascendent; leaves falcate-secund, narrower, yellowish-green; capsule shorter. Husn. Muscol. Gall. 35.—Oregon and Washington.

83. **Dicranum scoparium crispulum** De Not.—Plants low: leaves crispate when dry.—Washington.

84. **Dicranum consobrinum** Ren. & Card.—Densely cespitose, yellowish green: stems erect, simple or dichotomous, tomentose, 5–8 cm. long: leaves rather crowded, secund or erect spreading, narrowly lanceolate-subulate, serrate in the upper half; costa serrate at the back toward the apex; cell-walls porose, scarcely thickened: perichætial bracts sheathing, truncate or emarginate at the apex, sometimes muticous, generally tipped with a short or little elongated subula: seta yellow, sub-flexuous; capsule cernuous or horizontal, narrowly cylindraceous, curved, not sulcate, long attenuate below, rufescent when old; lid long subulate: male plants gemmaceous, nidulant in the tomentum of the female stems. Bot. Gaz. 15: 39. 1890.—Minnesota.

85. **Dicranum Bonjeani Schlotthaneri** Barnes.—Mostly olive green: stem very short, 1–2 cm. high: leaves shorter and broader, margin entire or with a few indistinct teeth at the apex, often somewhat revolute. Bot Centralbl. 44: 386. 1890.—Oregon; Washington; Idaho; Wyoming.

86. **Dicranum Bonjeani Rœllii** Barnes.—Plants robust, in deep extended quite lax tufts, 4–8 cm. high, below pale, above yellowish green: leaves crowded, not undulate, lanceolate, entire, acuminate; costa vanishing in the acumen, only faintly canaliculate on the back and not toothed. *Loc. cit.*—Vancouver.

87. **Dicranum Bonjeani alatum** Barnes.—Dark green, 4–6 cm. high: leaves lanceolate, very sharply toothed; costa 2–3 cells thick, with 2–3 sharply toothed lamellæ; laminal cells shorter and broader, less thickened and less strongly pitted. *Loc. cit.*—Chicago, Ills.

88. **Dicranum brachycaulon** Kindb.—Allied to *D. spurium:* stems short, only 1 cm. high: the leaves smaller and shorter, oblong-ovate, acute,

not acuminate, entire, not papillose at the back; costa elevate, percurrent and smooth, alar cells brown: capsule small, pedicel 1 cm. long. Mac. Cat. 34.—On dry rocks in the open woods: Yarmouth, N. S.

89. **Dicranodontium Virginicum** Britt.—Dioicous: plants bright glossy green: stems matted below by a red tomentum, leafy nearly to apex, denudate roughened above, with a few leaves at summit: leaves erect or secund, straight or curled and twisted, narrowly subulate from a short thick base; caducous ones with a long slender smooth point; persistent ones serrate, blade inflexed, cells densely chlorophyllose, filled with oil globules, those of basal angles clear: perichætial leaves from a short base suddenly subulate, dentate at apex: pedicels lateral by innovations, pale, glossy yellow, twisted in two directions, very slender, arcuate when young, becoming erect before mature: capsules cylindric, ribbed only at mouth, beak straight or curved, shorter than capsule; peristome bright red, not deep set, teeth split unequally to middle, striolate at base, pale and granulose above: annulus none, spores small, calyptra cucullate. Prelim. Cat. Flora W. V. 488.—On sandstone boulders: Monongalia, W. Va.

90. **Dicranodontium Millspaughi** Britt.—Dioicous: plants light yellowish green, silky, cespitose: stems matted with rufous tomentum at the base, a few denudate-roughened by fragments of slightly caducous leaves: leaves secund or erect-spreading, narrowly subulate from a broad base, becoming tubular above by inrolled margins, basal angles not auricled, filled by large hyaline cells to base of broad brown vein, those of blade oblong or square next the vein, becoming spindle shaped and prosenchymatous towards margin; costa thick, excurrent into a slender dentate tip, rough on back: perichætial leaves sheathing half their length, tapering to a long slender obscurely serrate tip, outer shorter, abruptly subulate, more sharply serrate: pedicels recurved, burying capsule among leaves, erect when old, stout and twisted in two directions; capsules pyriform-cylindric with a distinct neck; lid as long as capsule, straight beaked; calyptra cucullate, entire; peristome red, connivent, teeth deep set, slender, split to middle or perforate, striolate below, granulose above: annulus none. Prelim. Cat. Flora W. Va. 488.—On sandstone boulders in deep woods: Tibbs Run, W. Va.

91. **Campylopus Schimperi** Milde.—Dioicous: tufts dense, compact, interwoven with rufous tomentum, fastigiate: stems slender, cuspidate, light silky green above, fuscous below, dichotomous with alternate innovations which are easily detached: leaves appressed when dry, erect-spreading, straight, rigid, narrowly lanceolate subulate, slightly toothed at apex, channelled in lower part, becoming tubulose above from incurved wings; costa broad, ⅔ width of leaf base: cells of the extreme base brown and vesicular, above hyaline, very narrow at margin, elongate rectangular towards the nerve, upper small and elliptic: perichætial leaves sheathing,

suddenly narrowed into a long subula: capsules pale, ovate, striate; annulus broad; lid half length of capsule, beaked; peristome small; teeth cleft to middle; spores large. Braithw. Brit. Moss Flora **1**: 130.—Greenland.

92. Campyopus Henrici Ren. & Card.—Cespitose, yellowish green: stems very short, without tomentum: leaves slightly secund, lanceolate-subulate and semitubulose from an oblong base, upper generally tipped with a short hyaline denticulate and often broken point; basilar cells rectangular (3–4 : 1), those of angles sometimes rather soft and yellowish, not forming distinct auricles, upper elongated, straight, linear; costa broad, ⅓ width of leaf: male flowers small, gemmiform, placed near tips of stems: female flowers and capsule unknown. Bot. Gaz. **13**: 198. 1888.—Sandy ground: Saline county, Kansas.

93. Fissidens incurvus brevifolius Ren. & Card.—Leaves broader and shorter: border of the vaginant lamina widening less at the base. Bot. Gaz. **14**: 94. 1889.—On the ground in woods: Baton Rouge, La.

94. Fissidens pusillus Wils.—Heteroicous: plants very small, simple or branched at base: stems short, inclined: lower leaves very small, larger above and mostly secund, narrow lanceolate, becoming smaller towards apex, sharp pointed, margin quite entire, border narrow, vanishing below apiculus, costa lost at point; vaginant lamina not reaching middle of leaf, inferior lamina semi-lanceolate, rapidly narrowed at base and lost before reaching stem; cells oval or rounded: capsule on a pale seta, very small, erect or inclined, oval-cylindric, strongly contracted below mouth when dry; lid conic, somewhat obliquely rostrate; peristome deep red, arising below orifice, teeth deeply cleft, legs subulate, filiform, rough; spores brown, smooth. Braithw. Brit. Moss. Flora **1**: 68.—Abundant on damp flat limestone rocks in woods: Ontario.

95. Fissidens obtusifolius Kansanus Ren. & Card.—Leaves with a broad border of elongated cells on the margins of vaginant lamina, and a narrow more or less distinct border on dorsal wing. Bot. Gaz. **15**: 40. 1890.—Saline county, Kans.

96. Fissidens taxifolius Langloisii Ren. & Card.—Habit a little more robust, leaves subobtuse, apiculate, dorsal lamina suddenly rounded at base as if auriculate. Revue Bryol. **19**: 78. 1892.—Louisiana.

97. Fissidens adiantoides brachyphyllus Kindb.—Leaves very short. Mac. Cat. 37.—On boulders: Belleville, Ont.

98. Fissidens falcatulus Ren. & Card.—Very small, gregarious, yellowish green: stems rather rigid, plumulose: leaves 4–8 pairs, falcate secund and rigid when dry, linear lanceolate, acute or sub-apiculate; vaginant lamina about one-half length, narrowly bordered, dorsal lamina not bordered, tapering below, apical lamina without a border, subentire or minutely crenulate at apex; costa pale, subpercurrent; cells hexagonal, pellucid: fruit unknown. Bot. Gaz. **19**: 237. 1894.—On the bark of trees: Louisiana.

99. Fissidens pauperculus Howe.—Dioicous: minute, loosely gregarious, flavescent: stems decumbent or ascending: leaves 3–5 pairs, increasing in size upward, lowest minute, upper oblong to obliquely spatulate-oblong, acute or shortly acuminate, margin slightly serrulate crenulate; border none; costa stout, vanishing below apex; vaginant lamina ⅓ to ½ length of leaf, unequal; inferior lamina ending at about middle of vaginant lamina in upper leaves or reaching base in lower; cells of vertical lamina mostly hexagonal, smaller and oval at margin, enlarged and oblong rectangular next to costa, those of vaginant lamina becoming longer and narrower towards base: seta terminal, flexuous, pale yellow; capsule yellowish, oval or oval-oblong, inclined or cernuous, slightly arcuate when dry; lid conic-rostellate, about equaling capsule; peristome red, normal; annulus pale, of 2–3 rows of deciduous cells. Erythea 2: 97. 1894.—On moist banks in company with *F. limbatus* Sulliv., Marathon county, Cal.

100. Ceratodon conicus Hpe.—Dioicous: tufts cespitose, dull yellow green above, fuscous below: stems short, rather slender, dichotomously branched: leaves erect appressed, deep green, smooth, crowded at tip into a small closed coma, straight wet or dry, rather broadly ovate lanceolate, margin quite entire, revolute to apex, nerve thick, excurrent into a long point; cells all small, regularly quadrate, basal larger and pellucid: perichætial leaves convolute-vaginant, obtusate with an excurrent nerve, laxly areolate: capsule on a pale red seta, erect, ovate-elliptic, rather wide, fuscous, when dry and empty but little altered, sulcate in upper part, not strumulose; lid purple, short conic; teeth pale, red at base, yellowish above, erect with fewer articulations, scarcely bordered externally. Braithw. Brit. Moss. Flora 1: 175.—At the base of a stump, Spence's Bridge, B. C.

101. Ceratodon heterophyllus Kindb.—Agrees with *C. purpureus*, in shape of capsule, stem leaves, not excurrent costa and revoluble annulus, but capsule often more curved and distinctly strumose; agrees with *C. conicus* in peristomial teeth having few articulations: differs from both in blunt perichætial leaves, and is also very peculiar in short concave subovaI leaves of long shoots. Ott. Nat. 5: 179.—On earth: St. Paul Island, Behring Sea.

102. Trichodon flexifolius Ren. & Card.[1]—Loosely cespitose, green: stems erect, simple, short: lower leaves small, lanceolate subulate, upper larger, patulous, very flexuous, from an oblong base gradually narrowed into a long linear subulate canaliculate subtubulose point, sinuate at margins, toothed at apex, and with a broad obscurely excurrent costa; basal cells rectangular, elongated (1 : 2–4), others small, quadrate, very chlorophyllose, with transverse walls slightly prominent: perichætial leaves similar, but dilated and sub-sheathing at base: male flowers on same plant,

[1] The authors of this species are not certain as to its generic positior, but state that by its vegetative system it is somewhat allied to *T. cylindricus*.

below female, small, gemmiform. Bot. Gaz. **14**: 94. 1889.—Sandy ground: Florida.

103. Ditrichum[1] **montanum** Leiberg.—Plants cespitulose, fastigiately branching, above more or less dichotomous: stem leaves erect or slightly curved, channeled and subulate above with a narrow lamina of two to three rows of cells, subserrulate, margin inflexed, apex coarsely toothed; costa broad, strong, vanishing below apex: leaf cells above and in middle hyaline or chlorophyllose, thick walled, quadrate rectangular below: plants monoicous, seldom synoicous: outer perichætial leaves similar, inner broadly sheathing: seta pale yellow, slightly twisted when dry; capsule narrowed at mouth, erect, ellipitical; when dry laterally compressed and longitudinally wrinkled: teeth cleft to base, legs equal, semiterete, minutely papillose, obscurely and distantly articulate, attached to a short basilar membrane; annulus double, narrow, dehiscent; lid long, conical. Bull. Torr. Bot. Club **20**: 112. 1893.—On the broken soil, upturned tree roots, etc in mountain regions, at all elevations up to 8,000 feet, Idaho.

104. Ditrichum ambiguum Best.—Dioicous: tufts loosely cespitose, stem rather stout, arcuate-erect with one or more innovations: leaves pale yellow, shining, crispate when dry, accrescent upwards, lanceolate-subulate, patent-subsecund, flexuose; lower erect at half clasping short base, lanceolate; upper with oblong erect bases, long lanceolate subulate, concave, the slightly thickened involute margins sinuate dentate; cells linear, oblong, indistinct above; walls thick, tortuous, striate; costa percurrent and dentate on back: perichætial leaves with longer sheathing bases not abruptly narrowed: seta long flexuous; capsule cylindrical, narrow, straight or slightly curved; lid conical-rostrate, blunt, nearly or quite erect, about ⅓ length of capsule; teeth reddish, long, straight, papillose, nearly or quite split to broad basal membrane; legs filiform except at slightly flattened connate bases, equal and regular: annulus large, adherent. Bull. Torr. Bot. Club **20**: 117. 1893.—Moist banks: Mason co., Washington.

105. Ditrichum flexicaule brevifolium Kindb.—Leaves very small, from an ovate oblong base, contracted to a short point; costa not excurrent: barren. Mac. Cat. 46.—On rocks: National Park: Rocky mountains.

106. Distichium Macounii C. M. & Kindb.—Tufts dusky green, very dense, compact, radiculose below: stems 2-3 cm. high: leaves patent or subfalcate from a short, suddenly narrowed, sheathing base, entire or with a few small teeth at apex; cells short subquadrate; costa sub-percurrent: barren. Mac. Cat. 40.—On banks subject to inundation: Columbia river, B. C.

107. Seligeria campylopoda Kindb.—Agrees with *S. recurvata* in shape of capsule and arcuate pedicel: differs in leaves broader, very much shorter, sub-linear obtuse, rarely short acuminate and subacute; costa not

[1] *Leptotrichum* of L. & J. Man. 105.

excurrent: perichætial leaves not ovate-oblong, thin costate: peristome darker red: male flower fixed on side of female. Mac. Cat. 41.—Damp and shaded limestone rocks: Owen Sound, Ont.

198. Blindia acuta flexipes Ren. & Card.—Pedicel flexuous, distinctly geniculate. Revue Bryol. **19**: 79. 1892.—Oregon.

109. Pottia heimioides Kindb.—Nearly allied to *P. Heimii:* differs in leaves shorter, the lower obtuse: costa sometimes excurrent: capsule longer and narrower, cylindric; seta golden yellow; peristome present but rudimentary. Mac. Cat. 43.—On earth: National Park; Rocky mountains.

110. Pottia intermedia Fürn.—Scarcely distinguished from *P. truncatula* with which it agrees in inflorescence, structure of stem and costa: plants larger, stem erect, longer, lax leaved below, dense above: leaves pale green, accrescent upwards, upper leaves long lanceolate, acuminate, margin revolute from base to middle; costa excurrent into a long yellowish-green point; cells in upper half quadrate or hexagonal, faintly papillose or perfectly smooth: capsule obovate to almost cylindrical, constricted below mouth when dry and with short, irregular folds; calyptra smooth, cucullate, covering half of capsule: lid about equaling capsule, obliquely rostellate; annulus compound, 2–3 rows of cells: peristome rudimentary; spores finely papillose. Limpr. Laubm. **1**: 531.—On earth: North West Territory.

111. Pottia littoralis Mitt.—Autoicous: resembling *P. intermedia*, pale below, green or bluish green above: leaves much longer, more erect, sheathing at base, more obtuse, with nerve excurrent in a short point, lower smaller with a long excurrent costa; upper cells smaller, quite smooth, with wall much more incrassate, basal pellucid, very narrow and elongated: seta pale orange red, elongated; capsule oblong oval, slightly narrowed at mouth, ferruginous: calyptra smooth, annulus adherent, of one row of cells; lid rostrate, slightly twisted, oblique; spores ferruginous, scarcely rough. Braithw. Brit. Moss Flora **1**: 198.—On earth: Yale, B. C.

112. Didymodon Canadensis Kindb.—Differs from *D. rubellus* principally in perichætial leaves thinner, from the ovate base abruptly attenuate to a short subulate acumen: borders not reflexed: basal cells very long; costa thinner: dioicous. Mac. Cat. 44.—On perpendicular rocks: Rocky mountains.

113. Didymodon Baden-Powellii Kindb.—Dioicous: tufts compact: leaves revolute nearly all around, distinctly dentate: short acuminate, the lower pale brown: perichætial leaves longer acuminate or subulate, entire: capsules more or less curved; pedicel pale red: lid blunt conic, very short (scarcely $\frac{1}{6}$ capsule). Mac. Cat. 262.—St. Paul Island, Behring sea.

114. Didymodon Hendersoni Ren. & Card.—Tufts compact, yellowish above, ferruginous below: stems erect, branched, 1–2 cm. long: leaves crowded, patulous when moist, subincurved, erect-imbricate when dry, ovate or oblong-lanceolate, entire; apex rounded-obtuse or minutely apic-

ulate or subacute, borders revolute but flat below point; costa stout, rufescent when old, vanishing at or below apex: cells small, distinct, thick-walled, irregular, roundish quadrate, minutely papillose, lower rectangular, rather elongated towards costa, quadrate or transversely dilated on borders: perichætial leaves not sheathing, oblong-lingulate, obtuse at apex: seta reddish, twisted to left above: capsule erect, cylindrical, badious when old, lid obliquely rostrate: peristome unknown. Bot. Gaz. 15: 40. 1890.—Crevices of rocks: Oregon.

115. Didymodon rufus Lorentz.—Dioicous: tufts compact or loose, dark reddish brown, brownish green above: stems 2–4 cm. high, erect or geniculate, forked or fasciculately branched: leaves crowded, spreading and recurved above middle, when dry erect appressed or slightly twisted, gradually acuminate from an ovate lanceolate base, margin entire, revolute on border; costa percurrent or vanishing below apex, round, rough on both sides; lamina of one layer of cells, long mamillose-papillose; cells equally and strongly thickened, lumen round or transversely oval, at base near costa elongated rectangular, faintly pitted, and several marginal rows quadrate: fruit unknown. Limpr. Laubm. 1: 559.—Greenland.

116. Leptodontium Hampe.—Leaves squarrose-reflexed, complicate-concave, flexuous, the margin serrulate or erose-crenulate: capsule leptodermous, narrow, erect; lid conic; peristome of 32 filiform straight erect smooth teeth, unequal or anastomosing here and there in pairs, or connascent; calyptra cucullate.

117. Leptodontium Canadense Kindb.—Tufts loosely cohering, nearly without rhizoids, dark green, blackish below: stem about 1 cm. high, nearly simple: leaves squarrose, flexuose, undulate and not recurved at borders, when dry curled, sublingulate, acute, entire below middle, coarsely and unequally serrate above, not margined; lower basal cells rectangular and subpellucid, upper at middle quadrate, uppermost rotundate, slightly papillose: costa finally brown, short excurrent: dioicous, only female plants found. Mac. Cat. 45.—On stones: in the Sydenham river, Owen Sound, Ont.

118. Trichostomum nitidum Schimp.—Dioicous: tufts compact, pulvinate, 1–1.5 cm. high, olive-green, within reddish brown and radiculose: stems rigid and dense-leaved: leaves accrescent upwards, fragile, spreading when moist, when dry arcuate-incurved, with faintly crenulate incurved margins, glossy shining on the back, linear lanceolate, mostly obtuse, short pointed by excurrent costa; hyaline leaf base forming $\frac{1}{6}$ leaf, hyaline cells continued upwards as a border, but less sharply marked off from chlorophyllose cells, latter round-quadrate, with simple or geminate papillæ on both sides: perichætial leaves half sheathing, gradually diminishing in size, almost subulate: capsule erect, nearly cylindric, faintly curved, when old somewhat furrowed; lid $\frac{1}{3}$ capsule, obliquely rostrate;

annulus indistinct; teeth of peristome rudimentary, yellowish-red, trun cate, papillose (?). Limpr. Laubm. **1**: 581.—United States, without locality, collected by James and communicated by Bescherelle. Bot. Gaz. **14**: 99. 1889.

119. Trichostomum Vancouveriense (Broth.) R. & C.—Dioicous: loosely cespitose, fragile, bright green, shining: stem simple, 3 mm. high, long radiculose below, densely foliate above: leaves twisted when dry, arcuate-inflexed, margin involute; when moist straight, spreading, nearly plane, linear lanceolate from short base, acute, margin slightly undulate, remotely and obtusely denticulate from below middle upward; costa green, excurrent; lamina bistratose, chlorophyllose cells round-quadrate, basal cells elongated, hyaline: perichætial leaves scarcely different: capsule erect or suberect, cylindrical, shining, striate, short-necked; annulus broad, triple, revoluble; peristome simple, pale, tubulose base short, teeth erect, strongly papillose. *Timmiella Vancouveriensis* Broth. Bot. Centralbl. **44**: 387. 1890.—On slightly moist ground: Victoria, Vancouver island.

120. Desmatodon subtorquescens C. M. & Kindb.—Nearly allied to *D. atrovirens* Smith (*D. nervosus* B. & S.), but tufts compact: stem higher (about 1 cm.): leaves green, not dingy, very short, suboval or subspathulate, smaller, less opaque; costa neither excurrent nor broader above: capsule cylindric. Mac. Cat. 48.—On earth on exposed cliffs: Gaspé coast, Can.

121. Desmatodon camptothecius Kindb.—Habit of *D. cernuus:* plants densely cespitose: leaves long, narrow-lingulate, sub-obtuse, entire or obscurely crenulate, faintly papillose, marginate and at base revolute, mucronate by excurrent greenish costa: capsule cylindric, arcuate; teeth short, cut into 2 or 4 partly coherent segments; annulus distinct; lid obliquely short beaked; seta flexuous, reddish yellow, spores large. Mac. Cat. 49.—Rocks: Gaspé coast, Can.

122. Desmatodon cernuus xanthopus Kindb.—Leaves less chlorophyllose, costa virescent: capsule larger; teeth more united; pedicel yellow-Mac. Cat. 48.—On earth: Manitoba.

123. Leptobarbula Sch.—Plants small, delicate, gregarious: leaves minute, linear, sparse, strongly verruculose, areolation dense, not carinate: flowers dioicous, male gemmiform, terminal: perichætium sheathing: calyptra long, narrowly cucullate; annulus compound, broad, revoluble; teeth of peristome perfect, loosely one-half twisted; spores minute, smooth. Syn. Musc. Eur. 181. 1876.

124. Leptobarbula berica Sch.—Dioicous: plants gregarious or forming small tufts, bright green: stems very low (1–5 mm.), mostly simple, radiculose only at base: leaves when dry crispate, when moist spreading and somewhat reflexed, thickly warty papillose on both sides and costa; lower leaves distant, lance-subulate, upper gradually longer (.85 mm.),

uppermost (1.5 mm.) and perichætial leaves (2 mm.) from a sheathing base (⅓ of leaf) gradually or suddenly narrowed into an acute or obtuse recurved subula; lamina with flat margins, very narrow in subula, crenulate by papillæ; cells of base elongate-rectangular, thick walled, the upper small quadrate (6–8μ): seta erect, 6–13 mm. long: capsule erect, cylindric-oval; lid ⅓ the sporangium, obtuse; annulus of 3–4 rows of large cells, revoluble; peristome tube .04 mm. high, teeth filiform, not nodose. Limpr. Laubm. 1: 596.—On earth: Revelstoke, B. C.

125. **Barbula macrorhyncha** Kindb.—Habit of *B. brevirostris:* leaves round-ovate, obtuse, involute all around even at the apex; costa not excurrent: capsule oblong-ovoid; annulus revoluble; teeth long, twisted at least twice, beak of lid more than ⅔ length of capsule; seta pale red or yellowish: dioicous: calyptra unknown. Different from *B. rigida* in very much shorter leaves and longer lid. Mac. Cat. 50.—On earth: Ontario.

126. **Barbula Henrici** Rau. (§ Chloronotæ).—Dioicous (?): plants short, branched, closely cespitose, canescent from white excurrent costæ: leaves spreading when moist, imbricated when dry, concave, short spatulate; costa keeled, filamentose near apex of leaf, excurrent portion as long as leaf, hyaline, serrate; cells quadrate and chlorophyllose above, hyaline and elongated toward base: fruit unknown.—On rocks: Saline Co., Kansas.

127. **Barbula Manniæ** C. Müll.—Slender, small, bright green: stems short, simple: leaves minute, few; base erect, slender, loosely reticulate, concave; lamina for the plant elongate, narrow, oblong; apex roundish obtuse; margin obscure, quite entire, revolute; cells minute, hexagonal, costa rather thick, with a few narrow longitudinal lamellæ and deciduous gemmæ above: inner perichætial leaves very narrow, linear-oblong: seta long, red, flexuous; capsule small, erect, cylindraceous, brown; lid with slender oblique beak; annulus persistent, rather large; peristome membrane pale, short, teeth slender, red. Flora **70**: 222. 1887.—On calcareous soil: Colorado.

128. **Barbula Egelingi** Schlieph.—Dioicous: very small, slender, simple: leaves aggregated into a minute tuft, few, small, imbricate; lamina oblong lanceolate, very entire, from a more pellucid loosely reticulate broader base deeply carinate-concave; margin above convex, scarcely revolute, rather broad, of larger yellow cells; costa slender, excurrent; cells minute, roundish hexagonal, thick, obscure: seta very slender, long, flexuous, red; capsule erect, minute, very narrowly cylindric; lid very short conic, oblique, spirally twisted; annulus narrow, simple, persistent; peristome with a short membrane. Flora **70**: 222. 1887.—Memphis, Tenn.

129. **Barbula carnifolia** C. M. & Kindb.—Stem very short, 2–3 mm. high: leaves lingulate, not margined, blunt; margins recurved below and above the middle at one side; cells finally subpellucid, upper and median subquadrate, lower basal near costa large rectangular and hyaline, margi-

nal shorter and narrower; costa red, thick, and subpercurrent or rarely short excurrent: inner perichætial leaves smaller and shorter: capsule longer than the straight lid: probably dioicous. Mac. Cat. 52.—*Sine loco.*

130. Barbula subcarnifolia C. M. & Kindb.—Smaller than *B. carnifolia*, differing principally in leaves shorter, suboblong, short apiculate, upper pellucid at flat margins, costa green: probably monoicous. Differs from *B. amplexa* in capsule longer than oblique lid. Mac. Cat. 52.—On earth at the base of trees: Pelee Island, Lake Erie.

131. Barbula brachyphylla angustifolia C. M. & Kindb.—Tufts compact, sparingly radiculose, rusty-red, bright-green at summit, 1–2 cm. high: leaves shortly ovate-lanceolate, acute or subobtuse, indistinctly papillose, densely disposed, when dry appressed, borders reflexed nearly all around; cells small, round-quadrate: costa broad, reddish and percurrent: barren. Mac. Cat. 55, 264.—On calcareous rocks where water drips in spring: Columbia river, B. C.

132. Barbula decursivula Kindb.—Tufts rusty red with green tops, about 2 cm. high: stem radiculose below, not rigid, branches long and filiform: leaves small, when dry loosely appressed, open when moist, very broad at the base, subovate or ovate-oblong, acute or subobtuse, nearly smooth or faintly papillose at back, loosely disposed, long decurrent: borders reflexed nearly all around; cells pellucid, subquadrate, only the alar elongate; costa reddish, broad and percurrent: barren. Mac. Cat. 264.—On earth and rocks: Hector, B. C.

133. Barbula sparsidens C. M. & Kindb.—Loosely tufted: plants small, green above, ferruginous below, nearly simple: leaves small, when dry incurved, when moistened subsquarrose, arcuate, ovate-lanceolate, distinctly papillose; borders reflexed nearly all around; lower basal cells rectangular, hyaline; costa pale, rough at back, percurrent: inner perichætial leaves shorter than outer: costa not or very short excurrent: capsule small, oblong cylindric, reddish, longer than oblique beak: peristome and seta red: dioicous. Allied to *B. fallax*, but differing principally in peristomial teeth spreading, loosely and not spirally twisted. Mac. Cat. 54.—On earth: British Columbia.

134. Barbula Dieckii Broth.—Dioicous: tufts densely cespitose but loosely cohering, above tawny to dark olivaceous: stem erect, dichotomously branched, fastigiate, loosely foliate: leaves when dry imbricate, when moist spreading, apex erect, uniform, concave, broadly ovate lanceolate, acuminate, acute, papillose, margin entire, revolute to a little beyond middle; costa green, subterete, strong, above weaker, vanishing at apex; lamina unistratose, cells thick walled, rotund-quadrate, strongly chlorophyllose, papillose on both sides, basal cells scarcely larger, subquadrate: perichætial leaves similar to others, but long acuminate, base loosely retic-

ulate, inner ones smaller, margin plane: sterile. Hedwigia 32: 205. 1893. —Growing on rocks: Washington.

135. Barbula subgracilis C. M. & Kindb.—Densely tufted; plants small, about 6 mm. high, green above, reddish brown below, nearly simple: leaves when dry subcrispate, when moistened squarrose, curved from ovate base, narrow, long subulate, nearly smooth; borders reflexed nearly all around; lower basal cells rectangular, more pellucid; costa reddish, percurrent or short excurrent: inner perichætial leaves broad, blunt, with a long excurrent costa, others acuminate, all faintly crenulate: capsule oblong cylindric, red-brown, longer than obliquely subulate lid; seta red: dioicous. Allied to *B. gracilis*. Mac. Cat. 53.—On rocks: Yale, B. C.

136. Barbula subgracilis viridior Kindb.—Plants higher, about 1.5–2 cm., green and branching above, decolorate-brown below: leaves when dry crispate, more papillose: costa green: capsules not found. Mac. Cat. 263. —On rocks: Sydenham river, Ont.

137. Barbula subicmadophila C. M. & Kindb.—Laxly tufted: plants about 1 cm. high, pale brown, nearly simple: leaves when dry loosely appressed, when moistened subsquarrose or patent, nearly straight, short, ovate-lanceolate, acute, faintly papillose; borders slightly reflexed at base, inflexed at upper part, papillose crenulate; cells nearly uniform, roundish or subquadrate, apical often larger and pellucid: costa pale, percurrent: perichætial leaves from a short ovate base long-acuminate sublinear; costa dark brown, long excurrent, filling nearly whole acumen: capsule oblong-cylindric, finally blackish; pedicel dark brown: dioicous. Mac. Cat. 53.—On dry rocks, covered at high water: Yale, B. C.

138. Barbula melanocarpa C. M. & Kindb.—Laxly tufted: fertile stem nearly simple, about 2 mm. high, the barren branching, 4 mm.: leaves when dry appressed, not twisted, when moistened open, olive green, short ovate, lanceolate acute, slightly papillose: borders reflexed below middle; cells nearly uniform, roundish or subquadrate; costa brown, short excurrent: perichætial leaves from ovate oblong base long acuminate, costa filling whole linear acumen: capsule oblong-cylindric, straight, finally blackish, obliquely short beaked; annulus not distinct, pedicel red: dioicous. Mac. Cat. 54.—On rocks close to the water: Yale, B. C.

139. Barbula spadicea Mitt.—Dioicous: resembling *B. fallax*, but more robust, in looser thicker tufts, dull brownish green above, fuscous below: stems simple or branched: leaves when dry incurved and imbricated, when moist spreading from the base, recurved, from a broadly ovate base elongated lanceolate, channelled, margin recurved in lower half, folds more distinct, nerve strong, distinct to apex: cells incrassate and rounded quadrate from base, only lowest elongated oval, obscure above, papillose: perichætial leaves lanceolate, recurved from a long, lax-celled base: seta red; capsule erect, cylindric, slightly curved, castaneous with a red mouth;

annulus of 3 to 5 rows of small cells; lid short rostrate, nearly half length of capsule; peristome short, teeth red, on a very short orange basal membrane, scarcely twisted. Braithw. Brit. Moss Flora 1; 266.—On earth by a brook: Lytton, B. C.

140. Barbula pseudo-rigidula Kindb.—Agrees with *B. rigidula* in tufts fuscescent: leaves from a short erect base, patent or recurved, contorted when dry, long lanceolate, revolute below, nearly smooth; basal cells pellucid and rectangular; costa brown, nearly filling narrow acumen: differs in leaf borders not thickened, inner perichætial leaves from an oblong base, narrow acuminate with a long excurrent costa: peristome pale and distinctly contorted. Mac. Cat. 264.—On earth by a brook: Lytton, B. C.

141. Barbula circinnatula C. M. & Kindb.—Nearly allied to *B. cylindrica* or rather intermediate between *B. elata* and *B. virescens:* differs in upper leaves green, circinnate-twisted when dry: peristome paler and annulus simple: leaf cells more distinct. Mac. Cat. 56.—On earth on rocks: Agassiz, B. C.

142. Barbula horridifolia C. M. & Kindb.—Densely tufted: plants about 3 cm. high, green above, rusty red below, more or less branching: leaves crispate when dry, when moist falcate, spreading at all sides, very long and narrow, ovate-lanceolate, carinate above, loosely disposed and long-decurrent, nearly smooth; borders reflexed at ovate base, basal cells pellucid, short rectangular, inner larger, upper cells small and obscure; costa red-brown, broader below, narrow above, vanishing in apex: barren. Mac. Cat. 57.—On damp rocks: Columbia River, B. C.

143. Barbula robustifolia C. M. & Kindb.—Very nearly allied to *B. tortellifolia:* differs in dark brown or olive-green color of whole plant: leaves more crowded, shorter, with an ovate oblong base, borders reflexed nearly to the middle on one side; upper cells larger and subpellucid, basal ones hyaline, and subquadrate; costa thicker and not excurrent, linear and distinct to apex: barren. Mac. Cat. 56.—Abundant on rocks: Vancouver; British Columbia.

144. Barbula tortellifolia C. M. & Kindb.—Very much resembling *B. horridifolia* in habit: generally more robust (often 4–5 cm.) and finally sometimes quite red: stem more divided: leaves broader, less distinctly decurrent, comal ones larger and crowded, short-pointed by excurrent costa: perichætial leaves suddenly acuminate, costa faintly excurrent capsule large, subcylindric, reddish, twice longer than beak: peristome long, once loosely contorted, whitish: dioicous. Mac. Cat. 56.—On wet rocks: Vancouver and B. C.

145. Barbula subcylindrica Broth.—Dioicous: tufts densely cespitose, pulvinate, dark colored above: stems up to 6 cm. high, erect, flexuous, dichotomously branched, branches fastigiate, densely foliate: leaves when

dry crispate, when moist recurved from the erect base, carinate-concave, comal longer, lanceolate subulate from lanceolate base, obtuse, minutely papillose, margin entire, revolute, plane; costa reddish, apex terete, slightly narrower, excurrent; lamina unistratose, cells round-quadrate and transversely oval, basal quadrate and short rectangular: perichætial leaves similar, entire, base laxly areolate: fruiting specimens unknown. Bot. Centralbl. **44**: 387. 1890.—Washington.

146. Barbula platyneura C. M. & Kindb.—Dioicous: tufts compact, semipulvinate, light brown: stems scarcely 1 cm. high: leaves suberect, when dry imbricated and contorted, short, ovate or ovate-oblong, subacute, papillose; margins strongly revolute; basal cells short rectangular, others subquadrate; costa thick, short excurrent or percurrent: barren. Mac. Cat. 52.—On dry rocks: British Columbia.

147. Barbula convoluta obtusata Kindb.—Leaves broader, generally obtuse, rarely subacute, not apiculate. Mac. Cat. 265.—On limestone rocks: Owen Sound, Ont.

148. Barbula chrysopoda C. M. & Kindb.—Differs from *B. convoluta* in short nearly indistinct stem: leaves sublingulate, very obtuse: perichætial leaves rounded or truncate at the apex, long exserted: lid spirally contorted. Mac. Cat. 57.—On earth in burnt woods: Revelstoke, B. C.

149. Barbula inclinatula C. M. & Kindb.—Dioicous: tufts laxly coherent, yellowish green: stem indistinct, not branching: leaves cirrhate-crisped and rigid when dry, suberect and nearly straight when moist, not undulate, from a thin ovate-oblong base attenuate, nearly sublinear, acute or suddenly pointed, very papillose; margins involute, cucullate above; costa yellow, pellucid, excurrent in an often denticulate point: perichætial leaves much broader and longer than others, whitish, subulate from a long lanceolate base; cells narrow, linear above also: capsule narrow cylindric, nearly straight, suberect; peristome long, several times convolute. Mac. Cat. 50.—On earth and gravel bars: Illicillewaet river, B. C.

150. Barbula subulata longifolia Kindb.—Intermediate between *B. subulata* and *B. angustata:* leaves long and narrow, acuminate and acute, distinctly denticulate above, papillose, yellow, bordered; costa long excurrent but shorter in perichætial leaves. Mac. Cat. 58.—On earth: British Columbia.

151. Barbula alpina Bruch & Schimp.—Closely related to *B. lævipila:* leaves not emarginate at summit, ending in a short point or simply mucronate: monoicous: tube of peristome half as long, scarcely one-sixth whole length; teeth once twisted. Husnot, Musc. Gall. 114.—On rocks: Quesnel, B. C.

152. Barbula ruralis subintermedia Ren. & Card.—Differing from related *B. intermedia* in leaf margin revolute to apex and more dentate. Ren. & Card. Revue Bryol. **19**: 84. 1892.—Arizona.

153. Barbula ruraliformis Besch.—Plants robust: stems 3–5 cm. high, branching: leaves squarrose spreading when moist, erect-contorted when dry, acuminate, lamina extended along each side of point as a scarious and denticulate membrane; point reddish in lower part, dentate: perichætial leaves strongly plicate: capsule and peristome as in *B. ruralis*. Husnot, Musc. Gall. 115.—Montana; Washington.

154. Barbula brachyangia C. M. & Kindb.—Dioicous: plants brown ferruginous, 2–3 cm. high: leaves small, upper close, curved, short ovate-oblong, obtuse or subacute, upper part scarcely longer than sheathing base; margins slightly recurved in middle; broad cells hyaline, nearly uniform, costa rough at back; hair point long, denticulate, greater part pale red: capsule small and short, oblong cylindric, sub-symmetric; pedicel red. Mac. Cat. 59.—On rocks: Becscie River.

155. Barbula laeviscula Kindb.—Tufts brown, radiculose at base of leaves, 3–4 cm. high: leaves narrow lingulate, carinate, nearly smooth or indistinctly papillose at recurved borders; lower marginal cells of leaf-base hyaline, short rectangular, in 1–2 rows, median yellow and porose, in 2–3 rows, inner larger, longer and hyaline; costa red, indistinctly papillose at back, denticulate and hyaline near long hispid hair-point: capsule subcylindric, attenuate at base to pedicel; peristome tube very much shorter than pale teeth.—Mac. Cat. 265.—On rocks: Rocky Mountains, B. C.

156. Barbula papillinervis C. M. & Kindb.—Allied to *B. ruralis:* upper leaves subacute, leaf-base narrowly margined, with pale yellow cells: calyptra very much prolonged below capsule. Mac. Cat. 60.—On rocks: British Columbia; Labrador.

157. Barbula intermedia Brid.—Stems 1–2 cm. high, erect, bifurcate, in compact olive green tufts, brownish below: leaves erect-spreading, not squarrose, oblong spatulate, rounded or emarginate at apex, slightly concave, not carinate, revolute on borders as far as middle; point shorter and less dentate than in *B. ruralis:* perichætial leaves acute: pedicel and capsule shorter; peristome shorter, teeth once twisted. Husnot, Musc. Gall. 116.—Montana; Washington.

158. Barbula aciphylla Bruch & Schimp.—Aspect of *B. ruralis:* leaves spreading squarrose when moist, erect contorted when dry, oblong lanceolate, very concave, revolute at border, acuminate, lamina prolonged on each side of nerve, which is extended into a reddish hair furnished with fewer teeth and more erect: flowers dioicous: perichætial leaves not folded: perigonial leaves not always ecostate, sometimes distinctly nerved: pedicel strongly twisted to left at base, and to right in upper part; capsule oval or oval-oblong; peristome shorter. Husnot, Musc. Gall. 115.—On rocks: Disco Island, Greenland; Gold Range, Selkirks, and Rocky Mountains, British Columbia.

159. Barbula leptotricha C. M. & Kindb.—Differs from *B. ruralis*

principally in shorter leaves, emarginate at apex, with a fine and nearly smooth hair point; basal cells hyaline. Mac. Cat. 60.—On limestone rocks: Manitoba.

160. Barbula lato-excisa C. M. & Kindb.—Differs from *B. leptotricha* in the leaves being green, nearly flat at borders; outer basal cells faintly chlorophyllose, narrowly marginate. Mac. Cat. 60.—On the bases of trees: Vancouver Island.

161. Barbula rotundo-emarginata C. M. & Kindb.—Dioicous: plants loosely tufted, brown, about 1 cm. high: stems beset with emarcid leaves or naked below; comal leaves close, patent when moist, scarcely curved, papillose, short obcordate, not sheathing; margins slightly or not recurved; cells subquadrate, inner basal greater and hyaline; costa red and thick, faintly rough at back, excurrent into a long hyaline or at base reddish more or less denticulate hair-point. Mac. Cat. 60.—*Sine loco.*

162. Barbula aloides Bruch & Schimp.—Dioicous: short, dull green: leaves erect spreading, longer, rigid, linear lanceolate, acuminate, acute, nerve incrassate in middle, convex at back, often reddish: capsule from curving of the seta, cernuous or subhorizontal, cylindraceous, subarcuate, rufo-fuscous on upper side, pale fuscous beneath; calyptra reaching a little beyond the lid; annulus of small cells, long persistent, lid rostrate, acute; teeth of peristome very slender, pale red, simply contorted, when dry arcuate incurved with points assurgent; spores smooth. *Tortula aloides*, Braithw.—Brit. Moss Fl. **1**: 211. Newfoundland.

163. Scouleria aquatica nigrescens Kindb.—Plants coarse and rigid, in large dense black tufts: leaves oblong lanceolate, blunt and entire at rounded apex, vein ending below it, often radiculose at base; margins serrate, basal cells rectangular next vein, prosenchymatous near margin but extending upward only a short distance; some leaves simply hyaline at base with all cells rectangular. Bull. Torr. Bot. Club **22**: 42. 1895.—Vancouver Island; Sicamous and Roger's Pass, B. C.

164. Scouleria marginata Britt.—Plants 3–4 cm. high, gregarious, in dense black tufts: stems wiry and naked at base, branching and densely foliate above: leaves crowded, curled and twisted when dry, only uppermost green, oblong lingulate, serrate above middle, or obscurely serrulate near base, teeth occasionally black and thickened; apex blunt, entire or toothed; vein thick, ending below it, smooth on back; basal cells green, rectangular, a narrow band near margin elongated, prosenchymatous, forming a dark dense border nearly to apex of leaf, superposed by rounded small cells: perichætial leaves surrounding capsules, ovate lanceolate: capsules small, broader than long, cupuliform when old; lid persistent on columella, bordered with red; peristome none; mouth bordered; spores green with a minutely roughened coat. Bull. Torr. Bot. Club **22**: 42. 1895.—Spokane Falls, Wash.; California.

165. Grimmia apocarpa alpicola H. & T.—More densely cespitose, lower, suberect: leaves shorter, broader, muticous; costa short: capsule larger, emergent, operculum long rostrate. Schimp. Syn. Musc. Eur. 243. 1876.—Greenland; Alaska.

166. Grimmia conferta pruinosa Braith.—More robust, in blackish tufts: leaves broader, upper gradually ending in long smoothish hairs: perichætial bracts larger, distiuctly papillose: teeth of peristome rufous-orange, more lanceolate, often reflexed against capsule. Braithw. Brit. Moss Flora 2: 7.—Cape Horn Mountains, Idaho.

167. Grimmia chloroblasta Kindb.—Differs from *G. conferta* principally in long hair pointed leaves: perichætial leaves larger and greener: lid of capsule short, conic apiculate; teeth very cribrose, nearly as in *Coscinodon pulvinatus*. Mac. Cat. 64.—On dry rocks: Spence's Bridge, B. C.

168. Grimmia heterophylla Kindb.—Differs from *G. conferta* in stem nearly simple: leaves patent when dry, upper caniculate; margins involute above: perichætial leaves very much longer: the peristome reddish, not papillose: tufts about 2 cm. high, when dry dark green above. Mac. Cat. 64.—On rocks: Spence's Bridge, B. C.

169. Grimmia atricha C. M. & Kindb.—Differs considerably from *G. conferta* in tufts densely cohering: leaves small and when dry appressed, muticous, short, ordinarily ovate-oblong, not recurved at the margins; cells not incrassate: perichætial leaves very much larger and broader than the others: capsule more wide-mouthed, teeth of peristome orange only below, yellow or hyaline above, entire, not rimose nor papillose; lid longer rostrate. Mac. Cat. 65.—On rocks: Sproat, B. C.

170. Grimmia pachyneurula C. M. & Kindb.—Tufts small, green: leaves small, when dry appressed, not twisted, when moist spreading, short ovate lanceolate, recurved on both sides, hairless and obtuse; cells uniform, subquadrate, not erose, the alar scarcely distinct; costa percurrent, thick, smooth at back: barren. Mac. Cat. 65.—On rocks: Revelstoke, B. C.

171. Grimmia Philibertiana Britt.—Dioicous: plants pulvinate, in small dark green cushions: stems naked and decumbent below, branching and spreading above: leaves erect incumbent when dry, not secund, spreading when moist, lanceolate, carinate, with recurved margins and toothed hair points, generally deformed and bearing globose propagula, or retuse and bifid along midvein; cells above rounded, hexagonal, faintly sinuous and oblong at base, discolored, with slight enlargement at basal angles; costa heavy, rounded at back, sulcate above: perichætial leaves broader, inner short, triangular and hyaline at base: pedicels one or two from same perichætium, twisted, variously bent; capsule broadest at mouth, smooth when dry, pale with a red rim; teeth recurved, red, undivided, segments broad below, slender and papillose above; lid straight or oblique; calyptra mitrate; annulus delicate.—Bull. Torr. Bot. Club 18: 51. 1891.

172. Grimmia elatior B. & S.—Dioicous: robust, 4-6 cm.: stems erect, naked at base, slightly branching, in broad lax tufts of a yellowish green color, brown in interior: leaves erect, lanceolate, concave carinate, borders revolute, hair point long and nearly smooth; basal cells rectangular, marginal scarcely distinct, upper round quadrate, more or less papillose; costa strong: perichætial leaves large, erect, laxly areolate: seta arcuate; capsule oval, striate, when dry sulcate: lid conic, straight; annulus large, compound (3); teeth broadly subulate, purple, densely articulate, irregularly cleft and perforated. Braithw. Brit. Moss Flora 2: 23.—Godhavn, Greenland. On rocks: Rocky Mountains.

173. Grimmia arcuatifolia Kindb.—Loosely tufted, tufts blackish, dark green above: stems 5 cm. long, denudate at base: lower leaves small, upper long and not crisped, hooked-curved when moist, ovate lanceolate, long acuminate and acute, reflexed at least at one border, with a short denticulate hair point: most basal cells pellucid, long, narrow, upper basal cells sinuous, marginal uniseriate, hyaline or not distinct; other cells chlorophyllose, quadrate, not sinuous: costa percurrent, canaliculate, pellucid in the middle. Mac. Cat. 69.—On dry rocks: Vancouver Island.

174. Grimmia Hartmani Sch.—Dioicous: tufts large, lax, dense-leaved, yellowish or olive green above, dark at base: stems 3-10 cm., procumbent, naked at base: leaves often more or less secund, erect spreading when moist, slightly crispate when dry, oblong lanceolate, upper ending in a slightly denticulate hair, carinate, revolute at border, sometimes only on one side; lower marginal cells quadrate, distinct, cells near costa rectangular, upper roundish-quadrate; young terminal leaves tipped with globose propagula, formed of quite a number of cells, or occasionally bifurcate: perichætial leaves shorter, from a longish concave base, lanceolate, pointed, with laxer more transparent cells: capsule longish oval-oblong, smooth; seta erect or curved: annulus of three to four rows of small cells; calyptra mitriform, lobed; teeth lanceolate, entire or slightly perforated, orange red, smooth at the base. Husnot, Musc. Gall. 135.—Summits of Chilco Range, Idaho.

175. Grimmia depilata Kindb.—Tufts large and compact, brown or green above: stem elongate: leaves when moist arcuate, ovate lanceolate, recurved on both sides, generally hairless and obtuse, sometimes with a short hair point; alar cells hyaline, elongate, in 4-5 rows, the others more or less erose: perichætial leaves from a sheathing base narrowed into a large canaliculate sublinear and obtuse acumen: capsule nearly smooth, when dry finally rugose, not distinctly costate; teeth red, deeply cleft below middle, when dry spreading, connivent when moist; beak more or less oblique; pedicel arcuate when dry. Mac. Cat. 69.—Vancouver Isl., alt. 3,000 feet.

176. Grimmia Arizonæ Ren. & Card.—Differs from *G. trichophylla*

and *G. Californica* in broader leaf base, upper ⅔ bistratose, more dense, more obscure, hair point longer, striate and coarsely denticulate; from *G. Olneyi* in more robust habit, longer hair point and incrassate inferior leaf cells. Revue Bryol. **19**: 85. 1892.—Arizona.

177. Grimmia prolifera C. M. & Kindb.—Tufts soft, coherent and very radiculose, when dry blackish below, proliferous with long green shoots: stem slender, naked below, 3-4 cm. long: leaves when dry incurved or crisped, upper often falcate when moist, narrow, from the oblong appressed subvaginant base attenuate to a short acute acumen, muticous or rarely furnished with an apical hair-point-like cell, margins recurved at least at one side; lower basal cells narrow rectangular, others and upper subquadrate, all thin walled, faintly yellowish and pellucid; costa yellow brown, percurrent.—Differs from allied *G. contorta* principally in the leaves shorter, muticous, upper more distant than lower. Mac. Cat. 67. —British Columbia.

178. Grimmia tortifolia Kindb.—Nearly allied to *G. torquata:* differs principally in shorter leaves and leaf cells. Mac. Cat. 68.—On rocks: Revelstoke, B. C.

179. Grimmia funalis Sch.—Dioicous: densely cespitose, greenish above, brown below: stems 1-5 cm., branching, eradiculose: leaves when dry erect and spirally incumbent, when moist erect spreading, small, lanceolate, upper with hyaline points or extended into a smooth hair, margin recurved, costa narrow, vanishing at apex: basal cells rectangular, upper quadrate: perichætial leaves broader at base, concave, piliferous: seta arcuate, capsule small, oval, slightly striate; lid conic, beak short; annulus large, compound (3-4); teeth purple, lacunose or torn at apex into two papillose legs. Husnot, Musc. Gall. 132.—Smith's Sound, Greenland.

180. Grimmia Hendersoni Ren. & Card.—Closely related to *G. decipiens:* seta longer, capsule subcylindric and narrower, lid longer rostrate, basal areolation looser. Revue Bryol **19**: 86. 1892.—Oregon.

181. Grimmia pachyphylla Leiberg.—Mats wide, dense, inflated: stems 5-12 cm. high, repeatedly dichotomous, subsimple, plants intermixed, erect or ascending from a decumbent base, radiculose: leaves imbricate when dry, spreading when moist, upper portion more or less recurved, oblong or broadly lanceolate, shortly decurrent, carinate above and reflexed on margins, strongly costate, nerve more or less channeled, above becoming laminoid, gradually narrowing into a sparingly toothed hair; cells long rectangular below, subquadrate in middle, small quadrate above, all sinuous; margin of 2-3 rows of quadrate cells; extreme base and angles of irregular oblong or subrhombic cells: dioicous: capsule oval or oblong, pendent on a twisted seta, red, narrowed at mouth, collum distinct, substrumose, when dry erect and irregularly 4-8 costate; teeth 2-cleft to below middle, sometimes merely lacunose along middle line, papillose above, ar-

ticulations few; annulus compound (2). Bull. Torr. Bot. Club **20**: 113. 1893.—Granite, gneissoid and slate rocks: Idaho.

182. Grimmia cinclidodontea C. Müll.—Monoicous, male flower terminal on a special branch: branches fasciculate: leaves subsquarrose-spreading, loose, strict when moist, rather long and narrow, regularly concave, from an oblong base gradually attenuate, apex rather obtuse, margin quite entire, flat or a little curved; costa thick, occupying whole point; cells minute, round, their walls smooth, shining: perichætial leaves larger: capsules short pedicellate, immersed, hemispherical, macrostome, exannulate, often aggregated; operculum obliquely rostellate; peristome teeth broad, lanceolate, intense red, broadly trabeculate, apex perforate and irregularly cleft. Bot. Centrahbl. **44**: 388. 1890.—On wet rocks: Ellensburgh, Wash.

183. Grimmia crassinervia C. Müll.—Monoicous: habit of *G. conferta* but leaves wholly pointless, slightly papillose; costa rather thick, occupying almost all tne acumen: perichætial leaves long acuminate from a broad base, quite entire: capsule immersed, pyriform-cyathiform, macrostome; seta short; operculum very obliquely rostrate; calyptra long persistent, cucullate, smooth: teeth lanceolate, rather short, somewhat perforate at apex. Bot. Centralbl. **44**: 389. 1890.—Victoria, Vancouver Is.

184. Grimmia tenella C. Müll.—Dioicous: tufts small, dirty green: stem slender, fasciculateiy branched below, branches parallel, somewhat flexuous slender: leaves erect spreading, scarcely crispate, subulate, narrowly oblong-acuminate: hair point rather short, hyaline, straight or slightly flexuous, slender, sharp, sharply denticulate; margin quite entire, scarcely involute; costa rather broad for the leaf, excurrent: cells all chlorophyllose, thick walled, a few at base quadrate, toward apex round: perichætial leaves larger, broader: seta slender, short; capsule scarcely surpassing leaves, erect, small, oblong, truncate, leptodermous, pale with age, smooth; lid minute, obliquely rostrate; teeth small, slender; calyptra narrow, cucullate. Bot. Centralbl. **44**: 388. 1890.—Cœur d' Alene, Idaho.

184*a*. Grimmia Manniæ C. Müll.—Dioicous: tufts slender, compressed, intensely green; stems fastigiately branched, very small, densely foliate, loosely coherent: stem leaves densely imbricate, small, from a broad truncate base deeply carinate, open, obtusely short acuminate; margin plane, quite entire; costa slender, green, excurrent; cells at base small, green, empty, hexagonal, rather thick walled, above minute and obscure: perichætial leaves very closely imbricate, much larger, more obtuse, cells larger, more involute, all rather fleshy: seta long exserted, slender, reddish, somewhat spirally twisted; capsule erect, globose-urn-shaped, thick walled, rufous; lid conic; peristome teeth short, red, more or less split and perforate. Flora **70**: 233. 1887.—Napa Springs, Calif.

185. Grimmia elongata Klf.—Dioicous: tufts lax, pulvinate, dark below, olive green and shortly canescent at apex: stems slender, elongated,

dichotomous, sparingly branched, naked and decumbent at base: leaves divergent from an erect oblong base, rather rigid, elongate-lanceolate, lightly recurved at margin, subcomplicate-carinate, muticous, wings asymmetric; costa stout, excurrent, uppermost leaves with short hyaline points; basal cells linear-rectangular, dilated towards margin, upper quadrate, sinuose, apical minute: perichætial leaves oblong lanceolate, acuminate with short hair points: capsule exserted on a short straight seta, small, ovate, smooth; lid conic, obtuse; annulus of 2–3 rows of cells; calyptra cucullate; teeth yellow, broad, cleft or perforate only at the apex. Braithw. Brit. Moss Flora **2**: 30.—Greenland.

186. Grimmia sulcata Sauter.—Stems erect, branching, in olive green tufts: lower leaves muticous and obtuse, upper oblong lanceolate, with a short hyaline point, bistratose in upper part, longitudinally trisulcate especially above the middle; lower cells short rectangular: dioicous: perichætial leaves shorter and less sheathing than in *G. alpestris:* capsule exserted, oblong sub-cylindric; lid convex, beak a little longer than in *G. alpestris;* annulus persistent, scarcely distinct; teeth of peristome entire, red; calyptra cucullate, covering ¼–⅓ the capsule. Husnot, Musc. Gall. 129.—Franz Joseph Fjord, Greenland.

187. Grimmia microtricha C. M. & Kindb.—Plants in small blackish pulvinate tufts with greenish tops: leaves when moist sub-erect, short ovate lanceolate, margins recurved, plane only at the short base; cells short, alar narrow and hyaline: perichaetial leaves ovate obtuse: capsule oblong, smooth; teeth dark red: pedicel flexuous: dioicous, or monoicous on distinct branches.—Differs from *G. alpestris* principally in longer emergent capsules, recurved leaf margins, and short perichætial leaves. Mac. Cat. 70.—On rocks: Revelstoke, B. C.

188. Grimmia tenerrima Ren. & Card.—In small, compact, gray tufts: leaves small, oblong-lanceolate, lower muticous or with a short hyaline point, upper prolonged into a smoothish hair; borders generally reflexed in the upper part; costa canaliculate; basilar cells lax, quadrate, pellucid, thin walled, upper bistratose, subquadrate, with scarcely thickened walls: capsule exserted on a short pale pedicel, small, leptodermous, smooth, yellow or pale brown: lid convex apiculate; peristome orange red, teeth patulous when dry, papillose, perforated, more or less lacerate at the apex; calyptra cucullate: male flowers unknown. Bot. Gaz. **15**: 40. 1890.—Moist bluff towards the snow line: Mt. Hood, Oregon.

189. Grimmia mollis B. and S.—Dioicous: tufts lax, soft, dark green: plants robust, stem bifurcating: middle leaves erect spreading when moist, very soft, oval-lanceolate or oblong, obtusely rounded, concave cochleariform, plane on the border, unistratose; costa narrow, vanishing below the apex; lower cells rectangular, upper roundish-quadrate: perichætial leaves acuminate, with hyaline points: capsule short exserted, not passing be-

yond the summit of the perichætial leaves, elliptic; annulus simple; teeth of the peristome linear lanceolate, lacunose. Husnot, Musc. Gall. 127.—Greenland.

190. Grimmia sarcocalyx Kindb.—Differs from the allied *G. leucophæa* principally in leaves with a faintly denticulate hair point: capsule short oval; lid obliquely beaked: pedicel doubly longer than the capsule; vaginule pale red, inflated and fleshy.—Leaves short, very broad at base as in *G. leucophæa;* cells nearly all quadrate. Mac. Cat. 66.—On rocks: Spence's Bridge, B. C.

191. Grimmia sphaerica Schimp.—Stems erect, with inflated branches, tufts compact, grayish green: leaves erect, lower small, muticous; upper gradually larger, oval-lanceolate, concave, acute, slightly revolute at the borders, bistratose, apex hyaline, large and dentate above in the perichætial leaves; lower cells rectangular, upper quadrate or rounded with thickened walls: seta straight, very short; capsule sub-globose, symmetric, enlarged at mouth; lid convex, small, apiculate; annulus compound (2), persistent; peristome very rudimentary, scarcely reaching beyond the annulus, so that capsule appears gymnostomous: calyptra mitriform. Husnot, Musc. Gall. 124.— Canada.

192. Rhacomitrium protensum Braun.—Allied to *R. aciculare:* differs in stems longer, less denudate, branched many times, inclined, erect above, in depressed tufts of a yellowish green color: leaves crowded, when dry imbricate, when moist recurved and erect spreading, rarely secund, linear lanceolate from a long base, with obtuse entire apex, concave; margins revolute beyond middle or only on one side, unistratose; costa distinct, vanishing below apex: cells round-quadrate or short rectangular near apex, in the middle rectangular, and below linear, papillose, sinuous: inner perichaetial leaves shorter, plicate, sheathing: capsule erect, long to about cylindric: lid rostrate, beak straight; annulus compound, 2–3 rows; teeth of peristome split to base into two unequal papillose free or occasionally united legs: spores yellowish brown, punctate. Husnot, Musc. Gall. 139.—On rocks: Victoria, Vancouver Island; Greenland.

193. Rhacomitrium Macounii Kindb.—Plants fastigiately branching, innovations without lateral fasiculate branchlets: tufts loosely cespitose, naked at base, brown, with green tips: leaves loose, crispate when dry, patent or squarrose when moist, ovate-lanceolate, acute, muticous, smooth and entire, at one side slightly reflexed or erect, on other always erect; upper cells quadrate and obscure, scarcely or not erose, lower linear and sinuose, marginal cells uniseriate, quadrate-rectangular, hyaline, basal cells yellow; costa brown, percurrent: capsule oblong, dark brown, not striate; teeth orange, pertuse or cleft to below middle, smooth; pedicel straight or sub-erect and contorquate. Mac. Cat. 73.—In large masses on boulders: Rocky and Selkirk Mts. and Gold Range, B. C.

194. Rhacomitrium alternatum C. M. & Kindb.—Allied to *R. Macounii:* stem lower, more branched above: tufts loose, not naked at base, brown with green tips: leaves not crisped, when moist sub-erect or sub-patent, nearly straight, ovate lanceolate, acuminate-acute, often furnished with a short dentate hair point, smooth, reflexed at the base at least on one side; all cells erose, lower linear, upper short angular; costa greenish, stout, percurrent: perigonial leaves sub-ovate or short acuminate, acute or sub-obtuse: female plants not found. Mac. Cat. 73.—On boulders: Selkirk Mountains, B. C.

195. Rhacomitrium robustifolium Kindb.—Differs from *R. Macounii* in leaves less crispate, pellucid, very squarrose when moist, more reflexed on borders, often furnished with a short hair point: capsule oval, striate or plicate when dry; teeth dark purple brown, deeper cleft, papillose; beak oblique, needle shaped, very much shorter than capsule; pedicel slightly curved. Mac. Cat. 73.—On rocks: Lake Griffin, B. C.; Vancouver Island.

196. Rhacomitrium obtusum (Lindb.) R. & C.—Dioicous: short, densely pulvinate: leaves quite hairless, ovate oblong, gradually acuminate, obtuse at point, nerve lost far below apex, margin narrowly revolute: capsule oblong, narrowed at mouth; lid acicular; peristome fugacious, irregular, teeth with two unequal legs. Mac. Cat. 74.—On rocks: Lake Superior.

197. Rhacomitrium heterostichum alopecurum Hüb.—Dioicous: yellowish green, scarcely hoary: stem slender, elongate, fasciculate branched: leaves lanceolate acuminate, acute with a short or obsolete hair point: capsule elliptic-oblong, narrow at mouth; lid conic rostrate; teeth short, pale, cleft to base. Mac. Cat. 74.—On dry rocks: Halifax, N. S.; Selkirk Mountains and McLeod's Lake, B. C.

198. Rhacomitrium heterostichum occidentale R. & C.—Stems often nearly simple: pedicel very short; capsule small, pale, not shining; peristome pale. Bot. Gaz. **15**: 41. 1890.—On rocks: Lost Lake, Oregon.

199. Rhacomitrium micropus Kindb.—Habit of *R. heterostichum* or *R. canescens:* plants dirty green, branches nodose with numerous short branchlets: leaves very faintly papillose, ovate-lanceolate, long-acuminate, more or less revolute, hair point long and rough; cells yellow, upper short or elongate, alar distinctly quadrate: capsule small, oblong-cylindric; beak short, oblique; pedicel short. Mac. Cat. 77.—On rocks: Gold Range, B. C.; Hector, N. W. T.

200. Rhacomitrium microcarpum Palmeri Kindb.—Leaves long subulate, hairless, upper cells longer and more confluent, alar large and rectangular: capsule shorter pedicellate. Differs from related *R. Sudeticum* in deeply cleft peristome teeth and narrow leaf cells. Mac. Cat. 267.—St. Paul Island, Behring Sea.

201. Rhacomitrium speciosum C. Müll.—Dioicous: tufts very broad and lax, plants intricate, robust, green: stems dichotomously branched, elongate: leaves crowded, when wet quickly and very distinctly squarrose-recurved, dimorphous: the lower (older) ovate from a broad base, many times lightly plicate, rather long decurrent, acuminate, obtusate, cucullate; upper (younger) hair pointed, the hair stout, rather long, hyaline, denticulate-serrate; margin quite entire, below (up to middle or beyond) broadly revolute; costa broad, deeply canaliculate, excurrent; cells at decurrent angles loosely parenchymatous, basilar longer: perichætial leaves involute, erose truncate at apex: capsule cylindric, erect, narrowed below mouth, smooth, plicate with age; seta short, smooth, twisted; lid conic, long rostrate; calyptra long subulate, apex slightly rough, persistent, laciniate at base with 16 lobes; teeth very long and narrow, dirty red, smooth, bifid almost to base: annulus none. Bot. Centralbl. **44**: 388. 1890.—Victoria, Vancouver Is.

202. Rhacomitrium languinosum subimberbe Hartman.—Tufts extended, stems long, erect, a little flexuous, delicate, slightly nodulose, branches distant, short; leaf point shorter, sometimes almost disappearing. Fl. Miq. 46.—Miquelon Is.

203. Rhacomitrium canescens muticum Kindb.—Leaves without a hair-point: cells yellow; costa percurrent: barren. Mac. Cat. 77.—Gold Range, B. C.

204. Rhacomitrium canescens Delamarei Ren. & Card.—Tufts yellowish, stems long, nodulose, branches short, erect, leaves erect when dry, rigid, often broken at point, without a hair, almost smooth, costa percurrent: sterile, but very distinct from var. *lutescens* Lesq. & James. Fl. Miq. 46.—In extended mats on earth: Miquelon Island.

205. Hedwigia ciliata subnuda Kindb.—Leaves nearly hairless, the greater number broadly ovate, borders reflexed, cells larger, subquadrate. Mac. Cat. 78.—On rocks in woods: Ottawa: also near Wooler, Ont.

206. Zygodon H. & T.—Plants dichotomous, fastigiately branched, crowded and interwoven with radicles: leaves spatulate lanceolate, very chlorophyllose above, hyaline at base: capsule on an elongated pedicel, oval-oblong, with a soft swelling neck, less distinctly striate; peristome single or double, rarely none, the teeth resembling those of *Orthotrichum;* calyptra smooth, cucullate.

207. Zygodon viridissimus Brid.—Dioicous; tufts small, cushion like, bright green above, brownish at base: stems sparingly branched, fastigiate, brown radiculose at base: leaves dense, when moist recurved squarrose, when dry erect-appressed, or slightly twisted, toward apex complicate, oblong or linear-lanceolate, acutely acuminate, deeply carinate above, expanded below, minutely papillose, margins plane; costa pellucid, ending abruptly below apex; cells at base thin, quadrate hexagonal, above

small hexagonal rotundate: capsule erect, oval-oblong, neck short, olivaceous, when dry pyriform, obscurely 8-costate; lid obliquely rostrate; calyptra fugacious, rostrate; peristome none. Braithw. Brit. Moss Flora **2**: 61.—On trees: White Falls, between Norway House and Hudson Bay at York Factory.

208. Zygodon conoideus H. & T. Dioicous; tufts lax, light yellow green: stems nearly simple or sparingly branched, slender, beset with ferruginous radicles at base: leaves less dense, patent, curving upward, imbricated when dry, linear-lanceolate, acuminate, flat and slightly keeled, more papillose, nerve narrow, vanishing below apex; cells larger and more incrassate: capsule oval, tapering into a neck of equal length, narrower, striate towards mouth when dry and empty, leptodermous, pale fuscous; lid subulately beaked; peristome of 8 bigeminate pale yellowish teeth, reflexed when dry, truncate at apex, fugacious, endostome of 8 yellowish cilia, fugacious, often abortive. Braithw. Brit. Moss Flora **2**: 62.—Eastern States and Virginia.

209. Drummondia clavellata Canadensis Kindb.—Leaves larger and longer: inflorescence monoicous. Mac. Cat. 81.—On trees: Pelee Island, Lake Erie.

210. Ulota megalospora Vent.—Primary stems creeping, tomentose; tufts dense, bright green: all leaves when dry cirrhate-crispate; those of primary stem small (1 mm.), narrowly long subulate from a broadly ovate concave base: apex of one row of cells: base cochleariform, cells narrow, thick-walled; upper cells roundish angular, 7-8μ broad, walls thickened, each with a thick round papilla; margin irregularly crenulate by projecting cell walls; upper leaves of branches broader with a shorter subula: perichaetial leaves longer, from a longer base, short subulate: autoicous sporophyte 5 mm. high: capsule small, ovate, when dry sulcate and urceolate, constricted below mouth; striæ 8, extending to middle or beyond, of 4 rows of cells, neck long, defluent; stomata superficial; external teeth 8, pale, bigeminate, minutely papillose, above almost smooth, lineolate, split along divisural line $\frac{1}{3}$, otherwise entire; cilia 8, subulate, smooth, below of 2 rows of cells; annulus double; operculum apiculate from a conic base; calyptra sparsely hairy; spores very large, 55-61μ diam., green, minutely papillose, mixed with small spores scarcely 15μ diam. Bot. Centralb. **44**: 389. 1890.—Cascade Mts., Wash.

211. Ulota maritima C. M. & Kindb.—Differs from *Ulota phyllantha* in plants smaller, darker, green or black, not yellow: leaves shorter and less circinate when dry, long attenuate to subulate apex, distinctly papillose, costa narrower, rough at back: capsule short oval with short collum, pedicel shorter, thicker, curved when moist: peristome reflexed, teeth trabeculate, cilia long, carinate, of two rows of cells, finely granulate and striolate in both. Mac. Cat. 84. Bull. Torr. Bot. Club **21**:

72. 1894.—On rocks: British Columbia: Vancouver; Alaska Behring Sea; Miquelon Island.

212. Ulota Hutchinsiae rufescens Britt.—Plants more slender than the species, green or brown, not black: stems rufous tomentose: leaves less crowded, longer, acuminate: cells more dense and obscure, lower golden brown, rectangular, not linear or sinuous, marginal shorter, not hyaline: capsule pyriform, inflated. narrower at mouth: peristome double, teeth reflexed when dry, white, granulose, not trabeculate at apex: cilia 8, of two rows of cells, fugacious. Bull. Torr. Bot. Club 12: 69. 1894.—On trees in dense woods.

213. Orthotrichum Shawii Wils.—Monoicous: tufts lax, 1–2 cm. high, brownish radiculose at the base, green, olive-green or brownish above: leaves loosely imbricate when dry, when moist reflexed and spreading from an erect base, lanceolate from an ovate base, long and narrowly pointed, margins more or less revolute; costa vanishing below apex, lamina unistratose: cells papillose, thick walled, round-hexagonal, above larger and oval, near base elongated rectangular, at angles shorter and broader: perichætial leaves erect, less keeled, inner often smaller: capsule ovate, immersed, neck half length of capsule, gradually narrowed into seta, when dry and empty almost urnshaped, light weak folds above; lid short, bordered with orange colored cells; annulus persistent, 2–3 rows of cells; peristome simple, teeth 16, when dry reflexed, linear lanceolate, pale, split in middle here and there along middle line, thickly papillose. Limpr. Laubm. 1: 90. Bry. Eu. Suppl. Orthotrichum, *pl. 1.*—California.

214. Orthotrichum fastigiatum Bruch.—Closely allied to *O. affine*, but generally smaller, tufts only 1 cm. high: stem reddish radiculose, fasciculately branched: leaves more rigid, when dry appressed, when moist reflexed and erect spreading, shorter and broader, long lanceolate, mostly short pointed, keeled, plicate at base, margin revolute; costa percurrent; cells on both sides with simple or furcate papillæ, the upper thick-walled, roundish, in point larger, oval or oblong, at base linear (1:6), more transparent, at angles much shorter: perichætial leaves larger and broader, the inner with plane margins: capsule immersed, somewhat thicker, long pyriform, 8 costate; neck furrowed and gradually narrowed to seta; annulus of one or two rows of cells: peristome double, light yellow, teeth eight, when dry reflexed, trabeculate at apex, vermicular striate; cilia 8, robust, shorter than teeth. Limpr. Laubm. 1: 82.—Lake Superior.

215. Orthotrichum Sprucei Mont.—Autoicous: in dark green, sparingly branched tufts: leaves erect, loosely imbricate when dry, erect spreading when moist, ovate-spatulate, rounded at point and muticous or with a small apiculus; margin revolute at base, then recurved to some distance below summit; cells at base quadrangular, elongated near nerve, passing gradually into large, rounded or angular, smooth or faintly papillose

ones; costa slender, vanishing below apex: perichætial leaves longer, narrower, sulcate, with a short nerve; sometimes with a long filiform point: capsule immersed, oval-pyriform with a long sulcate neck, broadly 8-striate; annulus compound (2); teeth 8, bigeminate, yellowish, reflexed when dry, densely and finely papillose; cilia 8, shorter than teeth, sometimes 16; lid conic, rostellate. Braithw. Brit. Moss Flora 2: 81. 1889.—On willows: Clark's Fork of Coumbia River.

216. Orthotrichum urnigerum Myrin.—Monoicous: tufts lax, bright green to yellowish brown, reddish-brown radiculose at base: stems prostrate or in thick tufts, erect, 2–5 cm. long: leaves when dry loosely appressed, when moist becoming recurved and falcate spreading, lower lax upper larger and tufted, lanceolate from an ovate base, long pointed, keeled; margins strongly revolute as far as middle; costa vanishing below apex; cells uniform throughout in size, roundish quadrate or hexagonal, thick walled, papillose on both sides with simple or furcate papillæ, short rectangular at leaf base: perichætial leaves somewhat larger, erect, longitudinally furrowed at the base: capsule half immersed, thick oval, 8-striate; neck short, when dry suddenly contracted into seta; lid short, annulus persistent, compound; peristome double; teeth 16, papillose below, vermicular and longitudinally striate above; cilia 16. Limpr. Laubm. 2: 46.—Yellowstone National Park.

217. Orthotrichum Roellii Vent.—Tufts pulvinate cespitose, closely radiculose: stems erect, branching: leaves from ovate lanceolate to lanceolate acuminate, cells below incrassate, rotund, papillose with simple or furcate papillæ; cells above quadrangular, elongated, smooth; margin revolute nearly to apex: autoicous: capsule cylindric ovate, scarcely exserted, when dry faintly sulcate to middle, striæ of 2 short rows of cells, other cells quadrangular; stomata superficial; collum short, defluent into seta; peristome teeth 16, simple, approximate in pairs, when dry erect or spreading, above longitudinally striate, striæ below inclined, rarely mixed with papillæ; scarcely a vestige of cilia found, but when present shorter than teeth; spores 16–18μ, minutely papillose. Bot. Centralbl. **44**: 360. 1890. *O. lonchothecium* C. M. & Kindb., Mac. Cat. 90.—Rocks: Ellensburgh, Washington; trees: Krao Creek, Kootenai Lake, B. C.; Banff, Rocky Mountains.

218. Orthotrichum Schlotthaueri Vent.—Tufts dense, pulvinate, fuscous-green: stems erect, branched, 1.5–3 cm. high: leaves when dry closely appressed, when moist apex quickly recurved, then erect spreading, lanceolate from an oblong base, acute, 2–3 mm. long; upper cells rotund-angular, walls thick, papillæ thick, often furcate; margin reflexed: autoicous: capsule immersed, elongate-ovate and cylindrical, smooth when dry, not constricted under the mouth, not sulcate, more or less long pedicellate from defluent collum, all together 3–4 mm. high; stomata superficial; annulus

double or triple; teeth of the peristome eight, yellowish, each divided to the base into two legs slightly split at the apex and marked with a median line, when dry erect or spreading, distinctly articulate, more or less densely papillose, especially below middle; cilia more or less perfect, smooth, fugacious, sometimes wanting. Bot. Centralb. **44**: 390. 1890.— Garrison and Sun River Cañon, Montana.

219. Orthotrichum euryphyllum Vent.—Loosely cespitose, 2–3 cm. high, dark green, rufescent: stem erect, branching: upper leaves 4 mm. long, 1.5+ mm. broad, lower smaller, lanceolate from a broadly ovate base, apex roundish, entire, or obtuse and slightly toothed, margin revolute nearly to apex, so that apex is sometimes cucullate; costa ending far below apex; cells hexagonal, 12–13 μ diam., walls not thickened, reddish, papillae single, minute, or wanting: autoicous: capsule immersed, thick, broadly ovate, when dry constricted under the mouth, deeply sulcate to the middle, striæ 8, broad, of 4–6 rows of cells; column short, abruptly narrowed into the pedicel; annulus double or triple; peristome double, teeth 16, reddish, approximate in pairs, when dry radially spreading, each interruptedly cleft almost to the base in the middle line, papillæ minute, and arranged in more or less regular lines; cilia 16, eight robust, equaling teeth, papillose below, the intermediate eight rudimentary or abortive.—Bot. Centrabl. **44**: 417. 1890. On stones: Ellensburgh, Washington.

220. Orthotrichum nudum Dicks.—Monoicous: tufts lax, soft, green or dirty green, 1–2 cm. high, brown radiculose at base: leaves broader and softer than in *O. cupulatum*, obtuse, longtitudinally furrowed at the base; cells quite uniform: perichætial leaves longer and broader and somewhat sheathing at base: capsule emergent or exserted, larger and thicker than in *O. cupulatum*, pyriform with a long neck abruptly contracted into seta, with alternately long and short striæ, lid red margined, beak short; annulus compound (2–3), persistent; peristome double, teeth 16, when dry erect, longtitudinally striate or slightly papillose; cilia often rudimentary, 8 or 16, scarcely half as high as the teeth.—Limpr. Laubm. **2**: 42. *O. cupulatum nudum*, Braithw. Brit. Moss. Flora **2**; 78. On limestone rocks: Rockcliffe, Ottawa river.

221. Orthotrichum strictum Vent.—Sub-species of *O. Lyellii*. Leaves without gemmæ, rigid, lanceolate; capsule with short seta; otherwise as in *O. Lyellii*. Bot. Centralbl. **44**; 419. 1890.—Cascades, Enumclaw, Washington.

222. Orthotrichum bullatum C. Müll.—Monoicous: tufts lax, yellowish green: stems slender, dichotomously branched, fastigiate, 2 cm. high, flexuose: leaves not crowded, crispate or secund-twisted, when moist recurved from an erect base, rather broadly oblong, bluntly acuminate, quite entire, almost smooth; margin strongly revolute; here and there

plicatulate below, concave: costa thickish, carinate, glabrous, yellowish at base, vanishing below apex; cells small, elliptical, not thickened, larger and yellowish or orange at base: perichætial leaves larger, secund at apex; capsule immersed, inflated-oval, thin, pale yellow, strongly bullate, slightly plicate; operculum flat, erect rostrate; peristome simple, teeth 16, solitary, cupulate or erect, never reflexed, pale, narrowly lanceolate; calyptra slightly plicate, pale, shining, with few hairs.—Flora **70**: 223. 1887. California.

223. Orthotrichum speciosum Roellii Vent.—Densely pulvinate, blackish green: leaves nearly smooth, papillæ very minute, cells large as in *O. Killiasii;* margin revolute: capsule emergent, oblong-ovate, smooth; peristome normal. Bot. Centralbl. **44**: 419. 1890. Chicago, Argyle, Ill.

224. Orthotrichum elegans Schwægr.— Tufts dark green, 1–2 cm. high, softer and smaller than in *O. speciosum:* leaves lanceolate acuminate, recurved at border; cells at base colorless, thin walled, quadrangular, elongated, passing gradually into rounded-hexagonal cells above, with one or two small simple papillæ: monoicous: capsule small, thin walled, sub-cylindric, green and smooth before emptying, afterwards pale and slightly costate in upper part; collum distinct, more or less elongated; peristome double, 8 bigeminate teeth densely papillose, pale yellow, when dry reflexed against capsule but not revolute; cilia 8, filiform or linear, of rows of cells, papillose, convergent but not touching at points; operculum conic, apiculate, border pale red; hood conic-campanulate. Husnot, Musc. Gall. 169.— On ledges at Lake Pend d'Oreille, Idaho, to Kootenay River, B. C.

225. Orthotrichum Killiasii C. Müll.— Closely related to *O. speciosum* but generally smaller, tufts pulvinate or sometimes flat, rigid, dirty green: stem erect, branched, densely foliate: leaves appressed, when moist erect-spreading, narrow lanceolate, obtuse, younger leaves acute; margin revolute nearly to apex; cells thick walled, densely papillose with simple and furcate papillæ, above roundish or oval, at the base yellowish red, rectangular, towards margin quadrate: inner perichætial leaves larger, longitudinally furrowed at base: capsule immersed or emergent, long cylindric, with short 8-costate neck, when empty narrow cylindric, not furrowed and somewhat constricted at mouth; lid red margined, beak equal to diameter of base; annulus simple or compound (1–2); peristome double, teeth when dry erect, originally united in pairs but soon separated, densely papillose; cilia 8 (according to Schimper; to Venturi 16) robust, papillose, margins sinuous. Limpr. Laubm. **2**: 92.—Disco Is., Greenland.

226. Orthotrichum præmorsum Vent.— Densely pulvinate, 2–3 cm. high, bright yellowish green, below reddish yellow: leaves long acuminate from an ovate base, often apiculate, when dry often curved into a cone, when moist becoming suddenly recurved, then erect spreading,

costa ending in apex or apiculus: margin narrowly revolute; cells ovate or rotund above, chlorophyllose, walls thickened below (especially near nerve), elongated, narrow walls irregularly thickened, papillæ in upper part of leaf salient, simple or furcate: inflorescence autoicous: capsule emergent, ovate, collum equaling it in length, defluent into seta, when dry slightly constricted under mouth and sulcate, striæ 8, indistinct; stomata immersed; annulus simple; peristome double, teeth pale yellow, 8, when dry reflexed against wall of capsule apex truncate and fimbriate, remainder entire, or rarely apex lacunose, papillæ minute, distinct; cilia irregular, 8, fugacious, sometimes fragmentary: spores 15–18μ. Bot. Centrabl. **44:** 418. 1890.—Yellowstone National Park, Wyoming.

227. Orthotrichum rhabdophorum Vent.—Densely pulvinate, dark green: stems erect, somewhat branched, 1.5–2 cm. long, below tomentose radiculose: leaves when dry imbricate, when moist becoming suddenly recurved, then erect spreading, lanceolate, or lanceolate from an ovate base, acuminate, margin strongly revolute nearly to apex: cells above rotundate, walls thickened, papillæ bi- or tri-furcate, salient; inflorescence autoicous: perichætial leaves for most part reaching middle of capsule, sometimes capsule entirely exserted: capsule when dry and operculate ovate-cylindrical, with faint reddish striæ, when moist ovate-elongate, constricted below mouth, collum short, passing abruptly into seta, old capsules sulcate at least to middle; annulus double or triple; peristome simple or rarely double, teeth 16, when dry recurved, sparsely papillose; cilia if present more or less perfect, erect, spores 8–11–14μ. Bot. Centrabl. **44:** 418. 1890.—Cascades, Thorp, Washington.

228. Orthotrichum arcticum Schpr.—Tufts dense, more or less depressed, dark green or blackish, 1–2 cm. long; stems branched, rigid: leaves densely imbricate when dry, when moist becoming recurved and then erect-spreading, obovate or oval-lanceolate and more or less pointed, recurved at margin and revolute in lower half; costa vanishing below apex in lower leaves and almost at point in upper leaves; cells at base quadrangular, smooth and with unequally thickened walls, passing gradually above into relatively large rounded or subhexagonal cells with thick walls and provided with salient bi-or tri-furcate papillæ: perichætial leaves larger at base, more or less acuminate and a little longer than others: inflorescence autoicous: capsule emergent and sometimes exerted, oval or oval oblong, when dry sub-urceolate and faintly furrowed; collum straight and abruptly contracted; annulus triple; peristome double, teeth 8, bigeminate, split to middle and more or less lacunose along the middle line, finely and densely papillose, reflexed when dry; cilia often fragmentary, not passing half height of teeth, of one or two rows of cells. Husnot, Musc. Gall. 172.—Greenland.

228*a*. Orthotrichum Macounii Aust.—Autoicous: robust, in broad

dense yellowish tufts fuscous below: stem 1 cm. long, sparingly branched: leaves when dry erect, when moist rather strict sub-patent, ovate lanceolate, very acute, sub-carinate, minutely papillose, apex entire, margin revolute; costa sub-percurrent; cells very minute, obscure, basal a little broader, scarcely more pellucid: capsule very narrow cylindric, smooth, pale straw-yellow, long exserted, defluent when dry, into a long a strongly sulcate collum; peristome teeth 16, short, subulate, when dry erect-incurved, pale, hyaline, distinctly 8–10-articulate, minutely granulose papillose: cilia 8, half shorter than teeth, narrow; lid long apiculate; calyptra sparsely hairy. Bull. Torr. Bot. Club 6: 343. 1879.—Rocks: Cascades, B. C.; Washington: Idaho.

229. Orthotrichum Blyttii Schpr.—Tufts dense, wide, 1–3 cm. high, brownish or olive-colored: leaves erect spreading, imbricate when dry, recurved when moist, obovate-lanceolate, revolute at border almost to summit; cells at base quadrangular, smooth, passing gradually into rounded or sub-hexagonal cells above, with thickened walls, papillæ simple or bi- or tri-furcate, sometimes salient but variable, older leaves not papillose: perichætial leaves a little larger at base: capsule emergent, oval or oval-oblong, when dry 8 costate; collum straight and suddenly contracted at base, making fruit more or less pyriform; annulus persistent, compound (3–4); peristome double, teeth 8, split more or less along middle line, finely and densely papillose, reflexed when dry; cilia 8, more or less complete, sometimes very small or half height of teeth, of 1–2 series of cells. Husnot, Musc. Gall. 174.—Greenland.

230. Orthotrichum pumilum Americanum Vent.—Tufts small, lax, soft: leaves almost without papillae: capsule with 8 bands composed of 2 series of rectangular cells faintly marked; teeth 8, obtuse at point, split along middle line, finely papillose. Husnot, Musc. Gall. 180.—On trees, locality unknown.

231. Orthotrichum Rogeri Brid.—Tufts lax and irregular, 1–1.5 cm. long, green or dark green: leaves more or less flexuous when dry or loosely imbricate, when moist erect-spreading or only upper lanceolate half of leaf spreading, carinate, lanceolate from oblong base sometimes concave or even cochleariform, frequently rounded at point, obtuse, acuminate or short apiculate, entire on border or denticulate near apex; border more or less revolute; costa ceasing below apex; cells elongated quadrangular at base, smooth, walls slightly thickened, passing gradually into rounded cells with thickened walls above, papillæ very small, simple, rarely more pronounced: inflorescence autoicous: capsule more or less emergent, costate when dry and empty, contracted below mouth before empty, oval oblong with collum slightly defluent into seta, sometimes longer than sporangium; annulus double, persistent; peristome double, teeth 8, bigeminate, reflexed when dry, yellowish orange or darker, more or less split or lacunose at points,

densely and finely papillose or slightly lineolate above; cilia 8, weakly papillose or lineolate, of 1 or 2 series of cells. Husnot, Musc. Gall. 186.—Idaho.

232. **Orthotrichum Hendersoni** Ren. & Card.—Pulvinate, yellow green: stems dichotomous, 1-2 cm. long: leaves patulous, flexuose when moist, slightly crispate when dry, from an oblong base linear lanceolate, acuminate, carinate, borders strongly revolute; costa vanishing below apex; cells thick walled, elongated, sub-rectangular below, in upper part: roundish or angular, papillose capsule subexserted on a short pedicel, oval oblong, suddenly constricted to pedicel, 8 striate, becoming cylindraceous and contracted below mouth when old and empty; lid convex, apiculate; teeth 8, bigeminate, yellow, minutely granulose, not striolate lengthwise, reflexed when dry, split at apex; cilia 8, smooth; spores papillose. Bot. Gaz. **15**: 42. 1890.—On bushes: Coast Mts., Oregon.

233. **Orthotrichum pulchellum productipes** Ren. & Card.—Much more robust than type, with larger leaves, a longer pedicel, and teeth of peristome larger and paler. Bot. Gaz. **15**: 43. 1890.—On trees and shrubs: Portland, Oregon.

234. **Orthotrichum pulchellum leucodon** Vent.—Tufts cespitose, bright or pale green: peristome pale, becoming white.—Bot. Centralbl. **44**: 419. 1890. Vancouver Is., Washington.

235. **Orthotrichum ulotaeforme** Ren. & Card.—Pulvinate, yellow green: stems dichotomous, 1-2 cm. long: leaves patulous, flexuous when moist, slightly crispate when dry, carinate; borders strongly revolute, sometimes sinuate at apex; costa vanishing below apex; cells thick walled, lower elongated, narrow, sub-sinuous, upper roundish or sub-hexagonal, slightly papillose: capsule exserted on a long pedicel, oblong, 8 striate when dry, suddenly contracted to pedicel; lid depressed, rostrate; teeth 8, bigeminate, or 16 more or less connected in pairs, pale yellow, minutely granulose, striolate lengthwise, truncate and split at apex, reflexed when dry; cilia 16, long, nodulose, nearly smooth; spores papillose: inflorescence monoicous. Bot. Gaz. **15**: 42. 1890.—On bushes with *O. Hendersoni:* Coast Mts., Oregon.

236. **Encalypta subspathulata** C. M. & Kindb.—Monoicous: stem very short, about 0.5 cm. high: leaves bright green, spathulate or lingulate, twisting when dry, upper spreading when moist; inner basal cells short rectangular, smooth and hyaline, finally red-brown, outer ones much longer, narrower, and yellowish; costa faintly reddish below, yellow above, long excurrent: capsule cylindrical, short necked, smooth or finally furrowed when dry; peristome pale, partly incomplete and membranous, but distinct and high; calyptra small, papillose in narrower part, yellowish green, not covering whole capsule, not fringed; pedicel red. Mac. Cat. 93.—On rocks, Frazer River, B. C.; on earth: McLeod's Lake, B. C.

237. Encalypta leiomitra Kindb.—Nearly allied to *E. rhabdocarpa*, but leaves shorter, often subspathulate, costa vanishing at apex: peristome teeth nearly blunt; calyptra not papillose; spores larger. Mac. Cat. 94.—On rocks: Clearwater River, Athabasca.

238. Encalypta cucullata C. M. & Kindb.—Monoicous: leaves cucullate, perichætial ones long acuminate acute, with a long hair point; costa percurrent, red at base: calyptra papillose all around. Mac. Cat. 96.—On earth: Columbia river, near Revelstoke, B. C.

239. Encalypta leiocarpa Kindb.—Monoicous: stem 3–4 cm. high, dichotomously branched, radiculose: leaves erect-patent, lingulate, faintly revolute nearly all around, without a hair point; lower decolorate brown, sub-acute, incurved; comal larger, green, obtuse, slightly twisted; basal cells hyaline, marginal very papillose; costa faintly papillose, not excurrent, in lower leaves brown, in comal green or reddish at base; perigonial leaves with a short thick tip: capsule straight, smooth, cylindric with an apophysis; peristome simple, orange; pedicel red; calyptra papillose all around, not fringed. Mac. Cat. 95.—Crevices of rocks: summit of Mount Queest, B. C.

240. Encalypta Alaskana Kindb.—Differs from *E. longipes* Mitt. principally in capsule striate and not apophysate, peristome brown red, appressed to mouth when moist, costa nearly smooth: monoicous: lid of capsule obliquely rostrate. Mac. Cat. 269.—Mixed with a *Bryum* on earth: Ounalaska Island, Behring Sea.

241. Encalypta apophysata N. & H.—Stems 5–20 mm. high, erect, branching, in compact dark green tufts: leaves erect spreading when moist, crispate when dry, undulate, lanceolate elongate, apiculate by excurrent costa, revolute at base: seta rough at base, yellow above; capsule cylindric, thin-walled, smooth; collum thick and distinct; lid conic, long beaked; teeth of peristome long, linear, entire or lacunose along middle line, articulations quite numerous, orange, papillose; hood irregularly lobed and laciniate at base; spores papillose. Husnot, Musc. Gall. 198.—Rocky Mountains.

242. Merceya latifolia Kindb.—Densely cespitose: plants 1–2 cm. high, brown-ferruginous below, green at tips, divided, at base radiculose: leaves quite smooth, spathulate-lingulate, obtusate or subacute, entire, slightly reflexed at base, plane above, broad-bordered with larger, orange-colored cells; basal cells narrow, upper small and round; costa percurrent or scarcely excurrent. Habit of *Barbula ruralis*. Mac. Cat. 97.—On upper slopes of Mount Finlayson near Goldstream, Vancouver Island; California.

243. Tayloria acuminata Hsch.—Monoicous: tufts more lax and generally shorter than in *T. splachnoides:* stem reddish tomentose, with numerous gemmae: leaves soft, loosely appressed or spreading, with reflexed point, when dry falcate, rhombic-lanceolate, long pointed; margins

of lower half of leaf reflexed and entire, above plane and toothed, apex not concave; costa longer and vanishing in point; cells somewhat smaller: seta 1–1.5 cm. high, capsule erect, smaller, oval or elliptic, when dry almost globose, suddenly contracted into the long thin neck; columella generally only slightly excurrent; lid suddenly obliquely beaked; peristome inserted deeply, separated by a layer of epidermis, teeth 16, hygroscopic, when moist involute, when dry appressed against the capsule wall, or somewhat irregular, warty-papillose on the outside, cross walls quite prominent. Limpr. Laubm. 2: 151.—On damp rocks: Dry Cañon, near Devils Lake, Rocky Mountains.

244. Œdipodium Schw.—Plants small: leaves succulent, upper cells rounded quadrate, chlorophyllose: some flowers bisexual, others male: seta thick; capsule sub-spherical with a long collum; columella included; peristome absent: hood conic, cucullate; spores large.

244*a*. Œdipodium Griffithianum Schw.—Stems 5–15 mm. high, erect, in soft, dark green tufts: leaves succulent, forming a rosette at summit of stem, obovate-spatulate, large and rounded at summit, entire, ciliate at base; costate to below apex; lower cells rectangular, hyaline; upper rounded-quadrate, chlorophyllose: seta pale green, thick, passing gradually into the very long collum; capsule sub-spherical, orange; lid convex-conic or shortly apiculate; peristome absent, hood fugacious, conic-cucullate; spores large, papillose. Husnot, Musc. Gall. 201.—Greenland.

245. Physcomitrium turbinatum (Michx.) Brid.—Plants light green, gregarious, 8–20 mm. high; autoicous: stems short and simple, or taller and branching: leaves oblanceolate or obovate from an oblong base, serrate above middle; costa vanishing below apex or occasionally excurrent into an acuminate apex; lower cells oblong, upper rhomboidal or hexagonal, marginal longer and narrower, often yellow and inflated at their upper ends: seta erect or twisted and occasionally arcuate: capsule erect, globose pyriform when fresh, becoming turbinate and contracted below mouth and spore sac when dry, dark brown and often urceolate when empty; lid convex or mamillate, occasionally apiculate when dry, blunt; mouth bordered by 8–12 rows of cells and a narrow row of orange colored cells, with a hyaline vesicular persistent annulus incurved after falling of lid; calyptra cucullate, oblique and split unequally, 5–8 lobed and beaked; spores rough.—Bull. Torr. Bot. Club 21: 199. 1894. A common but variable species in old fields, grassy open places in gardens, etc., from Florida to Ontario, west to the Rocky Mountains and California (?).

246. Physcomitrium turbinatum Langloisii (R. & C.) Britt.—Plants pale yellow; stems usually short and simple, slender, occasionally tall and branching to 2 cm.: leaves narrow, acuminate: seta filiform; capsule small, almost campanulate, not contracted below mouth when dry: neck tapering,

often contracted below spore sac when dry. Bull Torr. Bot. Club **21**: 200. 1894.—Low swampy ground and in gardens, probably only in the Southern states.

247. Physcomitrium turbinatum Floridanum (R. & C.).—Leaves longer, long acuminate, coarsely serrate: capsule strongly dilated at mouth, when empty cup shaped, varying. Bull. Torr. Bot. Club **21**: 200. 1894.—Florida.

248. Physcomitrium megalocarpum Kindb.—The largest one of the genus, plants often 3–4 cm. high, light yellow or brown when old: stems short, simple: leaves spreading, flat and open when dry, not much twisted or shriveled, lanceolate from a lax oblong base; lower cells large, inflated at the angles, marginal longer and narrower in two rows, yellow, entire or serrulate; costa ending in acute or acuminate apex: seta erect or twisted and bent: capsule large, globose pyriform, nearly as broad as long, usually urceolate when dry, contracted at neck and below mouth when dry; lid conic, bluntly apiculate; mouth small, not flaring, bordered by a narrow orange-colored annulus with a second hyaline row and 8–12 rows of denser but slightly elongated cells; neck short, stomatose; spores rusty brown, spinose. Bull. Torr Bot. Club **21**: 200. 1894.—Pacific slope.

249. Physcomitrium Kellermani Britt.—Autoicous, antheridia terminal in basal buds: plants scattered or gregarious, dark brown when mature, small, seldom more than 3–5 mm. high: stems simple, with basal innovations: leaves few, rosulate, ovate acuminate; costa excurrent into subulate apex or ending below it; margins coarsely serrate; cells inflated, basal lax, scarcely elongated: seta short, scarcely exceeding perichætial leaves, occasionally long and exserted; capsule short pyriform or broadly flaring, bright brown when old; neck short, tapering or swollen into an hypophysis, stomatose, rugose; mouth bordered with 4–7 rows of cells and a narrow, persistent annulus of darker cells with a hyaline incurved row almost invisible; lid small, conic rostrate; calyptra large, three lobed; spores large, rough, warty, but not spinose. Bull. Torr. Bot. Club **21**: 204. 1894.—Kansas; Nebraska.

250. Physcomitrium Coloradense Britt.—Autoicous, antheridia in basal buds, few, large, without paraphyses; plants small, 3–4 mm. high, scattered or gregarious; stems short, simple or with basal buds; leaves few, radical, erect, concave, base short, auriculate; cells lax, upper cells shorter, marginal serrate or inflated above middle, with large irregular teeth, occasionally entire or serrulate only at apex; vein narrow, percurrent into a cuspidate apex or ending below it in lower leaves: seta short, immersed or partly exserted; capsule exserted, large for size of plants, nearly 2 mm. long, pyriform when fresh, becoming turbinate and contracted below mouth and spore sac when dry, bright orange or brown when mature; mouth bordered by 4–5 rows of narrow, elongated cells, and a

double annulas, the outer orange colored, inner vesicular, hyaline; lid large, conic, rostrate when dry, also bordered with orange cells; spores warty, not spinose. Bull. Torr. Bot. Club **21**: 206. 1894.—Colorado; on muddy banks of the Missouri River, Great Falls, Montana.

251. Physcomitrium Drummondii Britt.—Plants gregarious or scattered, 3–10 mm. high; stems with short basal branches; leaves narrow, strictly erect, lanceolate-acuminate, serrate above middle, marginal cells longer and broader, inflated or yellow, basal cells lax; vein thick, ending below the apex or excurrent into a cuspidate point: seta stout, straw-colored or brown when old, short, erect, slightly twisted; capsules pyriform turbinate, not contracted below flaring mouth when dry, bordered by 6–8 rows of narrow elongated thick brown cells very distinct from cells with sinuous walls of rest of capsule; annulus narrow, orange-colored, persistent, with a second incurved hyaline row; lid conic-rostrate, bordered by orange, beak as long as spore sac, which is shallow and broad; neck contracted below spore sac, stomatose: spores large, warty. Bull. Torr. Bot. Club **21**: 205. 1894. *Physcomitrium acuminatum* L. & J. Man. 198. 1884 in part.—Louisiana; Canada; Missouri; Oregon.

252. Physcomitrium australe Britt.—Autoicous, antheridia terminal and cotemporaneous with fruiting axis: plants gregarious, tall, slender, 3–4 cm. high; stems branching repeatedly and rooting at joints: lower leaves short, distant, with vein ending below the apex, upper crowded around base of seta, all narrow, oblong lanceolate, serrate above middle, marginal cells narrower and longer, teeth small, appressed; vein ending below acute apex: seta short, pale, twisted and curved; capsules often cernuous, subglobose becoming turbinate and flaring at mouth when dry and empty, small, often broader than long; neck tapering, contracted and stomatose; lid flat and apiculate when dry, conic when moist, bordered with brown; mouth bordered by 5–8 rows of large clear cells and a darker annulus, with a second row of hyaline cells incurved and almost invisible; surface cells irregular with thick walls; spores brown, rough, warty. Bull. Torr. Bot. Club **21**: 201, 1894.—Apalachicola, Fla.

253. Physcomitrium Californicum Britt.—Autoicous, antheridia terminal, becoming lateral by innovations: plants gregarious, 10–15 mm. high: leaves few, basal, oblong-lanceolate, bordered by a double row of elongated cells, entire or occasionally serrulate above middle; vein thick, ending below acute apex; cells lax, oblong, marginal obliquely septate: seta slender, twisted, often brown: capsules small, globose when mature and empty, more or less cylindrical when young; lid conic, short, blunt; neck short, wrinkled, and contracted below spore sac when dry, stomatose; mouth bordered by a narrow orange-colored annulus and 5–11 rows of slightly denser scarcely differentiated cells; calyptra cucullate, lobed and

long beaked: spores brown, warty, not spinose. Bull. Torr. Bot. Club **21:** 206. 1894.—On the ground: Calfornia.

254. Physcomitrium acuminatum (Schleich.) Br. & Sch.[1] Autoicous, antheridia terminal on basal branches: plants gregarious, pale green, slender, 10–15 mm. high: stems short, leaves almost radical, rosulate, oblong-lanceolate, acuminate; vein thick, ending below apex or excurrent into a cuspidate point; marginal cells elongated, in two rows, entire or subserrulate at apex, lower cells elongated, often brown at angles: seta pale, slender, twisted, often bent; capsules small, pyriform, becoming turbinate when dry, with a broad flaring mouth, not contracted below it; neck tapering, often abruptly contracted when dry; mouth bordered by 4–7 rows of narrow cells, but slightly elongated or thickened, those of walls smaller than in *P. turbinatum* and rounded; annulus double, outer row orange colored, inner hyaline, vesicular, falling in fragments with lid or persistent; lid blunt, conic or apiculate, bordered with orange; spores small, yellow, spinose. Bull. Torr. Bot. Club **21:** 203. 1894. L. & J. Man. 198 in part.— Not common: Central states west to Nebraska.

255. Funaria calcarea occidentalis Ren. & Card.—Differs from the type in the leaves more shortly and broadly acuminate, and the longer pedicel. Bot. Gaz. **15:** 43. 1890.—Wet mud banks: Oregon City, Oregon.

256. Bartramia breviseta Lindb.— Tufts 1.5–3 cm. high, very thick, brownish green above, brownish tomentose below: stem dichasially branched, densely foliate: leaves obovate, half sheathing, appressed, pale yellow green, from a slightly shining base gradually narrowed into an erect-spreading narrow somewhat twisted brittle very sharp subulate point, margin plane, acumen toothed; cells of the sheathing part of leaf smooth, elongated rectangular, towards the margins narrower and colored, cells of the acumen much smaller, rectangular to quadrate, sharply mamillose in the corners; costa percurrent, filling the entire acumen: perichætial leaves more sheathing, mostly exceeding the capsule in length: seta rigid, thick, brown; capsule large, erect, symmetric, almost globular, brownish, longitudinally furrowed, thin walled, small mouthed, when empty wide mouthed; lid small, convex, in the middle somewhat elevated; annulus none; peristome none or simple and rudimantary, formed of pale short obtuse irregular teeth. Limpr. Laubm. **2:** 538.— Crevices of rocks: Ounalaska, Behring Sea.

257. Bartramia glaucoviridis C. M. & Kindb.—Differs from *B. pomiformis* in its glaucous green color, sheathing leaves not margined, suddenly short cuspidate, costa often excurrent: monoicous. Mac. Cat. 105.— On damp rocks: Columbia River, Revelstoke, B. C.

---

[1] This description is given here because that in L. & J. Manual 198 is incomplete.

258. **Bartramia circinnatula** C. M. & Kindb.—Also allied to *B. pomiformis* but still more distinct than *B. glaucoviridis:* leaves green, loosely disposed, circinate, long sheathing, very long cuspidate: costa longer excurrent: probably dioicous. Mac. Cat. 105.—On rocks: Hastings, Burrard Inlet, B. C.

259. **Philonotis fontana cæspitosa** Sch.—Stems usually simple, leaves more distant than those of *P. fontana*, more or less secund, oval, short acuminate, toothed, plane on border, not plicate: perigonial leaves broader than long, triangular, subulate, costa reaching apex. Husnot, Musc. Gall. 269.—Indiana; Illinois.

260. **Philonotis fontana microblasta** C. M. & Kindb.—Male flowers very small, brown; perigonial leaves all acute, strongly costate. Mac. Cat. 107.—On damp earth: Rogers Pass, Selkirk Mts., B. C.

261. **Philonotis fontana Columbia** Kindb.—Lower leaves narrow, costa long excurrent, perigonial leaves acute or subacute. Mac. Cat. 107.—On wet rocks: Revelstoke, B. C.

P. fontana brachyphylla Kindb., Prince Edward Is., and *P. fontana serrata* Kindb., Selkirk Mts. and Islands of Behring Sea, are *nomina nuda.* Mac. Cat. 107.

262. **Philonotis seriata** Mitt.—Dioicous: in stiffish yellow-green tufts with rufous tomentum, readily falling asunder, and with habit of *P. fontana:* leaves in spiral rows, imbricated when dry, erect or sub-falcate, dimorphous, those of male innovations ovate, bluntish, nerve vanishing, the rest deltoid ovate, acutely pointed: nerve thick, reaching apex or vanishing, all somewhat decurrent, concave, with two deep plaits at base on each side, margin revolute in lower third, bluntly toothed by single or double papillæ; nerve very strong, rough at back, reaching to apex; cells above small and rectangular, with a papilla at lower and often at upper end, below laxer, oval, and longish with a central papilla on both sides: perichætial leaves with nerve excurrent: capsule on a long straight seta, cernuous striate and furrowed; lid conic obtuse; peristome rufous, endostome orange, finely papillose. Braithw. Brit. Moss Flora 2: 212.—Washington.

263. **Philonotis glabriuscula** Kindb.—Tufts radiculose below, 4 cm. high: stem slender: leaves small, green, distant, spreading and straight when moist, indistinctly decurrent, short ovate-lanceolate, short acuminate, acute, slightly papillose, pellucid, plane at margins, not plicate, minutely serrulate principally above; cells oblong hexagonal, the lower narrower, less chlorophyllose; costa sub-percurrent: barren. Mac. Cat. 107.—By springs; Canaan Forks, N. B.

264. **Mielichhoferia cuspidifera** Kindb.—Differs from *M. nitida* in leaves broad-ovate, suddenly cuspidate, entire or slightly crenulate above, cells a little wider and costa often percurrent. Mac. Cat. 110.—On damp rocks: Hector, Rocky Mountains.

265. **Webera Cardoti** Ren.—Loosely cespitose, pale green or yellowish: stems simple, erect, slender, rigid and brittle: leaves small, erect, imbricate, oblong-lanceolate, decurrent, strongly revolute on borders, obtuse or sub-obtuse, rarely sub-acute, generally sinuate denticulate at apex; costa very broad, green, percurrent or vanishing very near apex, widening below and occupying one-third of base; cells lax, truncate or sub-attenuate, 2–3 times longer than broad: seta reddish, flexuous, often geniculate at base; capsule oblong-sub-pyriform, symmetric, erect, yellowish or brownish, tapering to an attenuate neck; lid conic; peristome small, pale yellow, pellucid, very minutely papillose; teeth triangular-lanceolate, long acuminate, lamellæ 15–20; endostome more or less perfect, with split segments and cilia, or reduced to a variously raised and lacerate membrane; annulus compound (2–3). Bot. Gaz. **14**: 95. 1889.—On wet sandy rill-banks: Mt. Hood, Oregon.

266. **Webera polymorphoides** Kindb.—Tufts large, dense, dull green above, rufescent below, 4–5 cm. high: stem finally denudate at base, radiculose in middle: leaves crowded, not decurrent, ovate-oblong, acute or sub-obtuse, widely areolate, nearly entire and flat on borders, costa vanishing below apex; comal ones longer, sub-linear-lanceolate, short-acuminate, upper cells narrow, borders reflexed for greater part, costa thick, sub-percurrent: capsule oblong, short-necked, pendent; peristome pale yellow, segments with narrow basal membrane, cilia short, rudimentary; annulus narrow: lid mammillate; spores brown: dioicous. Mac. Cat. 111.—Hermit Mountain, Rogers Pass, Selkirk Mountains, B. C.

267. **Webera cruda minor** Ren. & Card.—Much smaller, capsule narrower, lid conic. Bot. Gaz. **15**: 43. 1890.—Oregon.

268. **Webera longibracteata** (Broth.) R. & C.—Dioicous: loosely cespitose, light glaucous green, shining: stem about 2 cm. high, reddish, delicate, erect, flexuous, simple, somewhat brownish radiculose near base, laxly foliate: leaves spreading, long decurrent, nearly plane, linear-lanceolate, short acuminate, acute, margin slightly revolute from base to middle, or nearly plane, serrate from apex to middle, not bordered; costa pale vanishing below apex; all cells elongated, narrow, scarcely chlorophyllose, smooth: barren. *Pohlia longibracteata* Broth. Bot. Centralbl. **44**: 419. 1890.—Argillaceous earth: Astoria, Oregon.

269. **Webera nutans subdenticulata** B. & S.—Stem simple: stem leaves narrower, longer pointed, plainly toothed; branch leaves ovate-lanceolate and loosely imbricate: capsule pendent, shortened, color uniform. Limpr. Laubm. **2**: 251.—Miquelon Island.

270. **Webera nutans macrospora** Kindb.—Leaves denticulate to the middle; costa excurrent; spores large. Mac. Cat. 113.—Summit of Gold Range, B. C.

271. **Webera canaliculata** C. M. & Kindb.—Allied to *W. nutans:*

median and comal leaves longer attenuate, denticulate sometimes below middle, narrowly areolate, costa thick, canaliculate and excurrent, comal revolute at borders, only lowest shorter and short-decurrent: peristome pale: lid low and flat. Mac. Cat. 113.—On rocks: Vesuvius Bay, Salt Spring Island, Gulf of Georgia, B. C.

272. **Webera microcaulon** C. M. & Kindb.—Resembling a small form of *W. polymorpha* in the very short stem and acute leaves agglomerate in small buds: differs principally in dioicous inflorescence and very large spores, when unripe about 0.03 mm. Capsules (not ripe) short obovate, annulate; neck short; lid low mamillate; pedicel straight, arcuate at apex: comal leaves scarcely revolute at borders, inner perichætial much shorter: tufts very compact; leaves green or finally blackish. Mac. Cat. 114.—Digges Island, Hudson Strait.

273. **Webera subcucullata** C. M. & Kindb.—Habit of *Michlichhoferia nitida:* intermediate between *W. cucullata* and *W. pycnodecurrens:* resembles the last in small compact tufts, small (unripe) short-necked capsule, and mamillate lid; but stems subjulacous, leaves dull green, densely crowded, not decurrent; lower leaves short, sub-obtuse, nearly as in *W. cucullata* but leaf cells narrower. Mac. Cat. 113.—Crevices of rocks: Mount Queest, Gold Range, B. C.

274. **Webera Ludwigii** Sch.—Dioicous: soft, laxly cespitose, red or blackish at the base, dark green above, scarcely glossy when dry: stem and branches purple, erect, slender, sparingly radiculose: lower leaves remote, broadly ovate, obtuse, entire, more crowded upward, erect spreading, long decurrent, not carinate; comal leaves densely crowded, oblong-lanceolate, serrulate at apex; margin narrowly recurved, nerve purple, vanishing below apex, thick at base; cells rather lax, thin, rhombo-hexagonal above, more rectangular at base: capsule on a flexuose reddish seta suddenly bent below capsule, sub-pendulous, oval-pyriform, brownish, annulate, slightly constricted below mouth; lid conical, obtuse, apiculate; peristome pale yellow, teeth linear-lanceolate, basal membrane of endostome reaching middle of teeth, processes gaping at keel, cilia 2-3. Brit. Moss Flora **2:** 154 as Pohlia.—Oregon; Cascade Mts. and Gold Range, B. C.; Greenland.

275. **Webera gracilis** De Not.—Dioicous: much more slender than *W. commutata*, in loose, yellow green, glossy tufts, blackish at base, with many rigid filiform shoots, short in fertile plants, elongated and often with red axillary gemmae in sterile: leaves erect, appressed when dry, rigid, ovate and ovate-lanceolate, short-pointed, without chlorophyll; margin plane, faintly serrate at apex; nerve thinner, lost at or below point: capsule turgidly ovate, cernuous, small, reddish brown; lid orange, hemispherical, apiculate. Braithw. Brit. Moss Flora **2:** 154.—Oregon.

276. **Webera micro-denticulata** C. M. & Kindb.—Tufts dense, glossy

green, about 3 cm. high: leaves small, loose when dry, open erect, decurrent, short, ovate oblong, nearly entire, more widely areolate with a red and not percurrent costa: comal ones longer, lanceolate, acute or sub-obtuse, narrow areolate, revolute at borders nearly all around, faintly denticulate above, costa pale and sub-percurrent: capsules (not ripe), small obovate, short-necked; lid low, mamillate: dioicous. Mac. Cat. 114.— Close to perpetual snow on Gold Range, B. C.

277. **Webera pycno-decurrens** C. M. & Kindb.— Tufts dense, glossy, bright green, 1–1.5 cm. high: leaves small, acute; lower ovate-oblong, crowded but short decurrent; comal very much longer sublanceolate, revolute at borders for greater part, denticulate above; inner perichætial leaves very much shorter, looser areolate; costa not excurrent: capsule obovate, red-brown, distinctly short-necked, annulate, orange-margined at the mouth: cilia sometimes appendiculate, inner membrane broad, teeth finally dark yellow: lid convex, orange-margined, mamillate; pedicel geniculate at middle: dioicous. Mac. Cat. 114.— On earth near perpetual snow on the Gold Range, B. C.

278. **Webera camptotrachela** Ren. & Card.— Stems erect, slender, simple or with few branches: leaves little crowded, erect, narrowly oblong lanceolate; acuminate, acute; borders plane or slightly revolute below, distinctly denticulate in upper part; costa strong, percurrent; cells elongated, sub-hexagonal or rhomboidal, 6–10 times longer than broad: external perichætial leaves more elongated, long narrowed-acuminate, more or less revolute on borders, serrulate with costa generally excurrent, 2 or 3 inner bracts smaller and shorter: seta reddish, flexuous, often geniculate at base: capsule small, subhorizontal or cernuous, oblong sub-pyriform, tawny-brown, with a long attenuated curved collum; lid convex, apiculate; annulus double: teeth yellowish, densely trabeculate; segments of endostome generally imperfect; cilia variable in length. Bot. Gaz. 13: 199. 1888.— California.

279. **Webera Columbica** Kindb.— Differs from *W. pulchella* principally in leaves more denticulate at least in the middle, costa red, annulus detached, revoluble. Leaves small, slightly reflexed, not glossy: capsule small, segments with 2 cilia. Mac. Cat. 115.— Moist banks: British Columbia and North West Territory.

280. **Webera albicans urceolata** Ren. & Card.— Capsule very short. Revue Bryol. 20: 1. 1893.— Oregon.

281. **Webera micro-apiculata** C. M. & Kindb.—Tufts small, dense and shining, bright green above, decolorate below, about 2 cm. high: leaves small, narrow areolate, densely imbricate and appressed when dry, when moistened sub-erect, not decurrent, ovate-lanceolate with a needle-shaped often incurved point, lower nearly entire, comal a little longer,

faintly and distantly sinuolate-denticulate above, borders not revolute, costa not excurrent: barren. Mac. Cat. 115.—Damp rocks: Revelstoke, B. C.: Hector, Rocky Mountains.

282. **Bryum Froudei** Kindb.—Habit of *Webera nutans*. Agrees with *Bryum inclinatum* in synoicous inflorescence, symmetric capsule, etc.; differs in leaves long acuminate, cells long and narrow, upper sub-linear, costa very long excurrent, peristomial segments quite free from teeth, spores smaller, cilia wanting. Mac. Cat. 120.—St. Paul Island, Behring Sea.

283. **Bryum sub-purpurascens** Kindb.—Agrees with *B. purpurascens* in red tufts, elongate shoots, costa scarcely or faintly excurrent, capsule long-necked, constricted below mouth, teeth orange colored, segments free, cilia smooth, spores small, lid large and mamillate, pedicel red: differs in inflorescence dioicous, all leaves red margined, costa long excurrent, and principally in curved sub-clavate capsule, resembling that of *B. meescoides*. Mac. Cat. 119.—On wet earth: Port Moody, B. C.

284. **Bryum angustirete** Kindb.—Differs from *B. pendulum* in leaves narrow, ovate-lanceolate, reflexed all around; upper cells very narrow, sub-linear, basal cells reddish; costa red: capsule sub-cylindric; pedicel arcuate above; teeth paler; spores small: synoicous. Mac. Cat. 119.—Damp earth: Rocky Mountains; Revelstoke, B. C.

285. **Bryum Roellii** Philib.—Polygamous: yellowish green: leaves aggregated on upper part of stem, ovate, or elongate-lanceolate, acuminate, almost perfectly entire; cells small; costa long excurrent into a rigid scarcely denticulate point; margin slightly thickened, rather distinct, not colored, in lower part sub-plane, above broadly reflexed: seta 2–4 cm. long; capsule oblong, about 3.5 mm. long, becoming pale; lid conic, often darker colored; annulus broad, pale; peristome from a red base very pale, internal closely adherent to outer throughout its whole length, segments irregular, laterally affixed to teeth or obsolete, cilia none; dorsal lamina of teeth very slender, scarcely visible; ventral lamina pale, divided and excavate, with the vertical dissepiments of the internal membrane adnate in 3–4 rows of cells; spores 20–25μ. Revue Bryol. 17: 56. 1890.—Cascades, Washington.

286. **Bryum brachyneuron** Kindb.—Agrees with *B. pendulum* in inflorescence synoicous, peristome orange, spores large: differs in leaves decurrent, short ovate, costa broad, abbreviate, not excurrent, shoots bearing globose gemmæ, peristomial teeth very much broader: stem red, very short: pedicel 1 cm. long or shorter, often scarcely emerging from tufts: costa of lowest leaves red, percurrent only in leaves of shoots and perichætial ones: capsules ventricose, short-necked, constricted below mouth. Mac. Cat. 120.—St. Paul Island, Behring Sea.

287. **Bryum Archangelicum** Schimp.—Synoicous, also with male and

more rarely with female flowers; tufts low, thick, pale green, reddish radiculose within: leaves not decurrent: lower ovate-lanceolate, comal leaves loosely imbricate, lanceolate from an ovate base, concave, narrowly margined, generally somewhat revolute, more rarely plane; costa strong, excurrent into a long yellow faintly toothed hair; cells above rhombic, below rectangular, at the insertion red, and quadrate or rectangular: seta arcuate above; capsule nodding or pendent, obovate, not constricted under mouth; peristome yellowish, pale above, narrowly bordered, inner peristome same height, free or slightly adherent, cilia none or rudimentary.—Limpr. Laubm. **2**: 308.—On earth: Gaspe Co., Quebec; on damp rocks: Hector, Rocky Mountains; Sabine Island, Greenland.

288. **Bryum mamillatum** Lindb.—Autoicous: tufts very thick and low: lower leaves small and distant, comal leaves crowded, not decurrent, long lanceolate, pointed, margin with a thick yellow border; costa very thick, excurrent into a short faintly toothed point; cells thin walled, rhombic above: capsule pendent, symmetric, globose-pyriform, neck short, rarely somewhat curved, longitudinally furrowed when dry; teeth of peristome orange, insertion red, yellow above, bordered; inner peristome free, yellow, basal membrane one-third length of teeth, cilia short, three. Limpr. Laubm. **2**: 328.—Greenland.

289. **Bryum Labradorense** Philib.—Plants branching, in compact tufts, radiculose: leaves pale green, reddish at the base, oval-lanceolate, with a large sheathing base, decurrent, acuminate with a short point formed by costa, which is flexuose and somewhat toothed; otherwise margin entire; lower leaves plane and nearly emarginate; upper leaves faintly marginate with two rows of elongated cells; border slightly reflexed at base; cells distinct, compact, rhomboidal: polygamous: capsule oval, narrowed slightly at the base to form a short collum; lid convex with a scarcely salient beak; teeth of peristome very short, regularly attenuate, nearly triangular; inner peristome adherent and imperfect, segments linear, lacunose between articulations; cilia none; annulus very large; spores very large. Rev. Bryol. **14**: 55. 1887.—Labrador.

290. **Bryum stenotrichum** C. Müll.—Synoicous: tufts slender, low, yellowish: fertile stems short, surrounded by a few slender very short rosulate stipitate innovations: perichætial leaves erect-imbricate, spreading when moist, small, concave, from a broad-ovate purpurascent base longish acuminate; costa yellowish, thick, percurrent into an elongate slender scarcely dentate sharp point; margin strongly revolute from base to plane point, quite entire, broadly yellowish bordered; lamina confluent with subula; cells regular, small, yellowish, scarcely granulose: stem leaves smaller, shorter aristate: seta slender, pale red, 1 inch long, cernuous arcuate above; capsule small, from a slender neck narrowly oblong, ochraceous brown: lid small, conic, short pointed; annulus broad, revoluble;

peristome small, outer teeth short, densely trabeculate, inner ones slender, short, sulcate, split to the short shallow sulcus, short cuspidate, cilia very short, single, rudimentary. Flora **70**: 219. 1887.—Alaska.

291. Bryum Edwardsianum C. & M. Kindb.—Nearly allied to *B. Warneum*, agreeing in peculiar peristome and very large spores (about .05 mm.), but differing principally in leaves longer acuminate, entire, revolute at borders; costa long excurrent: capsule narrower and lid lower: flagelliform branches absent: monoicous. Mac. Cat. 120.—On damp sandy soil: Prince Edward Island.

292. Bryum Knowltoni Barnes.—Plants densely cespitose, interwoven with red and brown rhizoids: stems copiously branched by innovations, reddish: leaves closely imbricated in bud like tufts at top of innovations, not twisted when dry, youngest bright green, older dirty yellow, carinate, concave, ovate to obovate-lanceolate, lower shorter, upper narrower, all abruptly and shortly acuminate; costa shortly excurrent, or dissolving in or ceasing below apex; margin entire, or rarely slightly denticulate here and there, slightly revolute or plane, border usually indistinct; cells rectangular and hyaline below, rhomboidal and densely chlorophyllose above: polygamous: capsule red brown or paler, rugose, pendent, oblong-pyriform; operculum small, strongly convex, apiculate, long persistent; annulus triple, revoluble; teeth linear lanceolate, strongly barred within, smooth above; segments of endostome free, strongly nodose, split between along keel, cilia two, rudimentary. Bot. Gaz. **14**. 44. 1889.—Crevices in rocks: Funk Island, Newfoundland.

293. Bryum fallax Milde.—Stems 5–10 mm., branching: tufts yellowish: leaves erect spreading, oval, decurrent, concave carinate, very shortly mucronate by excurrent costa, entire, marginate, revolute at border, upper cells hexagonal: dioicous: capsule pendent, symmetric or arcuate, oblong pyriform, contracted at mouth; collum as long as sporangium; lid conic, apiculate; annulus large; teeth yellow, segments of endostome split along keel, cilia rudimentary. Husnot, Musc. Gall. 238.—St. Matthew Island, Behring Sea.

294. Bryum œneum Blytt.—Dioicous: tufts thick, olive color and reddish green, when old almost copper colored, reddish radiculose within: leaves spreading, rigid, when dry falcate incurved and somewhat twisted, narrowed at base and decurrent; lower leaves small and distant, ovate or obovate, sharp pointed, upper leaves oblong lanceolate or broad lanceolate, long pointed, red marginate; margin revolute, entire; costa thick, red, generally excurrent; cells thick-walled, pitted, above rhombic-hexagonal, the basal rectangular: perichætial leaves lanceolate, much smaller, rigid: capsule pendent or nodding, club pyriform, somewhat curved, reddish brown: neck one-half sporangium, when dry furrowed; lid small, yellow, convex; annulus compound (2); teeth narrow,

linear lanceolate, yellow, orange at insertion, yellowish above, broad hyaline margined, finely punctate; endostome adherent, yellow, papillose, segments narrow, free, split, cilia 2-3, broad, short. Limpr. Laubm. 2: 332.—Greenland: Smith Sound, Clavering and Sabine Island.

295. **Bryum mamilligerum** Kindb.—Subspecies of *B. intermedium*, differing in leaves distinctly margined, nearly flat on borders: capsule oblique, distinctly constricted below mouth, often horizontally patent; lid mamillate, not apiculate; spores larger: stem very short. Mac. Cat. 122.—On damp rocks: Devils Lake, Rocky Mountains.

296. **Bryum cirrhatum megalosporum** Kindb.—Differs principally in large spores, about .03 mm. Mac. Cat. 122. On wet soil on rocks: Burrard Inlet, B. C.

297. **Bryum cuspidatum** Sch.—Synoicous: tufts low, rarely 2 cm. high, dense, radiculose within: leaves decurrent, narrower than in *B. bimum* and longer pointed; lower leaves small, oval, short pointed, upper larger, oval-lanceolate, pointed by excurrent costa, uppermost crowded in a coma, and over twice as large, with a very long acumen; margin recurved, yellow marginate, entire; costa excurrent as a toothed acumen; cells thin walled, faintly pitted, below rectangular, red, at decurrent angles somewhat elongated: capsule inclined to almost pendent, obovate, when deoperculate constricted below the mouth, lid short conic; peristome and endostome of equal length, teeth gradually narrowed, papillose, broadly bordered; endostome free, pale yellow, segments half length of teeth, split along keel; cilia three, appendiculate. Limpr. Laubm. 2: 343.—Illinois; Wisconsin; Idaho; Montana; Oregon; Washington; Vancouver Island.

298. **Bryum bimum angustifolium** Kindb.—Leaves narrow, loosely disposed: pedicel shortly emerging above innovations: stem 4 cm. high. Mac. Cat. 123.—On wet rocks: Cape Vincent, Ont.

299. **Bryum bimum atrotheca** Ren. & Card.—Capsule black red: leaves scarcely denticulate or quite entire at the point. Bot. Gaz. 19: 238. 1894.—Newfoundland.

300. **Bryum leucolomatum** C. M. & Kindb.—Nearly allied to *B. bimum*; differs principally in stem more robust and elevate, above 8 cm. high: leaves pale bordered, inner perichætial ones cuspidate: capsules not ripe, lid apiculate: synoicous. Mac. Cat. 123.—In a marsh: Revelstoke, B. C.

301. **Bryum Hendersoni** Ren. & Card.—In robust, yellowish green tufts: stems robust, purple, tomentose, erect, dichotomous, 2-4 cm. long, lower leaves distant, smaller, then becoming gradually larger, upper crowded, erect spreading when moist, loosely appressed when dry, concave, cucullate at apex, broadly obovate-lanceolate, or oblong sub-spatulate, short acuminate and reflexed apiculate by excurrent costa; generally dentic-

ulate above on the back by the prominence of cell-apices; margin narrowly revolute but flat toward point, strongly serrate above; cells reddish and rectangular at base, oblong-hexagonal in middle, ovate-hexagonal or rhomboidal in upper part, the marginal elongated, linear flexuose, forming a more or less distinct border; capsule inclined or pendulous, narrowly cylindrical, incurved, constricted below mouth and tapering to a long attenuate neck; lid convex or sub-conic, apiculate; teeth yellow, densely trabeculate, segments split, cilia 1–3, appendiculate; annulus of 3–4 rows of cells, very broad: dioicous. Bot. Gaz. 19: 44. 1894.—Moist sunny bluffs: Portland, Oregon; California.

302. **Bryum microstegium** Sch.—Synoicous: aspect of *B. sub-rotundum:* tufts very low, thick, green: lower leaves small, distant, oval-lanceolate, costa ending below the point; comal leaves numerous, crowded, almost imbricate, when moist erect spreading, outer oval-lanceolate; inner larger, oblong lanceolate, long acuminate, costa excurrent, marginate, border plane, entire, sometimes slightly recurved; cells thin walled, above narrowly rhombic, at base violet purple, rectangular: seta twisted, curved above; capsule nodding, with narrower and shorter neck, oblong-pyriform, mouth symmetric, small; when dry neck furrowed and capsule rugose; lid conic, apiculate; teeth faintly bordered, weakly papillose, abruptly narrowed above: endostome almost hyaline, segments split along the keel cilia three, appendiculate. Limpr. Laubm. 2: 348.—Greenland; Labrador.

303. **Bryum pallescens laxifolium** Kindb.—Leaves loose, not glossy, long and narrow; upper cells narrow: spores small. Mac. Cat. 124.—In damp woods: Kananaskis Pass, Rocky Mts.

304. **Bryum pallescens longifolium** Kindb.—Leaves dense, glossy, very long attenuate; upper cells narrow: spores small. *l. c.*—Wet gravelly soil: Morley, Rocky Mountains.

305. **Bryum nitidulum** Lindb.—Synoicous: tufts low and dense, above yellowish green, below reddish, within densely brown radiculose: stem scarcely branched, leaves gradually larger above, broad oval, acute, narrowly marginate, margin revolute to recurved point, entire; costa thick, nearly percurrent; cells small, thick walled, pitted, upper irregular rhombic, basal rectangular, reddish: capsule pendent, small, oval-pyriform, gradually narrowed into neck, large-mouthed, pale yellow, shining; lid convex, with long point; annulus triple; peristome large, teeth pale yellow, lanceolate-acuminate; endostome free, basal membrane one-half height of teeth, segments split along keel, cilia 2–3, appendiculate. Limpr. Laubm. 2: 347.—Greenland.

306. **Bryum teres** Lindb.—Autoicous: tufts low, yellowish green, shining: leaves erect, not decurrent, broad oval, obtuse, the upper with small points, concave, not marginate, entire; lower leaves with plane margins,

comal leaves revolute to middle, inner to apex; costa purple at base, vanishing below point; cells faintly pitted, above rhombic-hexagonal, basal red, rectangular hexagonal: seta curved above; capsule pendent, symmetric, pyriform, when dry contracted below the mouth; lid small, convex; annulus triple, separating in fragments; teeth lanceolate, abruptly subulate above the middle, narrowly bordered, papillose, endostome free, basal membrane ½ height of teeth, segments widely gaping along keel, cilia 2-3, long appendiculate. Limpr. Laubm. 2: 367.—Franz Joseph Fjord and Sabine Island.

307. Bryum microglobum C. M. & Kindb.—Tufts compact, green, radiculose below, small (about 1 cm. high): branches very short, bearing small buds: leaves narrow margined, sub-entire; stem leaves ovate oblong, short acuminate, faintly revolute at borders, branch leaves ovate-acute and not revolute: upper cells short except narrow margined ones; costa more or less short excurrent: capsule small, inclined, pale globose-pyriform, small mouthed; peristome perfect, teeth pale: cilia short, appendiculate; lid convex with conical mamilla: pedicel arcuate at apex: dioicous. Mac. Cat. 129.—On earth: London, Ont.

308. Bryum micro-erythrocarpum C. M. & Kindb.—Nearly allied to *B. erythrocarpum;* differs in stem shorter: leaves distinctly yellow-margined, laxer areolate; costa sometimes excurrent: capsule more ventricose, constricted below the mouth; lid longer apiculate. Mac. Cat. 124.—In wet gravel: Vancouver Island.

309. Bryum Blindii B. & S.—Dioicous: gregarious or in small dense tufts, brownish or light green, somewhat shining: stem fasciculately branched, radiculose below: lower leaves broad oval, short-pointed; upper stem and branch leaves ovate, short-pointed; comal and perichætial leaves oblong-lanceolate; all leaves imbricate, concave, not margined, entire, margin plane, only upper comal and perichætial leaves slightly revolute; costa strong, percurrent or excurrent; cells yellow-walled, considerably thickened, above rhomboid and rhomboidal, at base red, thin walled, rectangular and rectangular hexagonal: seta generally bent at base, hooked above; capsule pendent, symmetric, obovate or globose-pyriform; neck thick; mouth small, when empty scarcely changed; lid small, strongly convex, with small mamilla; annulus triple, separating spirally; peristome inserted below mouth, teeth yellow, with pale incurved point when dry, bordered, papillose; endostome yellow, papillose, basal membrane ½ height of teeth, segments lanceolate, suddenly subulate, somewhat split, cilia three, nodose or appendiculate. Limpr. Laubm. 2: 419.—On damp earth Rocky Mountains; on débris: Selkirk Mountains, B. C.

310. Bryum alpiniforme Kindb.—Allied to *B. alpinum* in habit. leaves chlorophyllose, basal cells quadrate, costa red: differs in leaves smaller, marginate, loosely disposed, more distinctly decurrent, border re-

flexed nearly all around, cells wider, upper hexagonal oval, costa often more excurrent: barren. Mac. Cat. 271.—On rocks: islands in Lake Nepigon, Ont.

311. Bryum hæmatocarpum C. M. & Kindb.—Tufts very tomentose below green innovations: leaves loosely appressed, when dry slightly corrugate but not twisted, crowded, not decurrent, subovate, acute, pellucid, narrow marginate, revolute at the entire borders all around, those of the innovations less distinctly revolute and margined to above the middle; cells pale yellow, upper short-rhomboidal; costa yellow, percurrent or in uppermost leaves slightly excurrent: capsule large, sub-oblong-cylindric, blood-red, twice as long as pale collum, pendent or patent, not appressed to pedicel; peristome dark yellow or orange below, pale above; segments free, very much shorter than membrane, cilia faintly appendiculate or rather nodose; annulus broad: lid nearly flat and apiculate: dioicous. Mac. Cat. 125.—On damp rocks: British Columbia.

312. Bryum percurrentinerve Kindb.—Tufts compact, dull green above, decolorate below: leaves when dry appressed and corrugate, when moistened sub-patent, crowded and slightly decurrent, ovate-obtusate, only uppermost ovate oblong and sub-acute, narrow margined, revolute at the entire borders for the greatest part: cells pellucid, upper wide, sub-rhomboidal; costa red, percurrent, in uppermost leaves pale. Allied to *B. Muhlenbeckii*, but differing principally in color, thinner, broader and shorter leaves, at the apex patent or sometimes reflexed, not cucullate. Mac. Cat. 216. Bull. Torr. Bot. Club 17: 274.—On dripping rocks: waterfall near Kamloops, B. C.

313. Bryum capitellatum C. M. & Kindb.—Tufts small, compact, yellowish green above, reddish rufescent below: stems sub-julaceous, clavate acute, radiculose at the base; innovations short: leaves gradually larger upwards, not decurrent, very concave, not margined nor revolute at the entire borders; cells wide, pellucid, upper sub-rhomboidal, lower sub-rectangular; lowest leaves very small, short-elliptic and blunt, loosely disposed, others crowded, median sub-oval and blunt, uppermost ovate-oblong, sub-acute; costa finally red, percurrent in upper leaves, abbreviate in lower: barren. Mac. Cat. 127.—Borders of ditches: Vancouver Island.

314. Bryum rubicundulum C. M. & Kindb.—Tufts compact, olive green, very radiculose to innovations: leaves appressed when dry, concave, obtuse, lower oblong, upper ovate, forming small buds, chlorophyllose, not yellow or hyaline, rarely reddish: borders revolute, narrow-marginate nearly all around; upper cells wide; costa red, sub-percurrent: perichætial leaves narrow, sub-acute, narrowly areolate: capsule inclined, obovate-oblong, short-necked, constricted below the mouth when dry, purplish brown; peristome pale yellow; inner membrane low, cilia short, nodulose or appendiculate: dioicous. Mac. Cat. 129.—Summit of Hermit Mountain, B. C.

315. Bryum Vancouveriense Kindb.—Differs from *B. cæspiticium* in leaves longer acuminate, at base red, reflexed only below middle; cells small, upper very narrow; costa very thick, excurrent in most leaves: capsule not pendent, not constricted below the mouth; lid deplanate; spores larger; pedicel very long: stem indistinct with gemmiform innovations. Mac. Cat. 129.—On wet slopes: Mt. Finlayson, Vancouver Island.

316. Bryum synoico-cæspiticium C. M. & Kindb.—Tufts dense, about 1 cm. high, radiculose only at base, green above, brown decolorate below: leaves erect, not decurrent, sub-ovate, acuminate, not margined, recurved at borders, slightly denticulate above; costa long excurrent, very rigid, thick, often denticulate, light brown: capsule turgid, oval, very short-necked, not or slightly constricted below mouth, pendent; peristome perfect; lid low, umbonate; spores about .015 mm.; pedicel geniculate below middle, arcuate at apex, thick, red: synoicous. Mac. Cat. 128.—On earth: old channels of the Illecillewaet River, Revelstoke, B. C.

317. Bryum heteroneuron C. M. & Kindb.—Sub-species of *Bryum capillare:* differs in leaves finally purplish-colored, less contorted when dry, distinctly serrate above, finally red-margined; costa dark purplish, either long excurrent with point thick and very rigid or vanishing below apex: dioicous: agrees with *B. Donianum* Grev. in clavate branches and smaller spores, but leaf borders not incrassate, capsule not so large. Mac. Cat. 130.—On earth: Ottawa, Ont.; Hastings, B. C.; on rocks: Vancouver Island.

318. Bryum heteroneuron brevicuspidatum Kindb.—Leaves short pointed. Mac. Cat. 131.—Vancouver Island.

319. Bryum elegans Nees.—Dioicous: tufts dense and soft, green above, reddish brown within, densely brown radiculose: lower stem and branch leaves obovate, concave, margin plane, border narrow; comal leaves crowded, imbricate, obovate from a narrow reddish base, carinate concave, margin plane, recurved only at base, toothed above; costa quite strong, excurrent as a smooth somewhat recurved awn: cells very lax, thickened, mostly rhombic hexagonal, at base rectangular and generally reddish: seta curved above; capsule horizontal or nodding, symmetric, long oblong to almost cylindric, with a neck equally long, when dry constricted below mouth; lid very convex, scarcely apiculate; annulus broad; teeth of peristome narrowly margined: basal membrane of the inner peristome ⅓ height of teeth; segments narrow, cleft or only split; cilia delicate, appendiculate. Limpr. Laubm. **2:** 388.—Miquelon Island.

320. Bryum Floridanum Ren. & Card.—Closely allied to *B. Donianum* but much more delicate, leaves shorter, border narrow, scarcely incrassate, margins plane. Revue Bryol. **20:** 4. 1893.—Florida.

321. Bryum acutiusculum C. Müll.—Dioicous; tufts slender, low, rather dense, tomentose: fertile stem short, simple or with few branches: leaves

aggregated in a small sub-rosulate tuft, erect-imbricate, spreading when moist, small, oblong-acuminate, regularly concave; costa carinate, yellowish, flexuous, excurrent into a short sharp point; margin strongly revolute, bordered, quite entire; cells small, very regularly rhomboidal, empty: capsule on a short (1.2 cm.) slender flexuous fuscous seta, minute, pyriform-oval, narrow, fuscous, leptodermous; neck elongate (comparatively), very slender, arcuate; lid minute, short conic and acutish from a convex base; annulus broad, revoluble; teeth of peristome very narrow, yellowish, median line none, margin scarcely cristate, prolonged into a sub-hyaline filiform point; segments of endostome a little shorter, very slender, little sulcate, neither gaping nor perforate, cilia single, equaling segments, remotely somewhat appendiculate. Flora **70**: 220. 1887.—On hornblende rocks: Chilcoot, Alaska.

322. Bryum Sawyeri Ren. & Card.—Loosely or densely cespitose, green or brownish: stems short, radiculose below, branching by several innovations, more or less copiously provided in upper part with brown thick simple articulate very caducous filaments arising from axils of leaves; leaves regularly distant, or upper tufted, open when moist, erect imbricate, often slightly twisted when dry, rather concave, oblong sub-spatulate, narrowed at base, shortly acuminate, plane on borders, obsoletely denticulate in upper part; costa percurrent or shortly excurrent; cells large, hexagonal, thin-walled, marginal cells elongated: seta reddish, capsule brown or rufescent, pendent, finally oblique or subhorizontal, defluent into a long attenuate neck, constricted below mouth after fall of convex apiculate lid; teeth of peristome densely trabeculate; segments split, cilia long, appendiculate: inflorescence seems to be dioicous, male flowers unknown. Bot. Gaz. **14**: 95. 1889.—On sandy ground at base of trees or on decayed logs: Enterprise and Beauclerc, Florida; Louisiana.

323. Bryum extenuatum Ren. & Card.—In loose yellowish tufts: stems depressed, radiculose, branching below perichætium by elongated innovations, erect, slender, flexuous, generally attenuate and flagelliform: stem leaves distant, equal, erect spreading when moist, imbricate when dry, concave, from a long decurrent base ovate-lanceolate, shortly acuminate-cuspidate, entire or sub-sinuate toward point; innovation leaves much smaller and narrower; margins revolute from base to above middle, costa excurrent into a very short point or vanishing just below apex; cells rhomboidal or hexagonal, rectangular at base, longer and narrower on margin but not forming a distinct border: seta flexuous, reddish below, yellowish above; capsule pendulous, narrowly cylindrical, constricted below mouth when dry, tapering to a long attenuate neck; lid convex, acutely apiculate; teeth pale yellow; internal membrane very broad, segments

split, cilia 2–3, long appendiculate; annulus of 2–3 rows: dioicous. Bot. Gaz. **15**: 57. 1890. — Wet sunny bluffs: Portland, Oregon.

324. Bryum erubescens Kindb.— Stems short, scarcely 1 cm. high, loosely tufted: leaves of innovations green, small; stem leaves few, reddish-brown, not decurrent, ovate-lanceolate, acuminate, red margined, not revolute at entire borders: areolation pellucid, decolorate, upper cells narrow rhomboidal or hexagonal: costa red, more or less excurrent; inner perichætial leaves smaller, immarginate, slightly sinuolate above, with a percurrent costa: capsule small, regular, pendent, narrow-oblong, constricted below mouth; cilia appendiculate; lid convex, mamillate; spores extraordinarily large, about 0.03 mm.: dioicous. Mac. Cat. 118.— On roots of trees: Lake Louise, Rocky Mountains.

325. Bryum obtusifolium Kindb.—Closely related to *B. Neodamense:* tufts broad and tumid, 4–7 cm. high, dirty green tinged with red: stems soft: leaves lax, long decurrent, oval, obtuse, very concave, not limbate, slightly reflexed to cucullate apex, entire; cells very lax, slightly thickened, faintly pitted, nearly all rhombic-hexagonal: sterile. Limpr. Laubm. **2**: 429. 1892.— Godhavn and other localities in Greenland.

326. Bryum erythrophyllum Kindb.— Closely allied to the arctic *B. obtusifolium:* barren stems laxly cohering, blood red, about 1 cm. high: leaves small, reddish, loosely disposed, flaccid, not decurrent, lower leaves ovate, sub-obtuse, upper leaves sometimes more attenuate, furnished with a rigid point to the excurrent costa, entire, sub-immarginate, not reflexed at margins; cells lax, nearly uniform; costa red, percurrent or slightly excurrent, in a short recurved point. Mac. Cat. 131.— In boggy places: Truro, N. S.; Revelstoke, B. C.

327. Bryum erythrophylloides Kindb.—Nearly allied to *B. erythrophyllum:* agreeing in leaves loosely disposed, rose-red, not decurrent: differs in leaves quite immarginate, narrower, ovate-lanceolate, long acuminate or acute; upper cells narrower; costa in upper leaves somewhat long excurrent, rigid: barren. Mac. Cat. 272.— Cypress Hills, Alberta.

328. Bryum anœctangiaceum C. M. & Kindb.— Tufts compact, radicupose, small, scarcely 2 cm. high; leaves small, rose colored, loosely disposed, not decurrent, spirally contorted when dry, ovate-acute, pellucid, narrow marginate, entire, faintly revolute, laxly areolate; costa thick, reddish, percurrent or short excurrent: probably monoicous, but male flowers not well developed. Mac. Cat. 130.—On rocks: Hector, Rocky Mountains, B. C.

329. Bryum crassirameum Ren. & Card.— In robust wide compact yellowish-green tufts: stems robust, stout, branched: leaves erect-spreading when moist, imbricate when dry, ovate-lanceolate, shortly acuminate, not decurrent, very entire or sub-sinuate at apex; margins revolute from base to near apex· costa percurrent or vanishing just below point; cells rectangular at base, hexagonal above, narrower on margins but not forming a distinct

border: seta reddish, flexuous: capsule pendulous, badious or ferruginous, cylindrical, constricted below mouth when dry, tapering to an attenuate neck: lid conic or sub-convex, apiculate; teeth yellow, densely trabeculate; segments split, cilia 2–3, appendiculate; annulus triple: dioicous.—Bot. Gaz. **15**: 57. 1890. Wet running bluffs: Oregon City, Oregon.

330. Bryum pseudotriquetrum gracilescens Sch.—Branches elongated, delicate; leaves more distant. Husnot, Musc. Gall. 249.— Wisconsin; Wyoming; Washington.

331. Bryum pseudotriquetrum hyalodontium C. M. & Kindb.—Differs principally in capsule pale brown and peristome pale, hyaline. Mac. Cat. 133.—On wet rocks: Hector, Rocky Mountains, B. C.

332. Bryum denticulatum Kindb.—Differs from *B. pseudotriquetrum* in leaves distantly denticulate to middle, lanceolate acuminate, reflexed at base: barren. Mac. Cat. 133.—In bogs and springy places: Cypress Hills, Alberta; Selkirk Mountains, B. C.

333. Bryum hydrophilum Kindb.—Closely allied to *B. pseudotriquetrum* but leaves narrower, ovate-lancelolate, reflexed at base or not at all: costa yellow; tufts loose, radiculose only below: flowers and capsules not found. Mac. Cat. 133.—In springy places: Vancouver Island.

334. Bryum Duvalii lato-decurrens C. M. & Kindb.—Differs in the upper leaves, looser disposed, longer decurrent; uppermost more distinctly apiculate, with a sometimes excurrent costa; longer short and broad: stem more radiculose. Mac. Cat. 132.—Wet earth: Selkirk Mts. and Revelstoke, B. C.

335. Bryum Duvalii Gaspeanum Kindb.—Differs in leaves narrow lanceolate, short decurrent, greater part margined, sometimes faintly denticulate above; costa percurrent or short excurrent. Mac. Cat. 272.—On wet rocks: Gaspé Co., Que.

336. Bryum meesioides Kindb.—Dioicous: densely cespitose: leaves yellowish, brown-margined, not decurrent, ovate-oblong or short lanceolate, short acuminate, faintly denticulate at apex, slightly reflexed on borders at base; cells rhomboidal oblong; costa red, scarcely excurrent, abbreviated in lower leaves: capsule narrowly pyriform, defluent to a longer collum, immature, arcuate, pale, wide-mouthed, constricted below mouth; lid convex, pale yellow, mamillate; teeth pale yellow, connivent; annulus double; cilia perfect, long and appendiculate; basilar membrane very low or indistinct. Mac. Cat. 133.—Wet rocks: Gaspé Coast, Que.; Banf, Rocky Mountains; Selkirk Mountains, B. C.; Vancouver Island.

337. Bryum Ontariense Kindb.—Intermediate between *B. roseum* and *B. Beyrichii:* comal leaves very numerous, lingulate, abruptly and shortly acuminate, revolute to ⅔ or ¾, yellow-margined above with great confluent teeth; costa stout. excurrent: capsule pale, with a distinct curved collum half as long, teeth papillose and hyaline above; lid convex,

short apiculate, not oblique. Mac. Cat. 135. *B. roseum* L. & J. Man. 240, not Schreb. In old logs and sometimes on limestone rocks in maple woods: Ontario; Quebec; New Brunswick; Ohio.

338. Bryum lucidum Britton.—Plants slender, scattered, not gregarious, light glossy green: stems from radiculose stolons, simple and naked below: leaves rosulate, not twisted when dry, broadly elliptical above, with parallel margins at base, blunt, with costa vanishing below apex, or with a serrate cuspidate point; vein heavy, frequently red at base; margins of long prosenchymatous cells forming small appressed teeth, entire below; cells of the lamina parenchymatous, elongated-hexagonal: dioicous: setae single, stramineous, lustrous and sulcate; capsule reflexed, horizontal or erect, constricted below mouth, neck short: teeth with a faint median line, segments of endostome split, cilia 3–4, not appendiculate, faintly papillose, very irregular, variously divided and elongated; lid apiculate. Bull. Torr. Bot. Club **18**: 53. *Bryum simplex* Kindb., Mac. Cat. 135. *Mnium Roellii* Broth., Bot. Centralbl. **44**: 420. 1890. Idaho; Montana; Washington; Gold Range, B. C.

339. Bryum bullatum C. Müll.—Dioicous: very small, slender: perichætium with few very short very slender julaceous branches: stem leaves minute, very densely imbricate, oval, very shortly acuminate, carinate-concave: margin plane, quite entire; costa yellow, slender, vanishing below apex; cells small; pellucid, elongate, narrowish: perichætial leaves larger, longer, from a lanceolate narrow base ligulate attenuate, obtusish; costa much longer, flexuous, carinate, reddish; cells much longer, looser, yellowish: capsule nutant on a slender reddish seta scarcely 1 in. long, very small, oval barrel-shaped, when young bullate-tuberculose; collum none; annulus broad; lid shortly convex-conic, ochraceous; peristome teeth small, slender; margin scarcely cristate; segments very narrow, cilia nodose (?). Flora **70**: 221. 1887.—Takhin Valley, Alaska.

340. Bryum hæmatophyllum Kindb.—Stems short, loosely tufted or solitary: leaves small, red, densely crowded, not decurrent, ovate or ovate oblong, acute, indistinctly margined, reflexed at entire borders; cells red, nearly uniform and loose; costa very broad, not (or very shortly) excurrent: perichætial leaves oblong lanceolate: capsule (not ripe) regular, pendent, obovate, lid convex, short apiculate, pedicel thin, spores small: dioicous. Mac. Cat. 118.—On wet rocks: Rocky Mountains.

341. Bryum oligochloron C. M. & Kindb.—This species is still doubtful, being found only in a barren state.—It is peculiar in upper leaf-cells very narrow; leaves ovate-lanceolate, long acuminate, nearly hyaline and costa long excurrent. Mac. Cat. 129.—On rocks: British Columbia.

342. Bryum microcephalum C. M. & Kindb.—This is a doubtful species, not having been found with capsules. It somewhat resembles *B. cæspiticium;* stem proliferous with small male buds, leaves contorted,

costa percurrent or short excurrent, inflorescence dioicous. Mac. Cat. 134.—On rocks: British Columbia.

343. Brynm pygmæo-alpinum C. M. & Kindb.—Tufts small, dense: stem sparingly radiculose to the buds: leaves small, olive-green, finally reddish, flaccid, not glossy, laxly areolate, hyaline; uppermost close, others loosely disposed, not decurrent, very much smaller; all subovate or oval obtuse, uppermost sometimes subacute; borders not margined nor revolute; upper cells short rhomboidal; costa broad, purplish, percurrent or in uppermost leaves slightly excurrent: barren. Mac. Cat. 126.—On wet rocks: Vancouver Island.

344. Brynm sanguilentum Ren. & Card.—Quite similar to *B. torquescens*, but more delicate: leaves when dry not twisted, scarcely bordered: capsule narrower: flowers dioicous. Differs at first sight from small forms of *B. capillare* in the narrower blood-red capsule, and in the leaves scarcely or indistinctly bordered. Musc. Am. Sept. **20**: 31. 1893. *B. capillare* var., Lesq. & James Man. 236.—California.

345. Mnium cuspidatum tenellum Kindb.—Differs in all parts being smaller. Mac. Cat. 136.—On earth in woods: Prince Edward Island.

346. Mnium macrociliare C. M. & Kindb.—Bisexual: loosely tufted: stem densely foliate, sometimes stoloniferous: leaves green or bright green, sub-distichous, not decurrent, pale-margined, simply or doubly dentate-ciliate, sub-ovate; perichætial smaller and narrower; costa always excurrent: capsules single or two, oblong, inclined or pendent; lid pale, conic, red-margined, short-rostrate; teeth yellow; pedicel purplish below, yellowish above. Mac. Cat. 137.—On rocks: Revelstoke, B. C.; on earth in damp woods: Ontario.

347. Mnium insigne intermedium Kindb.—Agrees with *M. insigne* in leaves long decurrent, long dentate, cells hexagonal-rotundate: differs in synoicous inflorescence. Mac. Cat. 139.—On earth: Prince Edward Island; wet rocks: British Columbia; in damp woods: Vancouver Island.

348. Mnium serratum Macounii Kindb.—Inflorescence paroicous: leaves red-margined; costa excurrent: lid obliquely rostrate. Mac. Cat. 139.—In dry woods Prince Edward Island.

349. Mnium decurrens C. M. & Kindb.—Dioicous: loosely tufted: stem very loosely foliate, naked below, elongate: leaves green or finally reddish, sub-distichous, long decurrent, often red at margins and wings, doubly dentate, lanceolate: inner perichætial ones sublinear, red cuspidate; cells smaller than in *M. umbratile;* costa sub-percurrent, often red, in inner perichætial leaves excurrent: capsule single, oval, inclined; lid pale, conic, not margined, short apiculate, not rostrate, teeth dark yellow; pedicel reddish. Resembles *M. orthorrhynchum* in size of capsule; leaf cells not much larger: differs from *M. umbratile* in narrow leaves, less twisted when dry. Mac. Cat. 140.—On stones: British Columbia.

350. Mnium inclinatum Lindb.—Dioicous: close to *M. orthorrhynchum:* plants 2-3 cm. high, slender: leaves larger above, uppermost oblong, obtuse, narrowly thick margined, double-toothed; costa toothed on back, vanishing in point, cells small, not pitted: seta 1.5 cm. long, curved above; capsule hypnoid, erect or inclined, ovate; neck long, gradually narrowed into seta; peristome yellow; membrane of endastome ½ length of teeth, reddish-brown, segments split; cilia delicate, scarcely nodulose; lid either straight or obliquely beaked. Limpr. Laubm. 2: 456.—On rocks and trunks of trees (Drummond); Ottawa, Ontario; British Columbia.

351. Mnium pseudo-lycopodioides C. M. & Kindb.—*M. lycopodioides* L. & J. Manual 246; not of Schwägrichen. From the closely allied *M. orthorrhynchum* it is separated by excurrent costa of upper leaves, and narrower capsules. Mac. Cat. 140.—Newfoundland; New Brunswick; Quebec; Adirondack and White Mts.; Rocky Mountains; British Columbia.

352. Mnium Niagaræ Kindb.—Intermediate between *M. spinulosum* and *M. serratum*, but readily distinguished by wide mouthed capsule: loosely tufted without creeping stolons, fertile stem simple: leaves dark green, crisped when dry, indistinctly decurrent, doubly dentate at red-margined borders, lower more loosely disposed, oblong, upper lanceolate; cells rotundate-hexagonal, often pellucid; costa red brown, excurrent at least in upper leaves; perichætial leaves narrow, sublinear, dentate, innermost very short: capsule solitary, pendent, narrow, often appressed to pedicel, sub-clavate-cylindric, constricted below wide mouth, teeth yellow; lid obliquely rostrate; pedicel pale red: inflorescence synoicous. Mac. Cat. 141.—On earth in woods: Ontario.

353. Mnium Blyttii B. & S.—Dioicous: tufts dense, 6-8 cm. high, bright green with red, densely red radiculose: leaves more crowded above, lower oval, acute, entire, upper oval oblong, acute, uppermost spatulate, acute, all narrowed at base, decurrent, red marginate, toothed to middle, with a double or single row of short, blunt teeth; cells not in divergent rows, irregularly roundish-angulate, faintly thickened, not pitted: capsule horizontal or nodding, long oblong, slightly curved; lid strongly convex, blunt; annulus double or triple; teeth of peristome yellowish-green, blunt, papillose, bordered; endostome nearly orange, basal membrane ½ length of teeth, segments broad, split, suddenly subulate. Limpr. Laubm. 2: 460.—Bases of stumps and on earth: Rocky Mountains and British Columbia.

354. Mnium hymenophyllum B. & S.—Densely cespitose, tufts from glaucescent to bright green, reddish below, when old blackish brown, interwoven with red rhizoids: plants 2-6 in. high (occasionally higher), erect, branched: leaves rather crowded, erect-spreading, long; decurrent, broadly ovate-acuminate, rather obtuse border narrow, entire or with prominent

cells here and there; costa vanishing below apex; cells roundish-hexagonal: dioicous; male flowers discoid, antheridia few, paraphyses strongly thickened at apex; female flowers and fruit unknown. Bry. Eu. Mnium Suppl. 5. pl. 400. Hartm. Skand. Flora **2**: 51. [Ed. 10.].—Greenland.

355. Aulacomnium palustre congestum Boul.—Tufts thick, radiculose: branches short: upper leaves slightly secund, sharp pointed. Limpr. Laubm. **2**: 530.—Isl. Miquelon.

356. Aulacomnium palustre laxifolium Kindb.—Leaves laxly disposed. Mac. Cat. 145.—British Columbia.

357. Timmia Megapolitana Bavarica Brid.—Leaves uniform in size; leaf sheath not papillose on back.—*T. Bavarica* Hessl. Limpr. Laubm. **2**: 581.

358. Timmia Norvegica Zett.—Dioicous: tufts lax, yellowish-green, below brown and laxly radiculose: leaves when old easily breaking off at insertion, above longer and narrower, from a short faintly sheathing base gradually linear-lanceolate, short pointed, erect-spreading, when dry falcate or spirally incurved twisted and almost crispate, from apex to middle short toothed, faintly toothed for remainder: costa strong, red, percurrent or vanishing; cells coarsely papillose in lower dorsal half, upper cells roundish quadrate or hexagonal, below gradually rectangular, in sheathing part elongated rectangular, distinctly pitted: capsule horizontal, oblong oval, short-necked; cilia of endostome delicate, not appendiculate.— Limpr. Laubm. **2**: 580. On muddy banks: Hector and discharge of Devils Lake, Rocky Mountains; Greenland.

359. Timmia Austriaca brevifolia Ren. & Card.—Stems shorter; leaves more crowded, shorter and erect-imbricate, scarcely flexuous when dry. Bot. Gaz. **19**: 238.—Springdale, Colorado.

360. Atrichum undulatum altecristatum Ren. & Card.—Lamellae of the leaves much higher than in typical form; capsule narrower, erect. Bot. Gaz. **15**: 58.—Kansas; Pennsylvania.

361. Atrichum leiophyllum Kindb.—Plants erect, simple, naked below, densely foliate above: leaves smooth, lower very small, upper lanceolate, acute-cuspidate, not margined, base scarcely broader; borders sharply serrate with large teeth, basal only entire; basilar cells narrow, others round-hexagonal, all pellucid; costa percurrent; lamellae 6, disappearing below apex, entire or slightly crenulate; perichaetial leaves long cuspidate, costa excurrent: capsule single, sub-cylindrical, broad, slightly curved, constricted at mouth; lid obliquely rostrate from conic base. Mac. Cat. 148.—In damp woods: Vancouver Island; Selkirk ounta ;

362. Atrichum rosulatum C. M. & Kindb.—Dioicous: stem indistinct or very short: leaves rosulate, undulate, not margined, dentate at middle, sometimes beset with transverse rows of scales, lower sub-oblong, upper

short-lanceolate, sub-obtuse; costa scarcely percurrent, nearly smooth: barren. Mac. Cat. 148.—On bank of Columbia River, Revelstoke, B. C.

363. Oligotrichum hercynicum (Ehrh.) DC. — Stems 1–3 cm. high, erect, rigid: tufts large, lax, glaucous green or brownish: leaves erect-spreading when moist, imbricate and incurved when dry, oval and half sheathing at base, then lanceolate-linear, acute, concave, incurved on border and dentate above middle; costa with 10–15 lamellae on upper surface, contorted-undulate, and with 2–4 short dentate lamellae in the upper part on dorsal side: capsule ordinarily oblique, sometimes erect, oblong-cylindric, slightly contracted below mouth, at first yellowish, becoming brown, smooth, irregularly plicate when empty; lid convex-conic, beak short; teeth of peristome unequal, variable in number. Husnot, Musc. Gall. 277.—Greenland; St. Lawrence Island: Behring Sea.

364. Oligotrichum hercynicum latifolium C. M. & Kindb.—Leaves shorter, entire: capsule distinctly plicate. Mac. Cat. 149.—Selkirk Mts.

365. Pogonatum erythrodontium Kindb.—Stem erect, simple, or furnished with a short innovation above, naked below: leaves green, spreading, flexuous and not incurved when dry, plane and patent when moist, linear, lanceolate, acuminate, red-denticulate all around, not sheathing, undulate, hispid or margined; cells round-hexagonal, chlorophyllose (also the marginal): lamellae distinct, not confluent, numerous, 20–30; costa narrow, percurrent: capsule single, short, ovate cylindrical, erect, papillose, wide mouthed: teeth red brown, narrowly hyaline margined all around, narrowly lingulate: dioicous. Mac. Cat. 150.—Vancouver Island; British Columbia; Alaska.

366. Pogonatum alpinum microdontium Kindb.— Leaves nearly entire, or indistinctly denticulate.—Mac. Cat. 152.—St. Paul Is., Behring Sea.

367. Pogonatum Macounii Kindb.— Dioicous: laxly cespitose, green, brownish when old: stem rooting only at base, dichotomously branched: leaves very long; when dry spreading or patulose, flexuose and convolute; when humid sub-plane, linear-lanceolate; cuspidate from short sheathing dirty white base, densely and sharply serrate, spinulose and reddish at back towards the apex; lamellæ numerous, about 60, entire, each of round hexangular cells; costa long excurrent; lower cells or leaf and base elongate and narrow, upper oblong, cell walls often oblique and irregular; perichætial leaves shorter and more acute: seta robust, pale, finally orange; capsule obliquely inclined, cylindric oblong, without neck, narrowed below mouth, not angulose; lid large, conic-subulate, orange at base; teeth of peristome 32, short. Mac. Cat. 152.— On earth and rocks: British Columbia; Vancouver Island; Alaska.

368. Polytrichum conorhynchum Kindb.—Differs from *P. formosum* in leaves canaliculate, capsule shorter and broader, not attenuate at base:

differs from *P. gracile* also in capsule acute angulate, lid conic, rostrate, leaves long sheathing. Mac. Cat. 154.— In boggy ground; Selkirk Mts.

369. Polytrichum sexangulare Flörke.— Stem 2–6 cm. long, generally simple, erect, or decumbent, naked at base; tufts large, brownish green, not tomentose: leaves rigid, erect incurved, sometimes incurved, large oval and sheathing at base: then abruptly contracted into a lanceolate-canaliculate point, sub-obtuse, very entire; lamellæ about 30; perichætial leaves longer sheathing, muticous: capsule erect or inclined, angular, six-sided; lid long beaked; teeth unequal; calyptra not reaching base of capsule. Husnot, Musc. Gall. 279.— Mt. Hood, Oregon.

370. Polytrichum Ohioense Ren. & Card.— Stem erect, simple or bipartite, a little tomentose below: leaves spreading when moist, erect flexuous when dry, from a sheathing base linear-acuminate, cuspidate, serrate; lamellæ about 50; perichætial leaves longer with a hyaline base; pedicel 4–8 cm. long, reddish below, pale above; capsule erect, finally horizontal, tetragonal or pentagonal, rarely hexagonal, acute angled, rather narrowed towards the base, with a very small or indistinct hypophysis. Bot. Gaz. **13:** 199. 1888.— Northern, eastern and southern United States; British Columbia; Canada.

371. Polytrichum Canadense Kindb.— Stem low, about 6–8 cm. high: pedicel not much longer; capsule blackish, much shorter than in the type.—Prince Edward Island; Quebec, Ontario; Lake Nepigon; Selkirk Mountains, B. C.

372. Polytrichum commune minus Weiss.—Plants shorter and more slender: leaves dense, shorter and more erect; perichætial bracts less distinct. Capsule much smaller and shorter, less acutely quadrangular, lid with short straight beak; calyptra pale golden brown. Braithw. Brit. Moss Flora **1**: 59.—New Jersey.

373. Polytrichum polare C. Müll.—Dioicous: low, dendroid, everywhere dark green, below with closely appressed small scales, above fastigiately branched; branches long for height of plants, rather slender, again divided, flexuous, equal: stem leaves closely appressed, when moist erect spreading, rather strict, from a large rbroadly-sheathing base obovate; shortly lanceolate; costa broad, multilamellose, opaque, occupying whole lamina, excurrent into a short blackish point; margin strongly serrate with robust teeth (rarely none) lobed at base and very sharp at apex; cells elongate, very narrow, close, flexuous, yellow, at margin very slender forming a pale border, above sinuate-narrowed; scales of undivided lower stem quite entire or slightly dentate at base, very shortly lanceolate; perichaetial leaves like; capsule on short thick red seta (scarcely 1 in.), inclined, small, quadrangular, bistrumose at base; teeth very narrow, whitish. Bot. Zeit. **17**: 205. 1859.—Greenland.

374. Polytrichum juniperinum Waghornei Kindb.—Leaves dentate in upper part, not in lower part only; marginal cells papillose. Mac. Cat. 155.—Labrador.

375. Buxbaumia indusiata Brid.—Dioicous: very similar to *B. aphylla:* seta 5-10 mm. high, thicker, yellowish red with smaller warts; capsule erect or sub-erect, when old less inclined, ovate-oblong, both surfaces same color, slightly shining, pale olive-green, when empty yellowish brown; dorsal surface faintly swollen, the external cuticle at length ruptured along the dorsal side and revolute; neck shorter and thicker; lid shorter, convex-conic; annulus narrower: separating as single cells; outer peristome free, formed of three or four rows of teeth; teeth numerous, irregular, small on outside; larger within, linear, triangular in cross section, perforate here and there in middle line, pale red, papillose, when moist erect; inner peristome as in *B. aphylla.* Limpr. Laubm. **2:** 640.—On decaying coniferous logs: Washington; Idaho; Catskill Mts., N. Y.

376. Buxbaumia Piperi Best.—Dioicous: stemless; leaves reduced to yellowish ovate-oblong or palmate crenate-laciniate bracts; cells oblong hexagonal: bracts of fertile plants producing long rhizoids enveloping the fleshy vaginule in a felt like mass: seta about 1 cm., arcuate or flexuose, warty, obliquely inserted; capsule inclined, ovate oblong, unsymmetric, greenish, becoming pale yellow, section broadly elliptical, upper surface not deeply impressed nor strongly margined; neck distinct; cuticle thin, not glossy or but slightly so, rolling back in segments after loosening of broadly conical obtuse operculum; endostome of linear papillose hyaline fluted segments, lightly cohering by their thickened margins forming a truncated cone; peristome of a single layer, with rudiments of a second deeply inserted, teeth linear, reddish or dirty white, papillose, articulated, revolute, lightly connate; pseud-annulus usually of 3 layers. Bull. Torr. Bot. Club **20:** 116. 1893.—On rotten wood or on ground covered with woody debris: Washington; Idaho.

377. Fontinalis antipyretica Oregonensis Ren. & Card.—Stems very slender, soft, pinnate, yellowish and shining above, not naked below; stem leaves distant, open, lanceolate; branches cuspidate; branch leaves erect, imbricate at the top of branches; cells very long and narrow. Bot. Gaz. **14:** 96. 1889.—In swamps, on roots of trees: Oregon.

378. Fontinalis antipyretica rigens Ren. & Card.—Plants rigid, shining, of a yellowish or copper green recalling the aspect of *Hypnum cordifolium:* stems rigid, naked at base, branches spreading divaricate: leaves distant, spreading or erect-spreading, imbricate only at ends of branches, lanceolate, obtuse or sub-obtuse; cells narrow, elongated; frutification unknown. Monog. des Fontin. in Mem. Soc. Sci. Nat. Cherbourg **28:** 55. 1892.—Washington; Vancouver Island.

379. **Fontinalis Neo-Mexicana Columbica** Card.—Plants quite soft, lax, generally shining, bright or yellowish green: stems often red at base: leaves distant, spreading, imbricate at end of stem and branches, sometimes slightly flexuose when dry. Monog. des Fontin., l. c., 61.—British Columbia; Washington; Idaho; California.

380. **Fontinalis maritima** C. Müll.—Plants slightly rigid, yellowish green: stems elongated, naked at base; branches numerous, sometimes fasciculate, rigid, delicate, elongated, flexuose, erect, triangular cuspidate: leaves small, crowded, imbricate for the whole length of stem and branches, oval-lanceolate, acuminate, acute, entire, carinate-conduplicate, nearly straight; cells as in *F. Neo-Mexicana*, very narrow and elongated, walls rigid and slightly thickened; cells of the angles numerous, sub-hexagonal, yellowish or sub-hyaline: frutification unknown. Monog. des Fontin., l. c., 61.—Growing with Polysiphonia and other marine algæ, Neah Bay, Washington.

381. **Fontinalis Kindbergii** Ren. & Card.—Plants robust, soft, brownish, or sometimes yellowish or red, copper colored and shining above: stem generally more than a foot long, flexuose, naked and black at base, divided into many more or less pinnate branches; branches spreading or erect, a little flexuose, plumose, sometimes cuspidate: leaves dimorphous; stem leaves erect-spreading or loosely imbricate, more or less carinate or only plicate, broad oval-lanceolate, long narrow acuminate, cuspidate, entire or sub-denticulate at summit, concave, upper large, lower much smaller and shorter acuminate; branch leaves tristichous, divaricate, narrowly lanceolate, long acuminate, concave, inflexed on margins, canaliculate above, rounded or sub-carinate at back; cells long linear, at angles enlarged, subquadrate, yellowish or ferruginous; perichætial bracts convolute, suborbicular, entire at truncate-rounded apex: capsule immersed, oblong, lid conic; teeth narrowly linear, slightly papillose, often connected in pairs at apex, with 25–35 lamellæ, not perforated at dorsal line; lattice cone of endostome perfect, papillose, transverse bars appendiculate: dioicous. Bot. Gaz. **15**: 58. 1890.—In streams, lakes, and ponds: Vancouver Island; Oregon; Washington; Idaho.

382. **Fontinalis Kindbergii Howellii** Ren. & Card.—Stems rigid, subdendroid: regular pinnate, spreading, often recurved and plumose, leaves more rigid, dimorphism much more pronounced. *F. Howellii*, Bot. Gaz. **13**: 200. 1888.—Oregon and Washington.

383. **Fontinalis chrysophylla** Card.—Plants rigid, shining, golden yellow above, brown at base: stems delicate, naked below, irregularly pinnate; branches distant, spreading, plumose, sub-attenuate: leaves scattered, rigid, spreading or erect spreading, slightly dimorphous; stem leaves narrow lanceolate, concave, carinate-conduplicate, narrow acuminate, obtuse or sub-obtuse, entire or slightly denticulate at summit; branch leaves and

those of upper part of innovations narrower, long and narrowly acuminate, almost subulate; acute, not carinate, canaliculate, sometimes subtubulose above, entire or sub-denticulate at apex; cells compact, narrow, very long, attenuated, walls rigid, thickened; cells of angles dilated, large, oblong sub-hexagonal or sub-rectangular, brown or yellowish, forming distinct auricles; perichætial leaves broadly oval, obtuse, finally lacerate at summit: capsule immersed, oblong sub-cylindric; lid and peristome unknown. Monog. des Fontin., l c., 67.—Olympic Mountains, Washington.

384. Fontinalis Delmarei Ren & Card.—Dull green, naked below, much divided; branches irregularly pinnate, branchlets erect-spreading, attenuate: leaves crowded, erect, loosely imbricate, oblong lanceolate, obtusely acuminate, concave, not keeled, slightly incurved on the borders; cells linear-elongated, sometimes rather flexuous; alar cells few, small sub-hexagonal; perichætial leaves often lacerate at rounded apex: capsule immersed, oblong sub-cylindric; lid conic acuminate; teeth of peristome narrowly linear acuminate, lamellæ 14–20, divisural line distinct at base only and not perforated: cilia united at apex only, lower transverse bars imperfect, papillose, not appendiculate. Bot. Gaz. **14:** 96. 1889.—Growing on stones in streams: Island of Miquelon.

385. Fontinalis mollis C. Müll.—Plants soft, floating, of a beautiful green: stems long, naked at base, much divided, irregularly pinnate, branches robust, unequal, short-cuspidate or sub-obtuse, erect spreading: leaves loosely imbricate, or erect spreading, soft, plicate when dry, very concave, inflexed on borders, broad oval, obtuse, entire; cells at angles sub-hexagonal, yellowish, greenish or concolorous and scarcely distinct; others linear rhombic, sub-flexuose, very chlorophyllose, walls delicate; upper perichætial leaves oval sub-orbicular, truncate and finally lacerate at summit: capsule immersed, oval; lid conic, obtuse; peristome purple, teeth linear-acuminate, faintly papillose, lamellæ 28–32, entire or slightly perforated near base in middle line, generally cohering in pairs at summit; transverse bars of endostome imperfect, strongly muricate. Monog. des Fontin., l. c., 90.—Washington.

386. Fontinalis Novæ-Angliæ Howei Card.—Leaves more acuminate, sometimes sub-acute; capsule half immersed. Monog. des Fontin., l. c., 93.—On rocks in streams: Ft. Edwards, N. Y.

387. Fontinalis Novæ-Angliæ Eatoni Card.—More shining, copper color: stems softer, less regularly pinnate, branches erect: leaves crowded, more erect, a little firmer and more elongated. Monog. des Fontin., l. c., 94.—On rocks in streams: New Hampshire.

388. Fontinalis Cardoti Ren.—Plants soft, dirty green or yellowish: stems flexuous, naked at base, much divided, pinnate branches often fasciculate, erect-spreading, robust, obtuse or short attenuate: leaves quite crowded, erect-imbricate, very concave, inflexed at margin, broadly oval-

lanceolate, obtuse, denticulate at summit, rarely almost entire; alar cells dilated, oblong, yellowish or sub-hyaline, forming distinct auricles; others narrow, linear, sub-flexuose, attenuate, walls rigid and thickened; upper perichætial leaves sub-orbicular, broadly rounded or sub-apiculate at summit, not lacerate: capsule immersed, narrow, cylindrical; lid conic, elevated, acuminate; peristome purple, teeth narrowly linear acuminate, strongly papillose, lamellæ 13-16, middle line scarcely apparent; cross bars of endostome imperfect, cilia very muricate, united only at summit. Monog. des Fontin., l. c., 95.—Virginia.

389. **Fontinalis involuta** Ren. & Card.—Plants slightly rigid or soft, dirty green or yellowish: stems finally naked at base, much divided, pinnate; branches spreading or erect-spreading, distichous, obtuse or cuspidate, generally compressed: leaves quite crowded, rigid, erect-spreading, oval oblong, oblong-lanceolate or sub-linear, very concave, strongly inflexed at border, canaliculate, generally cucullate at apex, terminated by a broad short obtuse or sub-acute slightly denticulate acumen; cells of angles dilated, oblong or sub-hexagonal, brown or yellowish, forming distinct auricles; others linear, narrow, walls delicate or slightly thickened; fructification unknown. Monog. des Fontin., l. c., 96.—Louisiana; Florida; New Jersey.

390. **Fontinalis nitida** Kindb. & Arn.—Plants soft, lax, delicate, generally somewhat shining above, yellowish green, dark below, becoming black when old: stems delicate, flexuous, more or less naked below, branching; branches long, erect-spreading, more or less cuspidate: leaves scattered, erect-spreading, plane or slightly concave, oval lanceolate or oblong lanceolate, gradually narrowed, acuminate, acute or sub-obtuse, entire or sinuolate at the apex; cells of angles dilated, oblong, sub-rectangular or sub-hexagonal, yellowish, forming small auricles; the remainder, elongated linear-rhombic with delicate walls; upper perichætial leaves oval sub-orbicular, rounded or sub-apiculate, finally a little lacerate at summit: capsule immersed, small, oval, rounded at base; lid short conic; peristome reddish orange, teeth narrowly linear, often cohering in pairs, papillose, generally not perforate along middle line; cross bars of endostome perfect, strongly muricate, almost spinulose. Monog. des Fontin., l. c., 103.—On rocks and trunks of trees at the edge of water: British Columbia.

391. **Fontinalis tenella** Card.—Plants soft, very delicate, pale yellowish green: stems delicate, more or less naked at base, divided in elongated branches, sub-simple: leaves erect-spreading, soft, plane, narrowly lanceolate, very long and gradually acuminate, acute, entire or sinuate at summit; cells of angles dilated, oblong or sub-rectangular, yellowish or greenish, forming small auricles; others narrow, linear, walls delicate; upper perichætial leaves broadly oval or sub-orbicular, rounded, generally small apiculate and finally lacerate: capsule immersed, small, oval or oblong,

rounded at base; lid short conic; peristome orange red, teeth narrowly linear, often cohering in pairs, strongly papillose, lamellæ 15–20, entire along middle line; cross bars imperfect, strongly muricate. Monog. des Fontin., l. c., 105.— On submerged trunks of trees and granitic rocks: Lake Pend d' Oreille, Idaho.

392. **Fontinalis Duriæi** Sch.— Plants soft, lax, pale olive or yellowish green, often blackish at base: stems delicate, more or less flexuose, entire, foliate or naked below; branches distant, but quite numerous, unequal, short or elongated, spreading or erect, attenuate, tapering or cuspidate: leaves more or less scattered, spreading or erect-spreading, imbricate at extremity of branches, soft or slightly rigid, slightly concave, often almost plane, sometimes a little plicate longitudinally; stem leaves broad, oval-lanceolate, or oval-oblong; branch leaves oblong lanceolate, acute, sub-acute or sub-obtuse, slightly denticulate at the summit; cells of angles short, sub-hexagonal or sub-rotundate, brown or yellow; others elongated, narrow, attenuate, linear-rhombic, walls delicate and soft, sinuous, upper cells much shorter; upper perichætial leaves oval sub-orbicular, rounded at apex, short and obtusely apiculate, finally lacerate: capsule immersed, oval or short oblong, rounded at base, not contracted below mouth when dry; lid conic: peristome beautiful purple or orange-red, teeth linear, sometimes sinuous on margin, papillose, frequently cohering in pairs, entire or perforate along middle line; cross bars of endostome perfect. Monog. des Fontin., l. c., 111.—California.

393. **Fontinalis flaccida** Ren. & Card.—Plants very soft, yellowish: stems slender, naked below; branches subpinnately ramulose; branchlets spreading, slender, distant: leaves soft, distant, open, but convolute-imbricate at top of branches, elongated, narrowly lanceolate, plane or nearly so, obtuse or truncate, slightly denticulate at apex; cells thin-walled, median very long, upper much shorter; those of angles large, lax, sub-rectangular, or sub-hexagonal, hyaline or brownish, forming very distinct auricles; perichætial leaves broadly oval, truncate and finally lacerate at summit: capsule immersed, sub-cylindric, rounded at base, not contracted below mouth when dry; lid conic, elevated; peristome purple, teeth often cohering in pairs, narrowly linear-acuminate, weakly papillose, entire along middle line; cross bars of endostome imperfect, muricate. Bot. Gaz. **13:** 201. 1888.—Growing in stagnant or running water: Louisiana; Alabama; White Mountains.

394. **Fontinalis microdonta** Ren.— Plants very slender and delicate, soft, entirely yellow or dark green at the base: stems delicate, filiform, reddish, naked at base, irregularly pinnate, branches distant, erect or erect-spreading, attenuate or cuspidate: leaves scattered, erect-spreading, soft, narrowly linear lanceolate, very long acuminate, acute, slightly denticulate, sinuate or entire at summit; stem leaves almost plane, branch leaves

sub-canaliculate; cells of angles dilated, oblong, yellowish or sub-hyaline; others linear, narrow, attenuate, subflexuous, walls delicate; perichætial leaves broad oval oblong, slightly narrowed above, entire or finally more or less lacerate, and sometimes plicate at summit: capsule immersed, narrow, cylindric; lid conic, elevated; peristome purple, teeth narrowly linear acuminate, sometimes cohering in pairs at summit, papillose, entire or perforate along middle line; endostome very rudimentary, with complete transverse bars, cilia muricate, simply appendiculate. Monog. des Fontin., l. c., 120.—New Jersey.

395. **Fontinalis dichelymoides** Lindb.—Plants somewhat shining, yellowish above, dark brown at base, having the external appearance of *Dichelyma* or certain submerged forms of *Hypnum fluitans* and *H. Kneiffii:* stems slender, flexuous, not or slightly naked at base, more or less regularly pinnate; branches distant, erect, spreading, more or less elongated, sub-attenuate and often slightly curved at summit: leaves scattered, erect spreading or sub-secund, narrowly lanceolate, incurved at border, canaliculate, long acuminate, acute, entire; cells of angles dilated, oblong, subrectangular or sub-hexagonal, hyaline or yellow, forming quite distinct auricles; others linear, flexuous, attenuate, very narrow: fructification unknown. Monog. des Fontin., l. c., 122.—Growing on submerged rocks. Lake Vermillion, Minn.

396. **Fontinalis filiformis tenuifolia** Card.—Still more delicate than type, plumose, pale green: leaves very distant, more elongated, very soft when moist, rigid when dry: sterile. Monog. des Fontin., l. c., 126.—Louisiana.

397. **Fontinalis Langloisii** Card.—Plants slender, delicate, slightly rigid, dirty green or dark at base, yellowish above: stems delicate, flexuous, naked and black below, pinnate and sub-bipinnate; branches distant, distinct, very delicate, plumose, cuspidate: leaves very distant, subrigid when dry, erect-spreading or sub-imbricate, narrowly lanceolate, tubulose or sub-tubulose, generally cucullate, sub-obtuse or obtuse, rarely acute, nearly entire or slightly denticulate at summit; cells at angles a little dilated, oblong, greenish or sub-hyaline; others linear-rhombic, with delicate walls: fructification unknown. Monog. des Fontin., l. c., 126.—Louisiana.

398. **Dichelyma capillaceum elongatum** Kindb.—Stems more elongate, branches more distant, leaf base longer than excurrent part of costa. Mac. Cat. 160.—North of Lake Superior.

399. **Neckera Menziesii amblyclada** Kindb.—Stems densely pinnate; branches obtuse, rarely attenuate and flagelliferous: leaves shorter, suboblong. Agrees with the common form in the paraphylliferous stem. Barren. Mac. Cat. 162.—Rocky Mountains, B. C.

400. Neckera Menziesii limnobioides Ren. & Card. — Habit of a *Limnobium*, soft and dilated, cespitose, dark-rufescent: leaves smooth, or scarcely undulate, short, entire or obsoletely denticulate above, obtuse or apiculate, areolation lax, costate to middle or beyond.— Bot. Centralbl. **44**: 422. 1890.

401. Neckera peterantha C. M. & Kindb.— Subspecies of *N. oligocarpa:* secondary stems nearly simple, about 1 dm. long, rigid and more robust: leaves larger and more crowded, one branch of the costa prolonged sometimes to middle: antheridia and archegonia very numerous: capsule emergent. Mac. Cat. 162.— On rocks: Rocky Mountains, B. C.

402. Neckera Douglasii Macounii Kindb.— Leaves less attenuate: capsule turgid oval, completely exserted on long pedicel. Mac. Cat. 163.— Hanging in long festoons from limbs of trees in shady woods: British Columbia and Vancouver Island.

403. Homalia Macounii C. M. & Kindb.— Very nearly allied to *H. trichomanoides:* leaves longer, rather lingulate, lowest basal cells yellowish; perichætial leaves more suddenly narrowed to very short acumen: segments of peristome cleft between articulations. Mac. Cat. 163.—*H. trichomanoides* and *H. obtusata* Lesq. & James, Manual 285.—Canada; Newfoundland; British Columbia and Vancouver.

404. Pterigynandrum filiforme heteropterum Sch.— Plants more robust, darker green; branches shorter and larger: leaves secund, oval, spatulate, rounded and shortly apiculate at summit. Husnot, Musc. Gall. 311. — Washington.

405. Pterigynandrum papillosulum C. M. & Kindb.— Differs from *P. filiforme* in branch leaves acuminate and acute, denticulate nearly all round, less papillose; branches blunt and turgid as in the variety *heteropterum* of this species. Mac. Cat. 165.— On rocks: British Columbia.

406. Antitrichia Californica ambigua Ren. & Card.— Branches not julaceous: leaves not so closely imbricate, generally subsecund and narrower; cells longer: pedicel often flexuous. Resembles in habit *A. curtipendula*, but differs in cylindrical, narrow capsule, perichætial leaves longer acuminate, and shorter cells. Bot. Gaz. **15**: 59. 1890.— Portland, Oregon.

406*a*. Antitrichia tenella Kindb.— Tufts loose, green: secondary stems irregularly divided; branchlets numerous, the greater number very short: leaves small, sub-patent or loosely appressed when dry, ovate-acute or short-acuminate, dentate at apex, not striate, reflexed to apex: greater number of cells short, inner and middle narrow; costa with 1–2 accessory branches at base; disappearing below apex; perigonial leaves elongate: dioicous: female plants unknown. Mac. Cat. 165.— On rocks: Nanimo River, Vancouver Is.

407. Thelia compacta Kindb.—Stems closely creeping; tufts green, very dense and thick: branches erect, terete, obtuse, unilateral: paraphyllia none: leaves cochleariform, rotundate-obtuse, short apiculate, very scabrous at back, with simple, incurved, papilliferous cilia: borders spinulose dentate, or fimbriate ciliate; cilia long, curved up and dentate; costa obsolete or very short; perichætial leaves oblong, lanceolate, narrowly acuminate, fimbriate, capsule pale brown, ovate-cylindrical; teeth subulate, short and broad, sometimes horizontally divaricate when moist, distantly articulate, dusky, upper article cleft: basilar membrane short, scarcely ¼ length of teeth without segments; operculum conic-obtuse. Mac. Cat. 166.—Abundant on stems of young maples: central Ontario: New Brunswick.

408. Leskea sub-obtusifolia C. M. & Kindb.—Plants loosely tufted, yellowish green or fuscescent: stem sparingly radiculose, irregularly divided, beset with paraphyllia; branches curved at apex: leaves distant, decurrent, entire, distinctly papillose at back, loosely appressed when dry, spreading when moist, margins recurved at base: stem leaves broadly ovate, obtuse or sub-acute; branch leaves oblong, obtuse; cells round, alar quadrate; costa sub-percurrent: perichætial leaves large, short, ovate-lanceolate, short acuminate, costate: capsule oblong, inclined, sub-curvate; lid short, mamillate; monoicous. Mac. Cat. 169.—On trees subject to inundation: British Columbia.

409. Leskea cyrtophylla Kindb.—Tufts dense, dark green or brown, not shining: stems irregularly branching, filiform, with few rhizoids: leaves nearly uniform, very small, appressed when dry, open-erect when moist, concave, from a broad rotundate ovate base short acuminate, entire, faintly papillose, borders reflexed below; cells rotundate, sub-hyaline; costa indistinct or none: dioicous: capsules not found. Mac. Cat. 169.—On rocks on islands in Lake Nepigon.

410. Myrinia Schimp.—Leaves oval or ovate lanceolate, entire, smooth, shortly costate; cells rhomboidal except those of basal angles which are quadrate: monoicous: annulus none; peristome double, calyptra cucullate, descending to middle of capsule.

411. Myrinia (?) Dieckii Ren. & Card.—Cespitose, dirty green: stems depressed, soft, elongated, irregularly branching, branches ascending, curved, julaceous, attenuate: leaves imbricate, concave, ovate lanceolate, sub-acute or obtuse, margin plane throughout or revolute at base, entire or sinuate; costa broad, green, sometimes sub-bifurcate, disappearing far below apex; cells rhomboidal-hexagonal, smooth, wall straight, alar quadrate, numerous, all strongly chlorophyllose; perichætial leaves acuminate, apex obsoletely denticulate: pedicel red; capsule erect, sub-cylindric: dioicous. Bot. Centralb. **44**: 421. 1890.—Growing on tree trunks: Oregon.

412. Anomodon attenuatus brevifolius R. & C.—Leaves shorter, wider above, shorter apiculate, sometimes obtuse, apex entire or denticulate;

cells more distinct; costa less translucent. Hedwigia 32: 245. 1893.— Indiana; Illinois; Wisconsin.

413. **Anomodon heteroideus** Kindb.— Plants densely tufted, green, finally fuscescent or blackish: stem creeping, subpinnate, much branching and furnished with numerous, small, flagelliform branchlets, densely beset with very small oblong obtuse and nerveless leaves, paraphyllia broad; stem leaves sub-distant, decurrent, appressed when dry, open-erect when moist, from a broadly ovate base, suddenly narrowed to a long subulate or sub-linear acumen, entire, faintly papillose; margins revolute at base; branch leaves more attenuate; cells round oval, marginal basal ones quadrate; costa vanishing below acumen; dioicous: fruit not found. Mac. Cat. 172.— On flat limestone rocks and roots of trees: Ontario and Rocky Mountains.

414. **Lescuræa** Schimp.— Primary stem obscurely creeping, secondary fertile stems ascending, fasciculately radiculose, perichætial branch not radicant: leaves erect-spreading, costate, smooth, sulcate; cells narrowly oval or oblong rhombic, at angles narrowly quadrate: calyptra long, narrow, sub-tubulose, early deciduous; annulus narrow; teeth confluentin to a basilar membrane, firm, narrowly lanceolate, vermicular verrucose, orange; segments from a narrow membrane, equaling or shorter than teeth, irregularly appendiculate, whitish yellow; spores minute.— Synop. Musc. Europ. 620. 1876.

415. **Lescuræa imperfecta** C. M. & Kindb.— Tufts loose, green, not shining: stem pinnate, radicant; paraphyllia few: stem-leaves smooth, decurrent, often bistriate, from a short ovate base suddenly narrowed into a long subulate or filiform often curved acumen, when dry loosely appressed with a patent acumen, distant and patent-open when moist; basal margins recurved; branch leaves long attenuate; inner cells near the costa oblong sub-linear, margined sub-quadrate, the others oval-oblong; costa vanishing in base of acumen; perichætial leaves nerveless; cells sub-linear: capsule small, oblong, straight; lid conic, sub-obtuse; peristome double, teeth incurved; cilia short or none, basal membrane indistinct; seta smooth, fine, flexuous: dioicous. Mac. Cat. 170.— On earth and bark at bases of trees: Revelstoke, B. C.

416. **Platygyrium repens orthoclados** Kindb.— Branches elongate, not curved: all basal leaf cells orange; segments linear, not completely free at base, smooth or denticulate at one side, not shorter than teeth. Mac. Cat. 172.— On old logs: Ottawa.

417. **Pylaisæa pseudo-platygyrium** Kindb.— Tufts intricate: stem irregularly divided, or sub-pinnate; branches thick: leaves crowded, upper glossy green, others finally brown, from ovate-oblong base, long acuminate, acumen sub-filiform, often curved, distinctly denticulate: borders recurved to acumen; cells narrow and confluent except the quad-

rate alar ones; costa double, distinct; perichætial leaves serrulate, abruptly narrowed to long, hair-point-like acumen: capsules straight, sub-erect, cylindric, wide mouthed; segments free, longer than teeth; lid conic, short apiculate: monoicous. Mac. Cat. 173.—On decayed tree trunks: Lake Nepigon.

418. **Pylaisæa Selwynii** Kindb.—Differs from *P. intricata* in denser, darker green tufts: leaves broader, short-acuminate, reflexed to acumen at one border or both; the short alar and marginal cells more numerous: capsule short oval; segments adhering to two-thirds of teeth. Mac. Cat. 174. —Very abundant on old cedar fences: Ottawa.

419. **Pylaisæa filari-acuminata** C. M. & Kindb.—Agrees with *P. velutina* in leaves filiform acuminate, but acumen distinctly denticulate, often twisted; alar cells more numerous: capsule thicker, oblong; peristomial teeth nearly free from segments; lid not found. Mac. Cat. 174.—On logs subject to inundation: Revelstoke, B. C.

420. **Homalothecium sericeum** Sch.—Stem pinnate, creeping; branch leaves narrow, ovate lanceolate, short-decurrent, long subulate or filiform acuminate, plicate, faintly denticulate nearly all around or sub-entire; margin scarcely reflexed; cells narrow, alar quadrate; costa long, vanishing in base of acumen; perichætial leaves scarcely plicate, attenuate to a filiform point: capsule erect, sub-cylindric, straight or slightly curved; teeth pale; segments short, basilar membrane high, to one-third the segments; cilia none; annulus broad: dioicous. Mac. Cat. 176.—On bark of trees: Vancouver Island; on rocks: Rocky Mountains.

420*a*. **Homalothecium sericeoides** C. M. & Kindb.—Differ from *H. sericeum* in branch leaves more densely crowded, not decurrent, narrower, heteromorphous; some long acuminate, sub-entire, less reflexed at margins; others short-acuminate, strongly reflexed at margins to serrulate acumen: capsules and seta unknown. Mac. Cat. 175.—Crevices of granite rocks: Revelstoke, B. C.

421. **Homalothecium Nevadense subulatum** Ren. & Card.—Leaves long acuminate subulate, generally less plicate. Hedwigia 32: 253. 1893. *H. sericeoides* C. M. & Kindb., Mac. Cat. 175.—Washington; Idaho; British Columbia.

422. **Homalothecium corticolum** Kindb.—Tufts dense, glossy: stems pinnate, creeping; branches densely crowded, curved: stem leaves ovate, abruptly narrowed to recurved or straight acumen; branch leaves ovate-oblong, acute or short-acuminate, straight; all leaves more or less denticulate and reflexed all around; alar cells quadrate, not numerous, marginal also quadrate, others oblong-rhomboidal; costa stout, vanishing above middle; perichaetial leaves entire, long-acuminate: capsule cylindric-oblong, larger, slightly curved; teeth yellow; segments with high basilar

membrane; lid short apiculate: monoicous. Mac. Cat. 274.—On rocks: Vancouver Island.

423. Cylindrothecium Macounii (C. M. & Kindb.) Ren. & Card.—Tufts loose: stem sparingly divided, translucent; branches much compressed, elongate, not attenuate, shining green above: leaves patent, concave, short, ovate-lanceolate, attenuate to short subulate point, basal angles rounded; margins scarcely recurved below, faintly denticulate all around; cells faintly chlorophyllose, long sub-linear, lowest basal dilated, oblong, or the alar often sub-quadrate; costa none or very short and double; perichætial leaves small, convolute or connivent, longer acuminate, more distinctly denticulate at apex: dioicous. *Entodon Macounii* C. M. & Kindb., Mac. Cat. 177.—On earth: Ontario.

424. Cylindrothecium aciculare (C. M. & Kindb.) Ren. & Card.—Tufts compact, brown-yellow or variegated with green: stem much divided, very radiculose; branches very short, turgid, not attenuate: leaves imbricate, with difficulty loosed from stem, scarcely open when moist, finally golden yellow, from ovate oblong base suddenly narrowed to fine aciculiform or subulate point, denticulate nearly all around; cells not cholorophyllose, linear lanceolate or fusiform, alar not well defined; costa generally wanting: barren. *Entodon acicularis* C. M. & Kindb., Mac. Cat. 176.—Ottawa.

425. Cylindrothecium expallens (C. M. & Kindb.) Ren. & Card.—Tufts loose, pale yellow: stems sparingly divided, radiculose at the base; branches elongate, much compressed, not attenuate: leaves sub-distichous, patent, short ovate-lanceolate, acute, concave, nearly entire, denticulate only at apex, distinctly auriculate, not recurved at margins; cells not chlorophyllose, long sub-linear, inner basal dilated sub-oblong; auricles excavate, well defined, with large oval or roundish finally golden yellow cells; costa none or double, sometimes reaching to middle: barren. *Entodon expallens* C. M. & Kindb., Mac. Cat. 177.—In boggy soil in woods: Rocky Mountains.

426. Climacium dendroides Oregonense R. & C.—Leaves narrower at base: less serrate at apex, sometimes sub-entire. Bot. Gaz. **15**: 59. 1890. —On ground and old logs: Oregon.

427. Climacium Americanum Kindbergii Ren. & Card.—A remarkable form, distinct by shorter, more distant, loosely intricate leaves; cells nearly equal, short, ovate, scarcely 1–2 times longer than broad. Bot. Gaz. **15**: 59. 1890.—Louisiana; Massachusetts.

428. Orthothecium intricatum Hartm.—Stems 2–5 cm. long, delicate, decumbent below, becoming erect, branching somewhat: tufts compact, soft, olive or yellowish green: leaves erect, spreading, subsecund, narrowly lanceolate, long-acuminate, entire, not plicate: capsule erect, oval or

oblong, contracted below mouth: lid conic; membrane of endostome very short; segments a little longer than the teeth; cilia none: very rarely fruiting. Husnot, Musc. Gall. 317.—Rocky Mountains; Greenland.

429. Pseudoleskea atrovirens brachyclados Sch.—Plants larger, leaves larger, more shortly acuminate, not secund; cells of middle part shorter and differing little from others: capsule shorter. Husnot, Musc. Gall. 306.—Wyoming.

430. Pseudoleskea atrovirens filamentosa Boulay.—Branches elongated, very slender' hooked at the tips: tufts rather loose, pure yellow at the surface: leaves secund, oval-oblong, narrowed into a long linear sharp acumen, scarcely plicate, 1 × 0.3 mm.; median cells linear, 1:4–8, translucent, lateral cells quadrate, opaque, rather narrow, enlarged at the base: capsule oblong, arcuate. Musc. de la France **1:** 162. 1884.—Washington; Oregon; Montana.

431. Pseudoleskea atrovirens atricha Kindb.—Tufts very dense, soft-fuscescent, with green tips: stem very lax, nearly without paraphyllia and rhizoids. Mac. Cat. 180.—On rocks: Griffin Lake, B. C.

432. Pseudoleskea rigescens denudata Kindb.—Stem more rigid, nearly simple, curved only at apex, naked below and radicant: barren. Mac. Cat. 181.—Selkirk Mountains, B. C.

433. Pseudoleskea falciuspis C. M. & Kindb.—Plants densely tufted: stems much branching: leaves very papillose, denticulate above, short, ovate-lanceolate, attenuate to an acute or filiform often curved point, long decurrent; margins recurved to or above middle, not in upper part; cells rotundate, quadrate at angles; costa vanishing far below acumen: dioicous. Mac. Cat. 182.—On rocks: Sicamous, Revelstoke and Quesnel, B. C.

434. Pseudoleskea stenophylla Ren. & Card.—Dioicous (monoicous ?), male flowers small, numerous, gemmiform: tufts very intricate, yellowish: stem slender, tough, prostrate, strongly radiculose, irregularly pinnate; branches slender, attenuate, ascending: leaves erect-spreading, narrowly lanceolate, gradually long acuminate, entire or obsoletely denticulate above; margin revolute below; costa strong, vanishing in the green acumen; cells thickened, alar quadrate numerous, median sub-linear truncate, upper rhomboidal ovate, apical large and obtusely papillose; paraphyllia numerous, triangular lanceolate or subulate; inner perichætial leaves sheathing, oblong, rather suddenly acuminate, entire, costa very smooth, vanishing in acumen: seta red, smooth, above twisted to right, 6–8 mm. long; capsule erect, inclined or pendulous with age, ovate-oblong, red-brown, slightly constricted below mouth; peristome teeth brown, linear-lanceolate, lamellose within; segments from a short basilar membrane narrowly linear-subulate, entire, equaling teeth. Bot. Centralbl. **44:** 421. 1890.—Cascade Mts., Easton, Washington.

435. Pseudoleskea tectorum Sch.—Stems 1–5 cm. long, decumbent,

delicate; branches numerous, short: tufts depressed, very dense, dark or reddish green: leaves erect-spreading when moist, imbricate when dry, broadly oval lanceolate, acuminate, entire; costa delicate, often unequally bifid, vanishing toward middle; margin of 3–5 rows of rounded transversely elongated cells in lower part, the remainder oblong; inner perichætial leaves sheathing, lanceolate, abruptly narrowed into a narrow point, longitudinally plicate: dioicous: capsule erect, cylindric, ferruginous; operculum convex-conic, rostrate; teeth of peristome, short, yellow; endostome with narrow segments, a little shorter than teeth, constricted at articulations giving them a moniliform aspect, basilar membrane and cilia absent. Husnot, Musc. Gall. 302.—Greenland.

436. **Pseudoleskea malacoclada** C. M. & Kindb.—Plants densely tufted: stems not rigid, much branching, sparingly radicant, without paraphyllia; branches green or finally fuscescent: leaves crowded, entire, not decurrent, not distinctly papillose; stem leaves from a concave broadly ovate or rotundate base suddenly narrowed to subulate or filiform recurved acumen; branch leaves more attenuate to subulate and patent point; basal margins recurved; cells rotundate, alar quadrate; costa very short and double or none; perichætial leaves loosely connivent with a patent or curved acumen: dioicous. Mac. Cat. 182.—On dry rocks: British Columbia.

437. **Heterocladium heteropterum** Sch.—Stems 2–6 cm. high, filiform, decumbent, delicate, giving off irregular ascending branches: tufts dark-green: leaves spreading or sub-secund when moist, loosely imbricate when dry, papillose on both sides; stem leaves oval, acuminate, denticulate all around; costa faint, bifurcate, short; cells rounded-quadrate, oblong-linear in the middle; branch leaves smaller: capsule horizontal, oblong, neck distinct; lid conic, rostrate: rarely fruiting.—Husnot, Musc. Gall. 307. On damp rocks: British Columbia; Vancouver Island; Greenland.

438. **Heterocladium Vancouveriense** Kindb.—Plants minute, densely and irregularly pinnate, sparingly radiculose, rarely flagelliferous, dark green, not glossy; branches short, very slender: leaves ovate-deltoid, denticulate above middle, pellucid, faintly papillose; stem leaves decurrent, reflexed at base, acute; branch-leaves smaller, looser, more concave, oval and obtuse: cells hexagonal oval or rhombic, alar and marginal quadrate-rhombic; alar and marginal quadrate-rhombic; costa slender, short, scarcely reaching to middle; paraphyllia few or none; perichætial leaves longer acuminate, cells narrower: capsule small, oblong, sub-erect; peristome perfect, teeth yellowish, cilia 2, elongate: dioicous. Mac. Cat. 183.

On rocks: Vancouver Island.

439. **Heterocladium frullaniopsis** C. M. & Kindb.—Stem irregularly divided, brown red, not radiculose; branches short, obtuse, when dry incurved: paraphyllia none; leaves uniform, dark-green, not shining, when dry loosely or not at all appressed, sub-squarrose when moist, distant and

decurrent, cochleariform, roundish oval, obtusate, incurved at the apex, minutely denticulate above to middle, very papillose; upper cells rhombic, lower oblong, alar quadrate, inner basal reddish; costa short, more or less distinct, sometimes stout and simple: dioicous. Mac. Cat. 183.—On trees: New Brunswick.

440. Heterocladium aberrans Ren. & Card.—Intricate-cespitose, pale or yellowish-green: stems flexuous, creeping, radiculose, more or less regularly pinnate; branchlets ascending, flexuous: stem leaves squarrose, auriculate, from a cordate-ovate base, long-acuminate, generally subulate; borders plane, sinuate-crenulate all around; costa forked, with one division longer and vanishing about middle; areolation loose, pellucid, of soft thick-walled cells, elongated, linear, truncate or obtuse, 4–10 times longer than broad toward costa, others irregular ovate, roundish or sub-hexagonal, sometimes slightly papillose; branch leaves shorter, acute or obtuse; perichætial leaves acuminate to a reflexed denticulate point, thin-nerved: seta purple, smooth; capsule horizontal, ovate, curved; lid unknown; teeth yellow, acuminate, densely trabeculate; segments narrowly split, cilia shorter, nodulose. Bot. Gaz. **15**: 59. 1890.—On logs: Idaho.

441. Thuidium scitum lonchoneuron Kindb.—Stems irregularly divided, sparingly radiculose; branchlets thick: stem leaves more broadly revolute at borders below acumen, less papillose; costa stout, percurrent or excurrent; branch leaves quite acute: capsules not found. Mac. Cat. 194.—On old logs: Leamington, Ont.

442. Thuidium microphyllum lignicolum (Kindb.) Best.—Monoicous: tufts yellowish or bright green: stems simply pinnate with few rhizoids and short scarcely ramose paraphyllia; branches close, distichous, attenuate, flexuous or slightly recurved: stem leaves from broad cordate base attenuate to a long often curved point, faintly striate, reflexed on borders; branch leaves shorter, acuminate; all denticulate from middle upward, and papillose at back or on both sides; cells obscure, rounded; costa vanishing in or below apex: capsule cylindrical, arcuate, light brown; teeth pale; cilia long, perfect; annulus double; lid conical, short apiculate. *T. lignicola* Kindb. Mac. Cat. 185.—On rotten logs: Ontario and British Columbia.

443. Thuidium paludosum elodioides (Ren. & Card.) Best.—Throughout similar in habit to *Elodium paludosum;* leaves short acuminate, cauline leaves fimbriate at base; cells shorter, elliptical or oval, papillose. Differs from *Thuidium Blandovii* by more slender habit: stems more remotely and less regularly branched: stem leaves narrower; cells looser; paraphyllia shorter; perichætial leaves narrow, entire, very long subulate: monoicous: sterile. *Thuidium elodioides* R. & C., Hedw. **32**: 251. 1893.—Hobart, Indiana; New Bremen, Ohio.

443*a*. Thuidium Philiberti Limpr.—Plants medium sized, yellow to dark green, in intricate mats; stem 4–8 cm. long, creeping, pinnately

branched; branches pinnate or bipinnate; paraphyllia multiform: stem leaves triangular-cordate-acuminate, usually with a hyaline filiform point; margins revolute or recurved, at least below; cells oblong-quadrate to oblong-rhomboidal: dioicous; perichætial bracts loose, flexuous-spreading or reflexed, serrate, rarely with a few short cilia on the innermost, acumen about 3 times as long as the short scarcely costate body: capsule oblong-cylindric, curved horizontal; annulus narrow, indistinct, tardily or imperfectly deciduous; operculum conic-rostrate, curved; spores 12–16μ, almost smooth, mature in Oct.—In swampy places on ground or base of small trees: New Jersey; Pennsylvania.

444. Tripterocladium rupestre Kindb.—Plants intricate, cespitose, pale brownish-green, not glossy: stems irregularly divided; branchlets short, filiform, not creeping: leaves small, densely crowded, when dry appressed, open-erect when moist, scarious, pellucid, not chlorophyllose nor papillose, sub-ovate, acute or long acuminate, upper denticulate above, borders recurved below, sometimes to middle or above; cells in lower leaves sub-linear above, looser at base, in upper leaves looser, oblong linear, in all sub-quadrate at borders and base; costa none. Mac. Cat. 187.—On the face of a cliff: Yale, B. C.

445. Camptothecium lutescens occidentale R. & C.—Robust, branches strongly sericeous, capsule narrower, longer. Hednigia **32**: 254. 1893.—Washington.

446. Camptothecium dolosum Ren. & Card.—Sub-species of *C. æneum:* branch leaves shorter, broader; nerve sometimes dilated at apex and denticulate; inner perichætial leaves with apex suddenly truncate, lacerate or deeply incised dentate. Hedwigia **32**: 255. 1893.—Washington.

447. Camptothecium aureum Sch.—Plants smaller and more delicate than in *C. lutescens;* branches more crowded and shorter; tufts golden yellow: leaves shorter and less deeply plicate; cells of basal angles rounded-quadrate, forming distinct auricles; paraphyllia quite numerous, ordinarily oval lanceolate; perichætial leaves entire: pedicel scabrous; capsule oblong, contracted below mouth; lid conic, obtuse, teeth of peristome orange. Husnot, Musc. Gall. 319.—Vancouver Island.

448. Camptothecium Amesiae Ren. & Card.—Widely cespitose, bright yellowish green: stems prostrate, creeping, radiculose, pinnately ramulose; branchlets crowded, short, equal, erect, a little curved: stem leaves broadly triangular, narrowly long acuminate, carinate, plicate, generally plane on one side and revolute on the other, slightly serrulate at apex; costa vanishing in acumen: cells linear, attenuate, upper shorter, alar numerous, quadrate or subrectangular; inner perichætial leaves ecostate, narrowly lanceolate, long acuminate, entire: seta short, purple, rough, a little twisted to left; capsule narrow, long cylindric, sub-erect, or sub-horizontal and slightly arcuate; lid unknown; teeth orange, long

acuminate-subulate, strong, densely trabeculate; segments split their whole length; cilia long. Bot. Gaz. **17**: 202. 1888.—Mixed with *Hypnum pinnatifidum*, California.

449. Camptothecium Nuttallii tenue Kindb.—Branches longer, filiform: leaves smaller only at base, hooked denticulate at apex. Mac. Cat. 189.—Perpendicular rocks: British Columbia.

450. Brachythecium laetum fallax R. & C.—Branches julaceous, elongated: leaves narrower, longer acuminate, more or less revolute; alar cells soft, hardly incrassate. Hedwigia **32**: 257. 1893.—Calumet River, Ind.

451. Brachythecium laetum Roellii Ren. & Card.—Stems depressed, pinnate: branches julaceous, short, obtuse: leaves densely imbricate, broader, concave, shorter acuminate: alar cells as in preceding variety. l. c.—Calumet River, near Hobart, Ind.

452. Brachythecium laetum pseudo-acuminatum Ren. & Card.—Delicate, habit *B. acuminatum:* leaves deeply plicate, basal angles excavate; alar cells less numerous but distinct. l. c.—Calumet River, near Hobart, Ind.

453. Brachythecium digastrum C. M. & Kindb.—Tufts laxly cohering, olive-green, not shining: stem rigid, sub-pinnate or irregularly branching, radiculose below; branches sub-julaceous, obtusate: stem leaves when dry loosely appressed or sub-imbricate, crowded, patent or sub-secund when moist, decurrent, not auricled, plicate, biventrose, ovate, short acuminate with flexuous acumen, or when dry serpentino-corrugate; borders more or less recurved but not reflexed, sub-entire or faintly denticulate above; lower basal cells wide and sub-rhombic, alar rather quadrate-rectangular and not very distinct, upper conflate small very chlorophyllose, inner median sub-linear, others oblong-lanceolate; costa thick and sub-flexuous, long, vanishing near acumen; branch leaves ovate oblong, more distinctly revolute at borders, denticulate at acumen, narrower areolate: capsule asymmetric, sub-cylindric, curved; lid long conic; seta smooth; teeth of peristome conic connivent when moist, cilia nodulose, not appendiculate: monoicous. Mac. Cat. 190.—Ottawa, Ont.; New Brunswick.

454. Brachythecium Fitzgeraldi C. Müll.—Dioicous: tufts low, pulvinate, broad, yellow, loosely interwoven: stem with branches short, more or less parallel, slender, round-julaceous; branchlets very short, rather spreading, single: stem leaves closely appressed, when moist scarcely spreading with cordate base semicircularly impressed, rather broad ovate, short acuminate; more or less ventricose-concave on both sides of the narrow vanishing deeply canaliculate green costa; margin nearly plane, everywhere slightly denticulate; cells very narrow, long, pale yellow; alar cells many, small, hexagonal: fruit unknown. Flora **70**: 224. 1887.—Florida.

455. Brachythecium acuminatum sub-albicans R. & C.—Facies of *B albicans:* more robust, pale yellow: branches silky, julaceous: areolation denser, cells narrower. Bot. Gaz. **15**: 60. 1890.—Louisiana; Florida.

456. Brachythecium cyrtophyllum Kindb.—Sub-species of *B. acuminatum:* habit of a small form of *B. albicans:* plants cespitose, green, faintly glossy: stems irregularly divided, not creeping; branchlets filiform, sub-obtuse: leaves small, close, loosely appressed when dry, open-erect when moist, ovate-acute or short-acuminate, not sulcate nor decurrent, serrulate at least above middle; areolation loose, upper cells narrowly rhomboidal, inner sub-linear, alar sub-quadrate somewhat numerous and chlorophyllose; costa stout, reaching to ⅔; perichætial leaves ecostate: dioicous. Mac. Cat. 191.—On elm logs in thick woods: Ontario.

457. Brachythecium Roellii Ren. & Card.—Dirty or yellowish green: stems soft, depressed, scarcely radiculose, subpinnate; branches elongate, flexuous: leaves ovate-lanceolate, decurrent, quite long and narrowly acuminate, faintly plicate; margin sinuate or denticulate, plane in middle, revolute at base and at acumen; costa reaching beyond middle to ⅔ length; cells narrow, elongate, linear, alar cells few sub-quadrate: evidently dioicous. Hedwigia **32**: 263. 1893.—Vancouver.

458. Brachythecium glareosum Sch.—Related to *B. salebrosum:* stems decumbent, often very long, 15–20 cm., forming large yellow tufts, softer, shining: leaves more erect, longer acuminate; cells narrower, those of angles oblong: dioicous: capsule oblique or sub-horizontal; lid conic, longer. Husnot, Musc. Gall. 324.—On earth at roots of trees: Revelstoke, B. C.

459. Brachythecium albicans occidentale Ren. & Card.—Stems depressed, laxly foliate: leaves subsecund, less long acuminate, sometimes very distinctly denticulate. Hedwigia **32**: 258. 1893.—Washington; Montana.

460. Brachythecium harpidioides C. M. & Kindb.—Tufts compact, soft, radiculose below, whitish or bright green, not shining: stems intricate, irregularly branching or pinnate: leaves spreading, somewhat loosely disposed, decurrent, more or less arcuate, not auricled, plicate, nearly flat, ovate, subulate acuminate; borders faintly denticulate, recurved often all around; cells distinctly chlorophyllose, alar large sub-quadrate, others lanceolate: dioicous: capsules not found. Mac. Cat. 194.—On old logs in woods: Revelstoke, B. C.; New Brunswick.

461. Bracyhthecium salebrosum Waghornei R. & C.—Monoicous: tufts very dense: stems erect, turgid, not radiculose: leaves more crowded, imbricate: lid mamillate. Differs from *B. mamilligerum* Kindb. in leaves imbricate, not patulous when dry: stems not radiculose. Bot. Gaz. **19**: 238. 1894. Battle Harbor, Labrador.

462. Brachythecium mamilligerum Kindb.—Sub-species of *B. salebrosum:* monoicous: tufts very dense, radiculose: stem sub-pinnate: leaves very patent when dry, striate, long, narrowly ovate-lanceolate often filiform pointed; borders not or narrowly recurved, faintly serrate; alar cells few; costa generally vanishing in middle, sometimes longer; perichætial leaves long aristate: capsule sub-oval, curved; segments narrowly rimose, not open; cilia nodose, not appendiculate; annulus none; lid mamillate. Mac. Cat. 192.—On old wet logs: Sicamous, B. C.

463. Brachythecium salebrosum turgidum Hartm.—Habit of *B. glareosum:* branches long, sericeous-yellow, leaves appressed, entire. Hartm. Skand. Fl. **2**: 16. 1871.—In peat bogs: Stephen, Rocky Mts.; Greenland.

464. Brachythecium pseudo-albicans Kindb.—Differs from *B. albicans* in leaves looser, sub-distichous, shorter acuminate, faintly striate, denticulate all around; alar cells greater, all basal cells finally reddish: barren. Mac. Cat. 194.—On earth in woods: Vancouver Island.

465. Brachythecium spurio-acuminatum C. M. & Kindb.—Differs from *B. acuminatum* in tufts lax, loosely adhering to substratum: leaves denticulate, recurved at borders nearly all around; alar cells still more numerous and very chlorophyllose; perichætial leaves subulate-acuminate, not filiform pointed: inflorescence monoicous. Mac. Cat. 191.—On logs in woods: Ontario.

466. Brachythecium erythrorrhizon Sch.—Monoicous: intricate cespitose: stems creeping, divided, strongly radiculose: branches ascending incurved; branchlets short: leaves crowded, laxly imbricate, younger secund, broad ovate-lanceolate, long acuminate, unequally broad sulcate; perichætial leaves loosely imbricate: capsule cernuous short-ovate, incurved. Schimp. Syn. **2**: 646.—Washington.

467. Brachythecium sub-erythrorrhizon Ren. & Card.—Monoicous: intricate-cespitose, yellowish green, facies of *B. velutinum:* stems creeping, radiculose, sparingly branching, branches procumbent: leaves subhomomallous, oblong-lanceolate, long narrowly acuminate, bi-tri-plicate, sharply serrate all around; borders plane or partly revolute; costa vanishing above middle, sometimes forked and shorter; cells rather loose, pellucid, rhomboideal linear, alar quadrate sub-obscure; perichætial bracts lanceolate, long acuminate-subulate, acumen serrate: seta smooth, reddish; capsule sub-erect, turgid ovate, not or scarcely constricted below mouth when dry; lid unknown; teeth of peristome yellowish, triangular-lanceolate; segments narrow, split along divisural line; cilia 1 or 2, long, filiform. Bot. Gaz. **19**: 238, 1894.—Colorado.

468. Brachythecium pseudo-collinum Kindb.—Agrees with *B. collinum* in pinnate and creeping stem: decurrent leaves denticulate all around: short sub-oval capsule and smooth pedicel: differs in stems julaceous: leaves

larger and longer, ovate-lanceolate, more loosely disposed, spreading or patent, gradually tapering into short, half-twisted acumen; cells chlorophyllose, alar ones larger; costa longer, reaching above middle: monoicous. Mac. Cat. 196.—Queen's Co., New Brunswick.

469. Brachythecium laevisetum Kindb.—Habit of *B. populeum*: plants cespitose: green, glossy: stem irregularly ramulose: leaves close, suberect, open, ovate-lanceolate, acuminate and acute, sulcate; borders serrulate from middle upwards; basal cells dilated; costa long, reaching at least ng th of leaf; perichætial leaves nerveless: capsule small, incurved, oblong; outer teeth hyaline-margined, light brown; cilia short, not appendiculate; lid highly convex, not apiculate; pedicel very smooth: monoicous. Mac. Cat. 193.—On rotten logs: Gold Range, B. C.

470. Brachythecium Idahense Ren. & Card.—Imbricate-cespitose, bright green: stems depressed, creeping, irregularly pinnate; branches ascending, sub-incurved: leaves crowded, sub-secund, from an ovate base lanceolate, long acuminate, plicate, costate to above middle, borders denticulate all around or sub-entire, plane or more or less revolute; cells linear, attenuated, those of angles sub-quadrate, numerous; perichætial leaves rather suddenly acuminate, obsoletely costate or sub-ecostate: seta purple, smooth; capsule horizontal, ovate, gibbous, curved; lid obtusely conic; teeth lanceolate acuminate, densely trabeculate; segments broadly split; cilia long, nodulose: monoicous. Bot. Gaz. **15**: 60. 1890.—On logs: Idaho.

471. Brachythecium Novæ-Angliæ Delamarei R. & C.—Stems shorter, almost simple: leaves more distinctly imbricate, abruptly contracted into a short point. Fl. Miq. 50.—Island of Miquelon.

472. Brachythecium latifolium (Lindb.) R. & C.—Near *B. rivulare*: plants dioicous: very much smaller, straight, acute, acuminate at apex; irregularly and remotely sub-pinnate to sub-simple; branches short, divaricate, acute, simple: stem leaves pellucid, spreading, very long and broadly decurrent, rhomboid-triangular, gradually long acuminate, concave, not plicate; margin recurved below broadest part, very often auriculate; costa slender, vanishing at middle or a little above; cells nearly three times shorter, large, rhomboid-prosenchymatous, not vermicular: fruit not seen. *Hypnum latifolium* Lindb., Musci Scand. 35.—Miquelon Is.

473. Brachythecium pseudo-Starkei Ren. & Card.—Dioicous: loosely cespitose, green: stem erect or ascending, flexuous, laxly pinnate, branches elongate, attenuate: leaves not close, patulous, ovate-lanceolate, plicate acuminate, acumen long, sometimes tortuous; margin generally serrate; costa extending into the acumen; cells linear-rhomboidal, elongate, attenuate, alar lax soft quadrate hyaline: not fruiting. Bot. Cent. **44**: 423. 1890.—Washington.

474. Brachythecium rivulare obtusulum Kindb.—Stem irregularly divided; branches simple and elongate: leaves glossy, ovate, blunt or

short acute, striate, decurrent, indistinctly denticulate above or from middle; cells dilatate, principally the lower and the uppermost, alar and basilar finally orange-reddish, alar rarely greater, costa short and simple. Mac. Cat. 201.—New Brunswick: Ontario; Revelstoke, B. C.

475. **Brachythecium platycladum** C. M. & Kindb.—Tufts densely cohering, bright green, shining: stem irregularly branching; branches short obtuse, complanate: leaves loosely imbricate or patent, nearly flat, long decurrent, distinctly auriculate, faintly striate, broad, ovate, suddenly and generally short acuminate; borders not recurved, faintly sinuolate or subentire below middle, more distinctly denticulate above; cells pale, upper narrow, lower near base dilated, alar large and well-defined; costa short, reaching little above middle: capsule sub-oval, faintly curved; teeth dark yellow, entire at borders; cilia not apendiculate; lid unknown: dioicous. Mac. Cat. 195.—On stones: Ottawa, Ont.

476. **Brachythecium spurio-rutabulum** C. M. & Kindb.— Differs from *B. rutabulum* in dioicous inflorescence: leaves distinctly plicate, longer cuspidate: seta rough, short. Tufts dense: stems pinnate, and creeping leaves shining, when dry very spreading, loosely disposed, long decurrent borders recurved below the middle, faintly denticulate. Mac. Cat. 197 and Sicamous.— On bases of trees: Burrard Inlet, B. C.

477. **Brachythecium nanopes** C. M. Kindb.— Allied to *B. populeum* in habit, peristome, monoicous inflorescence, pedicel faintly rough above, long and subpercurrent costa of leaves: differs in stems not creeping, nearly without rhizoids, branches unilateral, leaves smaller and narrower at base, stem leaves long filiform apiculate, sub-entire and not or indistinctly recurved at borders, lower decurrent: capsule smaller, pedicel shorter, peristome pale orange, cilia long and indistinctly appendiculate. Mac. Cat. 201. On earth: Revelstoke, B. C.

478. **Brachythecium trachypodium** Sch.— Stems 3–5 cm. high, decumbent, furnished with branches and branchlets: tufts golden yellow, or greenish in part: leaves erect, loosely imbricate, oval or long lanceolate, long acuminate, denticulate, costate to middle, faintly plicate; cells of basal angles quadrate, others linear: some perichætial leaves abruptly, others gradually acuminate: monoicous: seta robust, very papillose; capsule almost erect, or oblique, oval or oblong, contracted below mouth; lid convex-conic, obtuse; peristome of *B. velutinum;* calyptra reaching base of capsule. Husnot, Musc. Gall. 328.— Greenland.

479. **Brachythecium reflexum Pacificum** Ren. & Card.— More robust, stem leaves larger, ovate-lanceolate, hardly triangular, somewhat acuminate, margin sub-revolute at base. Hedwigia **32**: 262. 1893.—Mt. Hood, Oregon.

480. **Brachythecium reflexum Demetrii** Ren. & Card.—Habit stronger,

branches thicker, erect, leaves broader, softer. Bot. Gaz. **19**: 239, 1894. Squaw Is., Labrador.

481. Brachythecium glaciale Sch.—Stems 2–5 cm., decumbent, much divided, branchlets subjulaceous: green or dark yellow: leaves erect-imbricate, decurrent; stem leaves broadly oval, abruptly or shortly acuminate, denticulate throughout, costate ¾ length, plicate; branch leaves narrower, longer acuminate; cells of the basal angles quadrate or rectangular, the middle linear of variable length; perichætial leaves erect-imbricate: monoicous: seta papillose; capsule almost erect, oblique or horizontal, oval or oblong; cilia nodulose, not appendiculate. Husnot, Musc. Gall. 328.— Greenland.

482. Brachythecium curtum Lindb.—From *H. Starkei* differs in its leaves broad and short; margin plane and short serrate; costa more slender, much shorter, smooth on back; cells broader. Differs from *B. œdipodium* in perichætial bracts shorter acuminate, more serrate: seta rather thick, slightly scabrous; capsule nodding more than horizontal; lid perfectly conic. Musci Scand. 35. 1879.—On earth in woods: New Brunswick; Prince Edward Isl.; Ottawa.

483. Brachythecium gemmascens C. M. & Kindb.—Tufts very dense, finally green, rufescent: stem irregularly branching, furnished with numerous male buds: leaves narrow, ovate-lanceolate with a twisted point, faintly denticulate all around, crowded, not decurrent nor auricled; cells pale, nearly all narrow, only lowest one or two basal rows dilated, alar not larger than inner;costa prolonged above middle,vanishing below acumen: capsule small, round-oval, oblique; teeth dark-orange; segments shorter than very high basal membrane, cilia not appendiculate; lid conic, short pointed; seta minutely verrucose, about 1 cm. long: monoicous. Mac. Cat. 195. —On wet logs: Columbia River, above Revelstoke, B. C.

484. Brachythecium leucoglaucum C. M. & Kindb.—Tufts loose with but few rhizoids, whitish or sub-glaucous-green, faintly shining: stem subpinnate or irregularly branching: leaves from ovate base suddenly tapering into a somewhat long filiform often half twisted point, sharply serrate above, faintly denticulate below, striate, decurrent, borders reflexed below; alar cells small, numerous, others narrow; costa long, sometimes sub-percurrent; perichætial leaves long, filiform-acuminate, arcuate-squarrose: capsule curved, oblong-cylindric; lid sub-obtuse when moist; pedicel faintly rough; peristome conic-connivent, teeth serrulate, pale above: segments open in middle; papillose above, cilia not appendiculate; monoicous. Mac. Cat. 197.—On loose earth: New Brunswick.

485. Brachythecium rutabulum Canadense Ren. & Card.—Of more delicate habit; leaves narrower, deeply plicate, long acuminate. Revue Bryol. **20**: 19. 1893.—Canada; Miquelon Is.; Washington.

486. Brachythecium rutabuliforme Kindb.—Agrees with *B. rutabulum* in very rough pedicel, monoicous inflorescence and form of leaves: differs principally in rigid stem,distinctly appendiculate cilia of peristome, and short pedicel: leaves sub-ovate, short-acuminate, nearly estriate, faintly denticulate. Mac. Cat. 198.—On stones in brook: British Columbia.

487. Brachythecium Columbico-rutabulum Kindb.—Tufts dense, faintly shining, finally brownish-green: stems elongate, pinnate creeping: stem leaves patent, from broadly ovate base long cuspidate, with filiform generally prolonged point, decurrent, very plicate, nearly entire, borders shortly reflexed below: cells not chlorophyllose, alar larger and well distinct; perichætial leaves sub-erect-patent with a long filiform arcuate point, faintly and distinctly denticulate: capsule oblong-cylindric, curved; peristome teeth not serrulate, segments very open in middle, cilia faintly nodulose, not appendiculate; pedicel very rough; monoicous. Mac. Cat. 198.—On wet and rotten logs in woods: Columbia River, B. C.

488. Brachythecium lamprochryseum C. M. & Kindb.—Tufts large, laxly cohering to substratum, with few rhizoids: golden yellow, shining or finally decolorate: stem elongate, often pinnate; branches generally short or sometimes more elongate and faintly curved above, sub-acute: leaves open, more or less loosely disposed, long decurrent, distinctly auriculate, very plicate, from triangular ovate base short acuminate, filiform or subulate cuspidate, often curved at apex, nearly flat, only auricles faintly revolute; borders faintly denticulate all around: most cells very long and narrow, lowest basal ones dilated and short, also the alar, all very sparingly chlorophyllose; costa broader at base, faint, reaching to middle, but in the smaller narrower and more loosely disposed leaves of some branchlets longer, reaching to acumen: perichætial leaves ecostate, when dry squarrose, inner sheathing with a short subulate acumen and a long filiform point: capsule short, sub-ovoid, thicker near base, slightly contracted below mouth, arcuate; lid unknown; teeth finally brown at least at base; cilia not appendiculate; pedicel very rough: monoicous. Mac. Cat. 199.—On stones: Vancouver Island.

489. Brachythecium mirabundum C. M. & Kindb.—Tufts large, very laxly cohering, nearly without rhizoids, silky or yellowish green, faintly shining: stem elongate, irregularly divided or prolonged into sciuroid-curved obtuse branches: leaves loosely imbricate, crowded, when dry subrugose, when moist patent, short decurrent, indistinctly auriculate, faintly plicate, from concave ovate and gradually acuminate base long cuspidate; borders broadly recurved at least at one side of nearly entire base to involute and distinctly denticulate acumen; cells pale, elongate, narrow, alar sub-quadrate and not much wider than other basal ones, all sparingly chlorophyllose; costa vanishing in acumen: perichætial leaves ecostate,

longer filiform-cuspidate, irregularly sinuolate, point patent or arcuate, basal cells larger rectangular: capsule small, at base distinctly gibbous, narrow, cylindric, curved; lid elongate-conic; pedicel very short, very faintly muriculate: monoicous. Mac. Cat. 199.—On old logs in woods: New Brunswick.

490. Brachythecium Villardi Ren. & Card.—Monoicous: similar in habit to *B. salebrosum:* stem depressed, creeping, radiculose, pinnate, branches ascending: leaves erect, imbricate or sub-secund, decurrent, ovate lanceolate, long and slenderly acuminate, plicate, margin more or less revolute, entire or in acumen faintly denticulate; costa reaching two-thirds length of leaf; cells narrow, elongated, linear, alar cells few, quadrate: pecicel rough: remaining characters not known. Bot. Centralbl. **44**: 422. 1890.—Washington.

491. Brachythecium cirrhosum Sch.—Stems decumbent, 3–10 cm. long, stoloniferous, more or less branching; branches ascending or erect, inflated, julaceous: tufts yellowish or golden green: leaves imbricate, very concave, sub-cochleariform, oval oblong, very abruptly contracted into a very long filiform point, shining, plicate when dry, often inflexed on the borders, denticulate in the upper part, sometimes entire; costa simple or double, vanishing near middle; basal cells quadrate or rectangular, rounded, others linear: fructification unknown. Husnot, Musc. Gall. 338.—Greenland.

492. Scleropodium cæspitosum sublæve Ren. & Card.—Pedicel nearly smooth, slightly rough only below capsule. Bot. Gaz. **15**: 61. 1890.—Sauvie's Island, Oregon.

493. Scleropodium Krausei (Müll.) Ren. & Card.—Monoicous: tufts low, rather robust and loose, pale green: stem sparingly branched; branches rather short, flexuous, round julaceous, turgescent, with obtuse apex: stem leaves closely or loosely crowded, narrowly oblong-lanceolate, cymbiform-concave, short pointed, point somewhat twisted, quite entire: base truncate, margin plane; costa very slender, yellowish, vanishing, often bifurcate; cells very narrow, vermicular, alar many small pellucid; perichætial leaves larger, seta rather short, red, smooth; capsule amblystegioid-cylindric, cernuous, coriaceous, ochraceous; lid conic, very short mamillate; annulus simple, rather broad; peristome teeth robust, broad, long, yellow, hyaline pointed, cristate: segments from a rather high yellow membrane, long, broad, sulcate, very smooth, not perforate nor gaping, cilia rudimentary, solitary. *Hypnum Krausei* C. Müll., Flora **70**: 224. 1887.—Alaska.

494. Isothecium Cardoti Kindb.—Rhizome creeping; secondary stems pinnate, ligneous, often curved, sometimes bearing rigid long and at the apex branching flagella: stem leaves ovate-lanceolate, subulate acuminate, faintly denticulate below, acumen serrate and twisted above; cells often yellowish, all long and narrow except basal, the alar and inner basal dark

yellow or orange quadrate or rectangular; costa stout, reaching ⅔ length of leaf; branch leaves shorter acuminate, sharply serrate above middle, borders often faintly reflexed to acumen; perigonial leaves sub-ovate, reddish at base; costa fine and short; perichætial leaves ecostate, from a short ovate base suddenly tapering to much longer, subulate acumen: capsule oval, horizontally patent or cernuous, teeth pale yellow; segments rimose in middle, prolonged into long and smooth cilia; seta smooth, arcuate above: monoicous. Bull. Torr. Bot. Club **17**: 278.— On bases of trees and logs: Washington; Vancouver; British Columbia.

495. Isothecium myurellum Kindb.— Tufts very loose, dark green, not glossy: stems creeping; branches erect, tree-like and ramose; branchlets curved, attenuate: leaves of branches appressed when dry, small, ovate, blunt or short acuminate, twice serrate or denticulate all around, smooth, scarcely reflexed on borders; alar cells round quadrate, middle ones narrow, upper rhombic; costa three-fourths length of leaf: perichætial leaves ecostate, oblong, with a long denticulate horizontally patent acumen and narrow cells: capsule oval oblong, inclined; segments with a low basilar membrane and two short cilia; annulus double; lid conical acuminate; pedicel smooth: dioicous. Bull. Torr. Bot. Club **12**: 278.— On decaying logs and on rocks: Vancouver Island; British Columbia.

496. Eurhynchium strigosum Barnesi Ren & Card.— Stems rather more robust, stem leaves larger, longer acuminate, branch leaves more elongated: capsule shorter broadly ovate. Bot. Gaz. **14**: 97. 1889.— On logs: Lake Pend d'Oreille, Idaho.

497. Eurhynchium strigosum fallax Ren. & Card.— Form robust, resembling in habit *E. myosuroides:* stem leaves very large, triangular-lanceolate, obtuse; branch leaves rounded at apex: capsule like that of typical form. Bot. Gaz. **14**: 98. 1889.— On logs: Lake Pend d'Oreille, Idaho.

498. Eurhynchium sub-strigosum Kindb.— Differs from *E. strigosum* in distant branches complanate: leaves long decurrent and twice greater, patent, sub-distichous: capsule very constricted below orifice; cilia appendiculate: monoicous. Mac. Cat. 205.— On rocks: British Columbia.

499. Eurhynchium crassinervium laxirete Kindb.— Leaves nearly entire or faintly denticulate above, shorter acuminate; cells larger: only male flowers found. Mac. Cat. 207.— On earth in woods: Queen's Co., N. B.

500. Eurhynchium colpophyllum flagelliforme Barnes.—Leaves lance ovate, small; branches long, almost flagelliform, attenuate. Bot. Gaz. **16**: 207. 1891.— California.

501. Eurhynchium Dawsoni Kindb.— Stems pinnate, not or rarely radiculose; branchlets patent: leaves green or brownish, not glossy, not

or indistinctly papillose, not long-acuminate from broad ovate base, recurved on borders below, long decurrent, open erect, denticulate all around; areolation variable, often sub-rhomboidal; costa thick, reaching nearly to apex: probably dioicous. Bull. Torr. Bot. Club **17**: 278.—On rocks: Vancouver Island; British Columbia.

502. Eurhynchium semiasperum C. M. & Kindb.—Plants loosely tufted, green: secondary stems sparingly radiculose, branching at one side; branches generally simple, acute: leaves sub-patent, from a broad-cordate base, fine acuminate, decurrent, nearly entire; alar cells numerous, reaching to costa, other cells narrower, the lower dilated; costa vanishing above middle: perichætial leaves sub-oblong, short acuminate, erect, entire, ecostate: capsule small, sub-oval erect or inclined; teeth papillose above; segments shorter than high basilar membrane: lid narrow, short rostellate; pedicel rough at least to middle, smooth below: monoicous. Mac. Cat. 207.—On rocks in a brook, British Columbia.

503. Eurhynchium Sullivantii Holzingeri Ren. & Card.—Branches shorter, generally obtuse: leaves broader, shorter acuminate. Bot. Gaz. **19**: 239. 1894.—District of Columbia.

504. Raphidostegium sub-demissum Kindb.—Differs from *R. demissum* in branches cuspidate, sub-julaceous: leaves smaller, long subulate, not or indistinctly recurved on borders: inflorescence dioicous. Mac. Cat. 208.—On rocks: Alaska.

505. Raphidostegium micans submersum Ren. & Card.—More robust: stems very much elongated, pinnate, intricate: leaves remote; perichætial leaves longer. Revue Bryol. **20**: 21. 1893.—Louisiana.

506. Raphidostegium sub-adnatum C. M. & Kindb.—Tufts green, intricate: branches short, sub-julaceous: leaves close, incurved at apex, ovate oblong, denticulate to middle, reflexed at margins below; inner cells sub-oblong, alar and marginal quadrate not vesiculose nor yellow; costa short, double; perichætial leaves larger, longer, appressed, a little longer acuminate: capsule cylindric, curved, very much narrower than rostrate lid; pedicel arcuate or flexuous: probably monoicous. Mac. Cat. 209.—On trees in woods: Ontario; Quebec.

507. Raphidostegium Kegelianum Floridanum Ren. & Card.—Scarcely distinct from the S. American type by the shorter and broader capsule, rounded or less attenuate below. Bot. Gaz. **15**: 61. 1890.—Trunks of palms: Florida.

508. Raphidostegium Roellii Ren. & Card.—Monoicous: delicate, densely cespitose, shining, yellowish green: leaves sub-homomallous or complanate, oblong lanceolate, decurrent, acuminate; margin plane or reflexed, denticulate above: costa double or very faint; cells elongated, narrowly linear, alar strongly dilated and hyaline or yellowish; perichætial leaves long-

acuminate, above coarsely and irregularly dentate, costa divided or obsolete: capsule sub-erect, oblong, sub-symmetric; lid not known; teeth long subulate, densely articulate; cilia more or less elongated, nodulose. Bot. Centrabl. **44**: 423. 1890. On trees: Washington.

509. Thamnium alopecurum Sch.—Plants robust: primary stems stoloniform, radicant, stout, with erect or inclined stems 8–12 cm. long; stems simple up to a certain height and distantly foliate, then branching; branches close, sub-distichous, having a dendroid aspect: tufts large and lax, dark green: branch leaves erect spreading, loosely imbricate, oval oblong, acute, coarsely dentate above; costa strong, ridged dorsally, vanishing near apex; cells rounded, oval or oblong, a little longer at base: diocious: pedicel smooth, arcuate at summit: capsule oblique or sub-horizontal, oval or oblong, contracted below orifice; lid conic, long rostrate. Husnot, Musc. Gall. 347.—In damp places along rocky cliffs: British Columbia.

510. Thamnium Leibergii Britton.—Dioicous: perichætial leaves, ecostate, with recurved apices, entire or slightly serrulate; leaves costate to just below apex, entire or slighty serrulate below, coarsely serrate above: pedicel 1 cm. long, falling off with capsules when old; inner peristome, with three appendiculate regular cilia as long as the teeth or occasionally irregularly united into one or two and scarcely appendiculate. Bull. Torr. Bot. Club **16**: 211. 1889.—On quartzite ledges, Idaho.

511. Thamnium Holzingeri Ren. & Card.—Green, slender, rather resembling in habit small forms of *Isothecium myosuroides:* primary stems creeping, stoloniform, secondary ascending or decumbent, more or less shrub-like, pinnate; branches complanate, generally attenuate: lower stem leaves small, erect spreading from a broadly deltoid base, ligulate-obtuse; costa vanishing about base of acumen; upper leaves larger, distichous, complanate, slightly asymmetric at base, oblong ligulate, obtuse or sub-obtuse; costa vanishing far from apex, sometimes forking above; branch leaves smaller, with the costa shorter and the lower margin inflexed: upper leaves acute; all the leaves plane and crenulate-serrulate on the margins, coarsely and irregularly dentate at the apex; cells parenchymatous, incrassate, short, chlorophyllose, roundish or sub-hexagonal above, ovate or oblong in the middle, sub-linear below, alar small rather obscure sub-quadrate or roundish; inner perichætial leaves sub-vaginant, oblong lanceolate, long loriform-acuminate, serrulate; costa thin; cells narrower: pedicel smooth; capsule erect, oblong, sub symmetric, constricted under orifice when dry; lid conic, obliquelybeaked; teeth yellowish, lanceolate-acuminate, subulate; segments narrowly split along divisural line, cilia 2 long nodose Bot. Gaz. **19**: 239. 1894.—Oregon.

512. Plagiothecium denticulatum microcarpum Ren. & Card.—Capsule very short and turgid, scarcely 1.5 mm. long; pedicel thick, flexuous, often geniculate at base. Bot. Gaz. **14**: 98. 1889.—Idaho; Washington.

513. Plagiothecium denticulatum squarrosum Kindb.—Distinctly squarrose when dry. Bull. Torr. Bot. Club 17: 279.—British Columbia; Behring Sea.

514. Plagiothecium membranosum Kindb.—Tufts dense, green, glossy: leaves distichous, crowded, patent, flat, ovate-oblong, acute or short acuminate, estriate, entire, or denticulate above middle, decurrent; cells very long and narrow, alar large, hyaline and sub-quadrate; costa none or obsolete: capsule cylindrical-obovate, horizontally curved; teeth yellow; pedicel smooth; lid unknown: probably dioicous. Mac. Cat. 215.—On dead wood: Ottawa and Belleville, Ont.

515. Plagiothecium brevipungens Kindb.—Tufts dense, dark green: stems prostrate, irregularly pinnate; branches attenuate: leaves crowded, scarcely decurrent; ovate-oblong, acute or short pointed, auricled, not plicate or reflexed on borders, entire or slightly denticulate at apex; upper cells long and narrow, alar very distinct quadrate inflated and hyaline; costa very short, thick and simple, or none: capsule curved, lid short, conical; pedicel smooth: monoicous. Mac. Cat. 215—On stones: Ottawa, Ont.

516. Plagiothecium aciculari-pungens C. M. & Kindb.—Dioicous: tufts dense, radiculose, depressed, glossy green: stem irregularly divided; branches few and short, not attenuate: leaves concave, open erect or patent, decurrent, entire, ovate-oblong with a short needle-shaped recurved or patent point; margins narrowly recurved below middle at one side; areolation uniform and dilated; angular cells large and not numerous, sub-rectangular; costa none or indistinct: capsules not found. Mac. Cat. 216.—On earth: New Brunswick.

517. Plagiothecium decursivifolium Kindb.—Intermediate between *P. latebricola* and *P. pseudo-latebricola:* agrees with the last in branches complanate, leaves distichous, capsule oblique: differs in leaves broader, short-pointed, decurrent, alar cells not distinct but decurrent ones rectangular. Capsule arcuate when dry, and finally furrowed; lid longer, often curved. Mac. Cat. 277.—On cedar stumps in a swamp: Belleville, Ont.

518. Plagiothecium Silesiacum Sch.—Plants more robust than *P. striatellum:* stems inclined, radicant, often fasiculately branched; branches arcuate, procumbent: tufts lax, drepressed, pale or yellowish green, shining: branch leaves erect-spreading, more or less secund, oval-lanceolate or lanceolate, gradually long acuminate, not decurrent, dentate in upper half; costa double, short, very faint; cells of the basal angles rectangular or oblong, middle linear; inner perichætial leaves sheathing, terminated by a long, dentate, recurved acumen: monoicous: capsule oblique or horizontal, cylindric, smooth, collum distinct, slightly contracted below mouth: lid conic; annulus simple; teeth pale, inner membrane half height of teeth. Husnot, Musc. Gall. 354.—Newfoundland; New Brunswick.

519. **Plagiothecium pseudo-latebricola** Kindb.—Tufts dense, radiculose, glossy green: stem irregularly branching; branches often curved, perfectly complanate, branchlets longer with smaller and narrower leaves: stem leaves small, distichous, not decurrent, shortly ovate lanceolate, suddenly tapering to a somewhat long filiform and straight point, entire; cells narrow, alar small few and sub-quadrate often wanting; costa obsolete; perichætial leaves sinuolate above: capsule obovate-oblong, oblique and faintly curved, often pendent; teeth pale; inner membrane clavate, cilia long, sub-appendiculate; lid conical: dioicous. Mac. Cat. 211.—On rotten wood: Columbia River, B. C.

520. **Plagiothecium bifariellum** Kindb.—Plants small, sparingly radiculose, loosely cespitose, dark or blackish green, not glossy: stems rigid, pinnate: leaves loose, small, spreading, smooth and not striate; stem leaves at base broadly ovate-cordate, decurrent, serrulate all around, abruptly attenuate to filiform hooked-deflexed and sub-entire acumen; cells narrow, linear, basal oblong; costa obsolete or reaching to middle: dioicous. Bull. Torr. Bot. Club 17: 279.—Wet places in woods: Vancouver Island.

521. **Plagiothecium attenuatirameum** Kindb.—Tufts green, faintly shining, loose, with few rhizoids: primary stem very short: branches elongate, long attenuate, finally flagelliform: leaves sub-distichous, lower broadly ovate, obtuse or obtusate, entire, long decurrent, concave, recurved at borders from base to above middle at least at one side; cells chlorophyllose, somewhat dilated, lowest very much wider and shorter and nearly uniform; costa generally short and double, rarely simple and reaching to middle; other leaves gradually smaller, narrower and more acute or acuminate: barren. Mac. Cat. 277.—On rocks: Quebec.

522. **Amblystegium fenestratum** Kindb.— Plants loosely coherent, green: stems capillary, irregularly ramulose: leaves small, spreading, very narrow, ovate lanceolate, acute, denticulate; cells dilated but elongate; costa more or less distinct: barren. Habit of *A. Sprucei*. Mac. Cat. 217.—On borders of a pond near London, Ont.

523. **Amblystegium speirophyllum** Kindb.—Plants loosely cespitose, dark green: stem capillary, irregularly ramulose, not or sparingly radiculose: leaves small, long-distant, spreading, sub-cordate or oval oblong, blunt or sub-acute, entire or denticulate; cells short; costa sub-percurrent, broad, sometimes very distinct: barren: probably dioicous. Mac. Cat. 217.—On rocks: Canaan's Fork, N. B.

524. **Amblystegium serpens xanthodictyon** Kindb.—Tufts loose, yellow-brown: stem pinnate: leaves from an ovate-oblong base acuminate, denticulate or entire; alar and often also lower basal cells quadrate, yellowish, others oblong except inner, sublinear near costa and in acumen; perichætial leaves very small, nerveless. Mac. Cat. 218.—On stones: St. Mary's river, Canada.

525. **Amblystegium Juratzkanum** Sch.—Closely related to *A. serpens*, but generally more robust: tufts dark olive green: leaves spreading; stem leaves distant, cordate-oval, short acuminate; branch leaves oval-lanceolate, longer acuminate, entire or denticulate; costa longer, reaching ¾ length of leaf, cells larger, sometimes smaller, very chlorophyllose, basal rectangular, middle sub-rhomboidal; perichætial leaves less abruptly acuminate, costate and plicate: monoicous. Husnot, Musc. Gall. 358. According to Husnot this species differs from *A. hygrophilum* in dark green color, leaves longer acuminate, longer costate and cells larger.—On dead wood, stones, and bases of trees in damp woods: Ottawa and Owen Sound, Ont.; Revelstoke, B. C.

526. **Amblystegium hygrophilum** Sch.—Monoicous: stems 3–5 cm., depressed, delicate; branches erect or ascending: tufts pale or yellowish green: leaves spreading in all directions, or squarrose, small stem leaves cordate-oval, branch leaves oval, long acuminate, entire: costa weak, vanishing near middle: cells of basal angles rectangular, forming small auricles, middle cells linear-rhomboidal; internal perichætial leaves oblong-lanceolate, long and finely acuminate, costate, entire: capsule sub-horizontal, oblong-cylindric, strongly arcuate when empty, contracted below mouth; lid conic; annulus very large. Husnot, Musc. Gall. 358.—Indiana; Illinois; Wisconsin.

527. **Amblystegium porphyrrhizon** Lindb.—Monoicous: slender, in habit between small forms of *A. riparium* and *A. serpens;* stem leaves rather remote, sub-squarrose-spreading, from deltoid-ovate to lanceolate ovate, slender, pale, excavate at the slightly decurrent angles; costa slender, yellowish, vanishing beyond middle; margin below obsoletely serrulate; cells narrowly oval-hexagonal, hyaline, quadrate loose and yellowish at angles: male fls. numerous, small, polyphyllous; leaves imbricate, short lanceolate, erect, from an ovate concave base; antheridia few; female fls. slender, sub-incurved: perichætial branch strongly radicant; inner leaves erect, imbricate, long lanceolate, subulate-acuminate; costa slender, yellowish, vanishing toward base and apex; margin faintly serrulate; cells very narrow, vermicular: capsule oblique, oblong-cylindric, cylindric when dry and deoperculate, sub-arcuate, constricted below mouth, yellow-fuscescent, thin walled, loosely and irregularly areolate: annulus? Schimp. Syn. 715. 1876.—Kansas; Canada: N. W. Terr.; Rocky Mts.; British Columbia, Miquelon Is.

528. **Amblystegium Schlotthaueri** Ren. & Card.—Sub-species of *A. serpens:* similar in habit to compact form of *A. serpens* but differs in pedicel thicker, strongly twisted to right; capsule erect, slightly curved, ovoid, mouth dilated, collum elongate, plicate: cilia of endostome shorter, solitary. Bot. Centralbl. **44**: 423. 1890.—Yellowstone Park, Wyoming.

529. **Amblystegium distantifolium** Kindb.—Stems irregularly branching, creeping: leaves green, distant, spreading when dry, patent when moist, long oval lanceolate, long cuspidate, not or indistinctly decurrent, sharply serrulate all around, chlorophyllose; cells wide, sub-oblong; costa thick, percurrent or nearly excurrent: barren. Mac. Cat. 222.—On rocks, Newfoundland.

530. **Amblystegium dissitifolium** Kindb.—Tufts compact, sparingly radicant, green, not glossy: leaves very loosely disposed, long decurrent, ovate oblong, short-acuminate, denticulate all around; areolation loose, upper cells narrower, alar larger quadrate and well distinct, as chlorophyllose as the other cells; costa percurrent: probably dioicus; only male flowers found. Mac. Cat. 220.—On flat limestone rocks which receive dripping water: Canada.

531. **Amblystegium sub-compactum** C. M. &. Kindb.—Differs from A. *compactum* in stems thicker, leaves larger and longer; capsule asymmetric, curved in young state, at least doubly greater. The British Columbia specimens have a peculiar habit; tufts are decolorate below, bright green above, and stems erect. Mac. Cat. 221.—Growing in thick tufts at the bases of trees around springs and margins of bogs, also on wet rocks: British Columbia and Canada.

532. **Amblystegium riparium longifolium** Sch.—Leaves narrow, lanceolate, long and finely acuminate. Husnot, Musc. Gall. 363.—Vancouver Island and Washington.

533. **Amblystegium riparium serratum** Ren. & Card.—Plants slender, creeping: leaves narrow, serrulate at apex. Bot. Gaz **14**: 98. 1889.—Roots of trees: Kansas.

534. **Amblystegium Floridanum** Ren. & Card.—Very small, appressed: leaves small, narrowly lanceolate, long acuminate, entire: capsules short, arcuate. Bot. Gaz. **14**: 98. 1889, as *A. riparium*, var.—Florida; Louisiana.

535. **Amblystegium Kochii** Sch.—Closely related to *A. riparium:* stems depressed, with ascending or erect branches: leaves spreading in all directions; those of large branches cordate-oval or broad oval; those of small branches long acuminate, denticulate, costate for ¾ length, basal cells rectangular; middle sub-hexagonal, much larger than in *A. riparium;* pedicel long; capsule oval or oblong; annulus simple. Husnot, Musc. Gall. 362.—Kansas.

536. **Amblystegium homalostegium** Jgr. & Sauerb.— Monoicous: tufts low, broad, dirty green, rather dense and rigid: stem creeping, pseudo-pinnate, with many short erect or curved densely aggregate slender simple branches: stem leaves densely imbricate, indistinctly secund, when wet making the stems appear julaceous and turgescent, broadly ovate from a cordate base, short acuminate, concave; margin plane, obsoletely denticu-

late; costa double, short; cells minute, indistinct, narrowly elliptic, pale, slightly papillose, alar quadrate; perichaetial leaves lanceolate-acuminate, longer, secund, concave, longitudinally plicate, ecostate; yellowish: seta yellowish-red, ascending; capsule horizontal, minute, asymmetric-cylindric, strongly constricted in middle, gibbous or strumose at base, wide-mouthed, brown; lid minute, short apiculate; peristome teeth very prominent, connivent when wet, red, strongly cristate, segments yellow, smooth, broad, carinate, imperforate, cilia solitary, broad, shorter and paler. *Hypnum homalostegium* Müller, Flora **56**: 484. 1873.—Trunks of trees, West Fowl River, Alabama.

537. **Hypnum Sommerfeltii** Myr.—Stems 15–30 mm. long, delicate, depressed, irregularly divided or sub-pinnate, branches ascending; tufts green or yellowish: leaves crowded, very spreading, sometimes sub-secund at extremity of branches; stem leaves broadly oval-lanceolate, long acuminate, denticulate below, ecostate or faintly bicostate; branch leaves oval lanceolate; basal cells quadrate or rectangular, forming yellowish auricles, others linear, broader than in *H. Halleri;* inner perichaetial leaves oblong, plicate: capsule sub-horizontal, oblong sub-cylindric, arcuate, contracted below mouth; lid convex conic; annulus large: monoicous. Husnot, Musc. Gall. 364.—On old logs, bases of trees, damp rocks and earth: Canada; British Columbia.

538. **Hypnum byssirameum** C. M. & Kindb.—Resembling a small form of *H. Sommerfeltii*, but leaves denticulate all around: barren. Mac. Cat. 323.—On the base of a dead tree, Ontario.

539. **Hypnum Macounii** Kindb.—Allied to *H. hispidulum:* habit of the European *H. Halleri:* monoicous: plants small, interlaced in dense brownish green tufts: stems pinnate, prostrate, sparingly radiculose: leaves densely crowded, squarrose-recurved, round deltoid, short acuminate, reflexed on borders of entire base to denticulate acumen: alar cells quadrate, pellucid, not numerous, others short oblong or short lanceolate; costa obsolete or none: capsule small, narrow cylindric, slightly curved; annulus simple; basilar membrane low; lid convex, obtuse, not apiculate; pedicel reddish brown, smooth. Mac. Cat. 224.—On earth and rocks: British Columbia; Rocky Mountains.

540. **Hypnum unicostatum** C. M. & Kindb.—Differs from *H. chrysophyllum* in dense tufts: stems more irregularly branching, creeping: leaves shorter-acuminate; alar cells smaller, not yellow: costa more distinct; perichaetial leaves gradually acuminate-subulate or filiform pointed with acumen arcuate: capsule smaller. Mac. Cat. 224.—Canada.

541. **Hypnum decursivulum** C. M. & Kindb.—Differs from *H. chrysophyllum* in leaves decurrent with broader base, borders recurved at angles; alar cells numerous, hyaline: barren. Mac. Cat. 224.—On old logs: British Columbia: Newfoundland.

542. **Hypnum Columbiae** Kindb.—Tufts dense: stems short, very tomentose, irregularly branching; branches short: leaves narrower than in *H. chrysophyllum*, from narrow ovate base gradually tapering into acumen; borders denticulate all around, recurved at angles; areolation often wide as in *Amblystegium;* costa reaching to acumen or sometimes longer; perichaetial leaves short-acuminate: capsule generally smaller and shorter than in *H. chrysophyllum*, curved; lid short-apiculate; peristome dark-yellow, not pale. Mac. Cat. 224.—On wet logs: British Columbia.

543. **Hypnum stellatum sub-decursivulum** Kindb.—Leaves smaller, decurrent, abruptly acuminate from a short ovate base; alar cells more numerous: not found fruiting. Mac. Cat. 225.—Growing with *Dicranum scoparium* on earth in a swamp, Ontario.

544 **Hypnum polygamum longinerve** R. & C.—Leaves narrower, long acuminate; costa stronger, extending into acumen: capsule paler, narrower. Bot. Centralbl. 44: 423. 1890.—Victoria; Vancouver Island.

545. **Hypnum polygamum fallaciosum** Lindb.—Larger, often strikingly like *H. aduncum Kneiffii* in habit: costa very variable, forked, longer or shorter, or wanting. Milde, Bryol. Siles. 346. 1869.

546. **Hypnum aduncum pungens** H. Müll.—Leaves erect, sub-imbricate, apical ones inrolled at the point, short acuminate or subapiculate, straight or a little curved. Renauld in Husn. Muscol. Gall. 387. 1894. Yellowstone Park.

547. **Hypnum aduncum attenuatum** Boul.—Slender, sometimes elongated: stem leaves short, deltoid, curved at point; costa with tendency to bifurcate: branch leaves small, without auricles. Ren. *l. c.*—Deer Lodge, Mont.

548. **Hypnum aduncum platyphyllum** Kindb.—Leaves very broad and short acuminate. Mac. Cat. 226.—On rocks in woods: Rockcliff, near Ottawa, Can.

549. **Hypnum aduncum Roellii** Ren.—Leaves distant, spreading, flexuous, apical oblong, then gradually long subulate acuminate, acumen flexuous and twisted. Ren. *ibid.* 372.—Yellowstone Park.

550. **Hypnum aduncum flexile** Ren.—Emergent, more slender: stems flexuous: leaves usually narrower, flexuous or slightly homotropous prolonged into a twisted subula. Ren. *ibid.* 373.—Vancouver; Hobart, Ind.

551. **Hypnum capillifolium** Warnst.—Dioicous: stem erect (5–15 cm.), pinnate: leaves secund or falciform, oblong lanceolate, gradually narrowed from the base, long subulate by the excurrent costa which is strong, 90–140μ wide at base, much thicker than the lamina; tissue delicate, basal cells distinctly and long excurrent, alar dilated, forming large convex auricles reaching almost to the costa. Ren. *ibid.* 379.—Idaho; Washington; Vancouver Is.; British Columbia.

552. **Hypnum symmetricum** R. & C.—Sub-species of *H. uncinatum:* leaves moderately striate, capsule narrow, cylindric, always exactly erect, symmetric; seta sometimes in pairs. Ren. *ibid.* 379.—Rocky Mountain and Pacific Coast region.

553. **Hypnum fluitans Jeanbernati** Ren.—Monoicous: tufts pale green, sometimes rather dense, 6–10 cm. high: leaves feebly homotropous except at summit, oblong or oblong-lanceolate, narrowed into an often short and rather broad acumen, truncate at base, sinuolate or slightly denticulate, sometimes dentate; costa slender (47μ), little surpassing the middle; median cells very long, alar little dilated, not vesicular, poorly delimited: seta 4–6 cm.—Ren. *ibid.* 381.

554. **Hypnum fluitans Delamarei** R. & C.—Monoicous: plants tall, slender (25 cm.): tufts floating, pale green at surface, dark brown within; some stems regularly pinnate: stem leaves falciform, strikingly recurved on some branches, on others simply secund, narrowly lanceolate, slenderly acuminate or short subulate, plainly dentate at summit; branch leaves linear, spreading, flexuous; costa colored, narrow (40–60μ), little surpassing the middle: median cells very long and narrow, remainder elongated and compact to the base, basal with walls a little thickened, alar small, occupying almost all the base, not forming distinct auricles: capsule short, erect, blackish; seta 4–5 cm., surpassing the stem. Ren. *ibid.* 384. Miquelon Is.

555. **Hypnum fluitans pinnatum** Boul.—Tufts yellowish green: stem rather short (8–10 cm.), erect, stout, usually pinnate: leaves falciform, oval or oval-oblong or narrower at base, slenderly acuminate or short subulate, usually denticulate at base and apex; costa reaching middle of point; auricles large, swollen, rounded composed of rather numerous cells with generally unthickened walls. Ren. *l c.*—Miquelon Is.

556. **Hypnum fluitans falcifolium** Ren.—Usually purplish or mixed with green or brown: stem 5–10 cm or longer, pinnate: leaves falciform, rather distant, lanceolate narrowed into a long subula often spirally twisted and sparingly toothed costa broad (80–90μ) at base, ending in the subula or reaching the point but not distinctly excurrent; median cells long and narrow; auricles composed of cells usually thickened and colored. Renauld, *ibid.* 387.—Yellowstone Park.

557. **Hypnum fluitans heminenron** R. & C.—Tufts pale green, depessed, intricate, small: stem prostrate, ascending at tip, slender, very short (1–3 cm.), vaguely branched, radicles distinct: leaves slightly homotropous, oblong-lanceolate, short decurrent, acumen moderate, with some teeth or sub-entire; costa very slender (33–48 μ), sometimes simple to beyond the middle, more often bifurcate in stem leaves, more feeble and shorter and sometimes almost wanting in branch leaves; median cells loose, unequal as to length and breadth, basal almost equal, also a little broader,

not forming distinctly delimited auricles. Ren. *ibid.* 388.—Packs Harbor, Labrador.

558. **Hypnum fluitans conflatum** C. M. & Kindb.—Stem slender, subfiliform, distinctly pinnate, not radiculose: leaves small, concave, distant, denticulate all around; stem leaves decurrent, from a broad ovate base suddenly narrowed into a very short, subulate-filiform straight point; alar cells very large, hyaline or faintly yellowish, others nearly uniform, oblong-lanceolate, conflate; costa pale yellow, vanishing in the acumen; branch leaves narrower, oblong-lanceolate, more or less short acuminate, curved or straight: capsule very small, arcuate, contracted below mouth: dioicous. Mac. Cat. 230.—In pools and bogs: British Columbia; Ottawa, Ont.; Labrador.

559. **Hypnum Moseri** Kindb.—Differs from *H. uncinatum* in leaves not striate, but sometimes recurved at base; costa faint, often failing: differs from all other *Harpidia* in stem densely radiculose. Mac. Cat. 229.—On bases and trunks of poplar trees: New Brunswick; Newfoundland.

560. **Hypnum filicinum aciculinum** C. M. & Kindb.—Costa excurrent to a rigid point. Mac. Cat. 231.—On wet rocks: British Columbia.

561. **Hypnum decipiens** (DeNot.) Kindb.—Monoicous: habit of *Hypnum commutatum* or *filicinum;* loosely interwoven, with green innovations, scarcely shining: stems 4 cm., paraphyllia present, pinnate; branches simple, slender, spreading; stem leaves sub-squarrose, broadly cordate-deltoid, short cuspidate, decurrent, plicatulate; margin reflexed below, denticulate all around especially at apex; costa strong, vanishing below apex; branch leaves small, ovate-acuminate, secund falcate; costa reaching beyond middle; cells short, sub-rhombic to oblong, strikingly papillose especially on lower face, basal on desecurrent, elongate, hyaline: perichaetial leaves membranaceous, pallescent, appressed, inner slenderly subulate, fimbriate: capsule on a long seta, thick-clavate from an erect base, cernuous, brown. *Thuidium decipiens* DeNot. Epil. 233. 1869.—On rocks: Rocky Mts.; Br. Columbia; Vancouver Is.

562. **Hypnum chloropterum** C. M. & Kindb.—Tufts laxly cohering, with few rhizoids, whitish or bright green, not shining: stem more or less densely pinnate, rigid: stem leaves small, patent also in dry state, loosely and long-decurrent, auricled, papillose at back, distinctly but faintly plicate, concave, broad-ovate, suddenly narrowed to a short (in the dry state twisted) acumen; borders broadly recurved below, sometimes to middle, denticulate all around from apex to auricles; areolation lax, more or less chlorophyllose, alar cells larger, sub-quadrate, numerous, others oval oblong, only the uppermost narrow; costa distinct, reaching above middle;

branch leaves more loosely disposed, sometimes ovate-oblong and narrow areolate; inner perichaetial leaves narrower, longer filiform pointed, nerveless: capsule small, sub-oblong, straight or curved; lid elongate-conic, oblique-apiculate, or rostellate; pedicel very rough, purple: monoicous. Mac. Cat. 231.—On rocks and on ground: Newfoundland; New Brunswick.

563. Hypnum pseudo-fastigiatum C. M. & Kindb.—Allied to *H. reptile*, but alar leaf cells more numerous, chlorophyllose and dusky, not decolorate; perichætial leaves nerveless: capsule scarcely constricted below mouth. Mac. Cat. 235.—On bases of vines in woods, British Columbia. On rocks, Ontario.

564. Hypnum fastigiatum Brid.—Stems delicate, creeping, radiculose, much divided, erect in middle of tufts, spreading around outside, short arcuate at summit; paraphyllia quite numerous, lanceolate or digitate: tufts very large, depressed, yellowish green near surface, brownish within: leaves falciform-secund, stem leaves oval-lanceolate, branch leaves a little narrower, gradually narrowed into a long, sharp point, entire or superficially denticulate, plain on borders or slightly revolute, hyaline at base; costa bifurcate, narrow and very short; quadrate cells of basal angles quite numerous, middle ones linear, attenuate: inner perichætial leaves half sheathing, acuminate, plicate, faintly bicostate: monoicous or dioicous: capsule erect or oblique, oblong-cylindric, arcuate, contracted below mouth; lid convex, apiculate, sometimes short rostrate; annulus narrow. Husnot, Musc. Gall. 400.—On dry rocks: Rocky Mountains; Greenland.

565. Hypnum Waghornei Kindb.—Differs from *H. fertile* in large and hyaline alar leaf cells, other basal ones not yellow: capsule tumid at base, slightly curved: paraphyllia very broad. Mac. Cat. 234.—Newfoundland.

566. Hypnum revolutum Mitt.—Stems 2–8 cm., ascending-erect, irregularly branched when tufts are compact, depressed and pinnate when loose; yellowish green, ferruginous within: leaves falciform-secund, oval or oblong-lanceolate, long acuminate, denticulate at summit, plicate when dry, strongly revolute from base to apex; costa none or double and short; cells of basal angles roundish quadrate or rectangular, rather numerous, forming small auricles, median cells linear, relatively short (1:6–8); perichætial leaves strongly plicate: capsule sub-horizontal, rather large, oblong, arcuate, strongly contracted below mouth. Husnot, Muscol. Gall. 402. 1894.—Morley and Hector, Rocky Mts.; Greenland.

567. Hypnum revolutum Villardi Ren. & Card.—Leaves short acuminate, not or scarcely plicate, alar cells numerous, large. *H. Heufleri Villardi* R. & C., Bot. Centralbl. **44**: 423. 1890.—Montana.

568. Hypnum Canadense Kindb.—Intermediate between *H. imponens* and *H. sub-imponens:* dioicous: densely cespitose, yellow or pale green:

stems creeping, densely pinnate ramulose; branches robust, thick and tumid: leaves close, falcate, with elongate-ovate or oblong base and short acumen, faintly or not striate, more or less denticulate all around, not reflexed on borders, larger than in *H. imponens;* cells very narrow, alar larger and pellucid, other basal cells yellow; paraphyllia few, subulate; perigonial leaves very broad-ovate, abruptly narrowed to a straight subulate point: capsule obovate, asymmetric or sub-cylindric and arcuate, thick and not striate; teeth yellow; segments orange, cilia short and not appendiculate. Mac. Cat. 236.—Newfoundland; Alaska; on stones: Nova Scotia and Quebec; on rotten logs: Rocky Mountains and Ontario.

569. Hypnum cupressiforme Pyrenaicum Ren.—Closely related to the variety *filiforme*, from which it is distinguished by the short acuminate leaves, quite strongly dentate. Fl. Miq. 55.—Miquelon Island.

570. Hypnum Vaucheri Lesq.—Plants resembling certain forms of *H. cupressiforme:* stems erect-fastigiate: tufts compact, dark green or yellowish: leaves crowded and imbricate, more or less falciform-secund, sometimes erect so as to give branches a sub-julaceous appearance, oval or oval-lanceolate, entire or sinuolate, plane on borders; costa very short, simple or bifurcated, one branch longer than the other; cells of basal angles more numerous and smaller than in *H. cupressiforme*, walls thickened, middle cells broader and shorter, 6–8 times as long as broad: fruit unknown. Husnot, Musc. Gall. 406.—Montana.

571. Hypnum Renauldii Kindb.—Agrees with *H. curvifolium* in stem more or less pinnate, inner basal leaf cells finally yellow: with *H. Lindbergii* in leaves decurrent, alar cells very much dilated, capsule not plicate when dry: differs from both in entire leaves. *H. pratense* differs in leaves not striate nor decurrent, and alar cells not evolute. Mac. Cat. 238.—On earth and old logs and sometimes on rocks: British Columbia; Canada; Newfoundland.

572. Hypnum Patientiae Lindb.—Closely related to *H. pratense:* differs from it by stems and branches not complanate, curved at summit: all leaves falciform-secund, broad oval-lanceolate, with a larger, entire acumen; costa none or double and very short; cells of basal angles large, forming hyaline auricles; middle ones linear, attenuate: c ap su
dric, arcuate, rarely fruiting. Husnot, Musc. Gall. 406.—On rocks: New Brunswick; Greenland; Miquelon Island; Newfoundland; Pennsylvania; Indiana; Wisconsin; Montana.

573. Hypnum Patientiæ elatum Sch.—Extensively cespitose, tufts yellowish or faintly rufescent: stems 2–3 inches long, erect, sub-fastigiately branched: leaves falcate and sub-hamate, narrower, long acuminate. Sch. Syn. 758. 1876.—Miquelon Island.

574. Hypnum Patientiæ demissum Sch.—Tufts deplanate, pale or

bright green, dark variegated: stems long, creeping, more or less regularly pinnate. l. c.—Miquelon Island.

575. **Hypnum Patientiæ Americanum** Ren. & Card.—Stems slender, prostrate, more or less distinctly pinnate: leaves smaller, with acumen shorter and broader. Bot. Gaz. **14**: 99. 1889.—On decayed wood and sandy ground: Louisiana.

576. **Hypnum arcuatiforme** Kindb.—Tufts dense, green, not glossy: stem creeping, sub-pinnate: leaves arcuate, ovate lanceolate, generally short-acuminate or sub-obtuse, entire, decurrent, not striate; alar cells large, well defined, orange, others pale and narrow; costa none or short and double: capsule sub-cylindrical, curved, not striate nor furrowed, constricted below the wide mouth, teeth when dry incurved, pale yellow, hyaline margined; cilia long, appendiculate: probably dioicous. Mac. Cat. 238.—On earth near Ottawa, Ont.

577. **Hypnum Dieckii** Ren. & Card.—Tufts yellowish or rufescent: stem depressed, pinnate; branches ascending: leaves falcate-secund, strongly circinate, from broadly ovate base suddenly acuminate, acute or subulate; margin plane, entire, rarely obsoletely denticulate above; costa double, short, sometimes very faint or prolonged to middle; cells linear, very narrow, obtuse, alar large, strongly inflated, hyaline or flavescent; perichætial leaves oblong-lanceolate, long acuminate, sub-entire, ecostate: dioicous: capsule horizontal or sub-pendulous, large, arcuate; lid unknown; teeth yellowish, strongly trabeculate, segments narrow, scarcely perforated along middle; cilia 2, nodulose. Bot. Centralbl. **44**: 423. 1890. Oregon.

578. **Hypnum pseudo-pratense** Kind.—Nearly allied to *H. pratense:* tufts more compact: branches radiculose below: leaves more crowded, not decurrent, more distinctly denticulate near apex: inflorescence monoicous: capsules not found. Mac. Cat. 239.—On old logs in woods: Ontario.

579. **Hypnum Haldanianum Roellii** Ren. & Card.—Branches short, interwoven, leaves short and broad acuminate, areolation dense. Bot. Centralbl. **44**: 424. 1890.—Tree trunks: Indiana.

580. **Hypnum flaccum** C. M. & Kindb.—Tufts large and loose, brown below, pale green above: stems pinnate, sparingly radiculose, red-brown; branches elongate, attenuate, distant and flaccid; paraphyllia few, multiform: leaves oblong-lanceolate, shortly subulate-acuminate, not curved, concave-involute, patent, with excavate dark orange auricles at base; stem leaves decurrent, slightly recurved at basal angles; branch leaves loose, sub-distichous, not decurrent nor recurved; cells narrow, long linear, not chlorophyllose, alar large, sub-quadrate, inner basal narrow, pale orange; costa short, double and indistinct or none: barren. Mac. Cat. 240.—On old logs or rocks: New Brunswick; Ontario.

581. **Hypnum subflaccum** C. M. & Kindb.— Tufts loose, glossy green: stem green, irregularly branching, not radiculose; branches few and long, flaccid, sub-compressed when dry; paraphyllia none: leaves striate, oblong-lanceolate, denticulate above to ¼, not curved, loosely appressed or sub-patent; basal angles hyaline, not excavate; stem leaves short-decurrent, acute or short-acuminate; branch leaves not decurrent, longer acuminate; cells narrow, long-linear, chlorophyllose, basal dilated, hyaline and irregular, sub-rectangular, inner rarely pale yellowish; costa none: dioicous: female plants not found. Mac. Cat. 240.— On earth: Ontario.

582. **Hypnum pseudo-drepanium** C. M. & Kindb.— Tufts loose, green, faintly glossy: secondary stems very long, flaccid, sub-pinnate, sparingly radiculose, faintly compressed; paraphyllia none; branchlets few and very short, curved at apex: leaves plicate, entire, from a short broad ovate base narrowed into a short incurved acute acumen, crowded, loosely appressed when dry, not decurrent, not distinctly chlorophyllose; basal cells hyaline, dilated, thick-walled, alar large, sub-rectangular, well-defined, others longer and narrower; auricles excavate; costa indistinct or short and double: dioicous; female plants not found. Mac. Cat. 240.— On old logs in woods: Ottawa, Ontario.

583. **Hypnum circulifolium** C. M. & Kindb.—Nearly allied to *H. dilatatum* Wils.: stem loosely foliate, denudate at the base; leaves patent when dry, sub-circular, faintly crenulate nearly all around, slightly decurrent, at the cordate base distinctly auriculate, in the middle carinate, narrowed above to an indistinct obtuse tip; alar cells large, inflated, sub-oval, apical also short, others narrow and flexuous; costa none or indistinct: barren. Mac. Cat. 242.— On rocks: New Brunswick.

584. **Hypnum pseudo-arcticum** Kindb.— Differs from *H. arcticum* in leaves crenulate, at least above middle; costa short and double, not reaching to middle; perichætial leaves short acuminate, serrulate: peristomial segments rimose in middle: stem sparingly radiculose. Mac. Cat. 242.— On stones in brooks: British Columbia.

585. **Hypnum Goulardi** Sch.—Tufts thick, very soft, variegated with red and green: branches flexuous-erect from a prostrate filiform eradiculose and partly denudate stem, very slender, soft, not radicant, sub-simple or oft divided, 2–4 cm. long; leaves small, rather distant, equally spreading when moist, coherent when dry; lower branch leaves minute, circular, others ovate-rotund, apex rounded or slightly obtuse pointed, strongly concave and sub-cochleariform, margin rather broadly recurved, quite entire, narrowly decurrent at angles, not excavate; costa bifurcate, long or almost obsolete; cells at apex rhombic, toward base flexuous fusiform, sub-vermicular or hexagonal-rhombic, at base loosely rhombic-hexagonal, at angles rectangular: flowers and fruit unknown. Synop. Musc.

Eur. 778. 1876.—On stones: Ste. Anne des Monts river, Gaspé Co., Quebec; Gunn river, Anticosti.

586. **Hypnum torrentis** C. M. & Kindb.—Differ from *H. Goulardi* in stems filiform, very rigid: leaves smaller, sub-circular, crenulate all around, reflexed at basal margins; costa thick and nearly percurrent: differs also from *H. arcticum* in loosely disposed decurrent leaves with large, angular cells. Mac. Cac. 243.—On sloping limestone rocks: British Columbia.

587. **Hypnum Norvegicum** Sch.—Appearance of *H. arcticum* but much smaller and more delicate: stems depressed, branches erect or ascending: leaves erect-spreading or sub-secund, small, oval or oval sub-orbicular, sinuolate, obtuse; costa very short, bifurcate; cells of basal angles quadrate or rectangular, not forming distinct auricles; middle quite short, linear-sub-hexagonal: capsule oblique, oval or oblong; lid convex, very shortly apiculate; annulus large. Husnot, Musc. Gall. 413.—Greenland.

588. **Hypnum Columbico-palustre** C. M. & Kindb.—Differs from *H. palustre* in leaves longer apiculate, faintly denticulate; margins recurved below at one side; alar cells dilated, well-defined; costa stout, vanishing above middle. Mac. Cat. 241.—On rocks: British Columbia.

589. **Hypnum polare** Kindb.—Loosely cespitose, tufts pale green, soft: secondary stem erect, fastigiately branched, flaccid, eradiculose: leaves loosely disposed, erect-spreading and slightly secund, ovate-oblong, gradually short and acute acuminate, strongly concave, margin erect, thin, at basal angles very slightly decurrent, not excavate, obsoletely crenulate only at very apex; costa simple, sub-terete, vanishing below apex; cells slightly hyaline, rhomboidal, 2 to 3 times as long as broad, middle cells longer and narrower, basal cells wider, alar cells few, hexagonal-rectangular, hyaline or slightly chlorophyllose. Schimp. Syn. 780. 1876.—Greenland.

590. **Hypnum eugyrium Miquelonense** R. &. C.—Leaves smaller, acumen short, obtuse or sub-obtuse; cells of basal angles hardly distinct. Revue Bryol. **20**: 28. 1893.—Miquelon Is.

591. **Hypnum eugyrium Mackayi** Sch.—Plants more robust; leaves erect-imbricate, distinctly denticulate at summit; costa simple or double, passing middle; auricles formed of smaller cells. Husnot, Musc. Gall. 412.—Tennessee.

592. **Hypnum ochraceum flaccidum** Milde. Stems long, loosely foliate: leaves throughout spreading every way, uniform brown, broad lanceolate, long pointed; costa long, double. Bryol. Siles. 376. 1869.—Montana; Oregon; Washington.

593. **Hypnum pseudo-montanum** Kindb.—Nearly allied to *H. montanum*: differing principally in stem longer and more robust: leaves larger and thinner, more loosely disposed, longer decurrent, not distinctly dentic-

ulate; alar cells large, reaching to costa which is simple and prolonged above middle: inflorescence monoicous: capsules not found. Mac. Cat. 243. — On rocks in streams: British Columbia.

594. Hypnum purum L.—Stems 8–15 cm., depressed or ascending, simply pinnate or with pinnate branches, delicate, julaceous; tufts large, soft, often depressed, pale green: leaves imbricate, very concave, decurrent, denticulate all around, plicate; stem leaves broad ovate, strongly contracted at base, apex round with an erect or curved apiculus; branch leaves narrower, oblong; cells of basal angles quadrate or rectangular, pale green, forming small auricles; middle cells linear flexuous; inner perichætial leaves lanceolate, long acuminate, costa: dioicous: capsule horizontal, oblong or sub-cylindric; lid conic, pointed; annulus double; teeth orange, segments wide open along keel. Husnot, Musc. Gall. 419.—Miquelon Is.

595. Hypnum stramineum laxifolium C. Müll. No description of this variety is at hand.—Greenland.

596. Hypnum stramineum compactum Milde.—Tufts thick, stems stronger and shorter, below (with leaves) yellow-brown: leaves shorter and broader. Bryol. Siles. 370. 1869.—Greenland.

597. Hypnum stramineum exiguum Ren.—Stems depressed, short, very delicate, filiform: leaves distant, very small. Fl. Miq. 57.—Miquelon Island.

598. Hypnum occidentale S. & L.—Plants densely cespitose; tufts intricate, depressed, bright green, sub-sericeous: stem much divided, filiform, sub-repent; branches prostrate, strongly branched, branchlets filiform or attenuate or thickish julaceous; leaves erect spreading when moist, imbricate when dry, ovate or lingulate, rather obtuse, concave, border denticulate above; costa thick, reaching middle; cells minute, oval-rhombic, alar quadrate, smaller; perichaetial leaves erect from a sheathing base, upper broadly ovate, uppermost lanceolate, obtusely short acuminate, reflexed: dioicous: capsule oblong-ovate to oblong-cylindric, inclined, sub-cernuous, exannulate, dilated below mouth when empty; seta smooth, scarcely 1 inch long, sub-cygneous; peristome teeth broadly lamellose within, segments entire, punctulate, cilia 2, shorter; lid long conic, acute, shortly oblique rostrate. Sull. Icon. Musc. Suppl. 105. *pl. 81.* 1874.—Roots and base of trees, Oregon.

599. Hypnum scorpioides Miquelonense R. & C.—Robust, submersed; tufts black, apical leaves only golden yellow passing to red; stems 15–35 cm.: leaves of principal branches sub-imbricate, slightly secund, bluntly acuminate; leaves of secondary branches rather crowded, erect, falciform and flexuous at point, narrower, oblong, long and narrowly acuminate, needle-pointed, sometimes toothed at apex; costa sometimes short bifurcate, sometimes single, feeble, reaching or surpassing middle; median

cells usually sinuous, somewhat pitted. Ren. in Husn. Muscol. Gall. 394. 1894.—Miquelon Is.

600. Hypnum incurvatum Schrad.—Stem 2–4 cm., delicate, creeping, irregularly branching; tufts small, depressed, silky, green or slightly yellowish: leaves erect spreading, sub-secund, more or less arcuate, oblong-lanceolate, long-acuminate, entire or distantly toothed at apex; costa none or very short and faint, or bifurcate; cells of angles quadrate, middle cells short, 6–8 times as long as wide: monoicous: two inner perichætial leaves sheathing, abruptly and narrowly acuminate, superficially denticulate at summit, not plicate, faintly costate: capsule horizontal, sometimes oblique, oblong or almost cylindric, arcuate, contracted below mouth; lid conic, short rostrate; annulus large. Husnot, Musc. Gall. 399.—Newfoundland.

601. Hypnum dilatatum Wils.—Stems 2–10 cm., prostrate, ascending, long denudate at base; tufts depressed, rather rigid: leaves sub-secund or secund, concave, sub-orbicular, obtuse or shortly and obtusely apiculate, narrowed at base, slightly denticulate at apex; costa bifurcate, very short or scarcely ¼ the leaf; cells of basilar angles large, hexagonal-rectangular, usually orange, forming rather disinct auricles, the rest longer than in *H. molle:* inner perichætial leaves sheathing, plicate: monoicous: capsule oblique or horizontal, oblong; operculum convex-conic. Husn. Muscol. Gall. 413. *H. molle* Br. & Sch., not Dicks.—Greenland; Canada; Rocky Mts.; British Columbia; Idaho; Eastern States.

602. Hylocomium squarrosum calvescens (Wils.) Husnot.—Plants a little more robust, branches more numerous: stem leaves larger above, more distinctly denticulate, slightly plicate: leaf cells, pedicel and capsule similar to type. Husnot, Musc. Gall. 425. *H. calvescens* Wils.—On rocks: Nova Scotia; British Columbia.

603. Hylocomium triquetrum Californicum Ren. & Card.—Very robust: leaves strongly rugose undulate, strongly papillose above: capsule short. Bot. Gaz. **15**: 61. 1890.—California.

INDEX TO GENERA.

INDEX TO VOLUME I.

ENGINEERING SERIES, Volume 1:

No. 1. Track, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 24, April, 1894. Price 25 cents.

No. 2. Some Practical Hints in Dynamo Design, by Gilbert Wilkes, M. Am. Inst. E. E., Special University Lecturer. Pp. 16, May, 1894. Price 25 cents.

No. 3. The Steel Construction of Buildings, by C. T. Purdy, C. E., Special University Lecturer. Pp. 27, October, 1894. Price 25 cents.

No. 4. The Evolution of a Switchboard, by A. V. Abbott, C. E., Special University Lecturer. Pp. 32, pls. 4, October, 1894. Price 35 cents.

No. 5. An Experimental Study of Field Methods which will Insure to Stadia Measurements Greatly Increased Accuracy, by Leonard Sewal Smith. B. C. E., Instructor in Engineering. Pp. 45, pl. 1, May, 1895. Price 35 cents.

No. 6. Railway Signaling, by W. McC. Grafton, C. E., Special University Lecturer. Pp. 38, July, 1895. Price 35 cents.

No. 7. Emergencies in Railroad Work, by L. F. Loree, M. Am. Soc. C. E., Special University Lecturer. Pp. 42, December, 1895. Price 35 cents.

No. 8. Electrical Engineering in Modern Central Stations, by Louis A. Ferguson, S. B., Special University Lecturer. Pp. 33, April, 1896. Price 35 cents.

No. 9. The Problem of Economical Heat, Light, and Power Supply for Building Blocks, School Houses, Dwellings, Etc., by G. Adolph Gerdtzen, B. S., Alumni Fellow in Engineering. Pp. 69, May, 1896. Price 45 cents.

No. 10. Topographical Surveys, their Methods and Value, by J. L. Van Ornum, C. E., Special University Lecturer. Pp. 39, December, 1896. Price 38 cents.

ENGINEERING SERIES, Volume 2:

No. 1. A Complete Test of Modern American Transformers of Moderate Capacities, by Arthur Hillyer Ford, B. S., Fellow in Electrical Engineering, with an introduction by Professor D. C. Jackson. Pp. 88, August, 1896. Price 35 cents.

ECONOMICS, POLITICAL SCIENCE, AND HISTORY SERIES, Volume 1:

No. 1. The Geographical Distribution of the Vote of the Thirteen States on the Federal Constitution, 1787-8, by Orin Grant Libby, A. M., Fellow in History, with an introduction by Frederick J. Turner. Pp. 116, pls. 2, July, 1894. Price 75 cents.

No. 2. The Finances of the United States from 1775 to 1789, with Especial Reference to the Budget, by Charles J. Bullock, A. B., Fellow in Economics. Pp. 157, June, 1895. Price 75 cents.

No. 3. The Province of Quebec, and the Early American Revolution; A study in English-American Colonial History, by Victor Coffin, Ph. D., Assistant Professor of European History. Pp. 307, June, 1896. Price 75 cents.

SCIENCE SERIES, Volume 1:

No. 1. On the Speed of Liberation of Iodine in Solutions of Hydrochloric Acid, Potassium Chlorate, and Potassium Iodide, by Herman Schlundt, Assistant in Chemistry. Pp. 33, December, 1894. Price 35 cents.

No. 2. On the Quartz Keratophyre and Associated Rocks of the North Range of the Baraboo Bluffs, by Samuel Weidman. Pp. 21, pls. 3, January, 1895. Price 25 cents.

No. 3. Studies in Spherical and Practical Astronomy by George C. Comstock, Director of the Washburn Observatory. Pp. 50. June, 1895. Price 40 cents.

No. 4. A Contribution to the Mineralogy of Wisconsin, by William Herbert Hobbs, Assistant Professor of Mineralogy and Petrology. Pp. 48, pls. 5, June, 1895. Price, 40 cents.

No. 5. Analytic Keyes to the Genera and Species of North American Mosses, by Charles Reid Barnes and Fred DeForest Held. Pp. 211, December, 1896. Price, $1.00.

The BULLETIN OF THE UNIVERSITY OF WISCONSIN is printed by the State and is issued at irregular intervals. It contains original papers by persons connected with the university.

Copies of the BULLETIN will be forwarded post free from the office of the State Superintendent of Public Property to all colleges, high schools, normal schools, and public libraries of the state which have a collection of 300 or more volumes, on making proper application at the Superintendent's office. Persons who reside in the state of Wisconsin can receive copies of the BULLETIN free by applying to the Secretary of the Board of Regents of the University and paying the cost of transportation. The postage required for the individual numbers thus far issued, is as follows: Eng. Ser., No. 1, 2c; No. 2, 2c; No. 3, 2c; No. 4, 3c; No. 5, 4c; No. 6, 2c; No. 7, 3c. No. 8, 3c; No. 9, 5c; No. 11, 5c; Hist. Ser., No. 1, 6c; No. 2, 7c; No. 3, 12c. Sci. Ser., No. 1, 2c; No. 2, 2c; No. 3, 3c; No. 4, 3c; No. 5, 10c. All the above are sent in one package by express for 25 cents.

The BULLETIN will be sent to any address from the office of the Secretary of the Board of Regents of the University on receipt of the price (see inside of cover) which includes cost of postage.

Communications having reference to an exchange of publications should be addressed to Mr. Walter M. Smith, University Librarian.

For list of Bulletins issued see inside of cover.